ICDSST 2020

6th International Conference on Decision Support System Technology – ICDSST 2020

on

Cognitive Decision Support Systems & Technologies

University of Zaragoza, Spain, 27th-29th May 2020

Editors:

I. Linden, A. Turón, F. Dargam, U. Jayawickrama

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About the EWG-DSS

The EWG-DSS is a Working Group on Decision Support Systems within EURO, the Association of the European Operational Research Societies. The EWG-DSS was founded during a memorable EURO Summer Institute on DSS that took place at Madeira, Portugal, in May 1989. Most of the participants of the EURO Summer Institute on DSS in Madeira in 1989 still continue nowadays to pursue their goals, working actively in their research areas related to OR and Decision Support Systems.

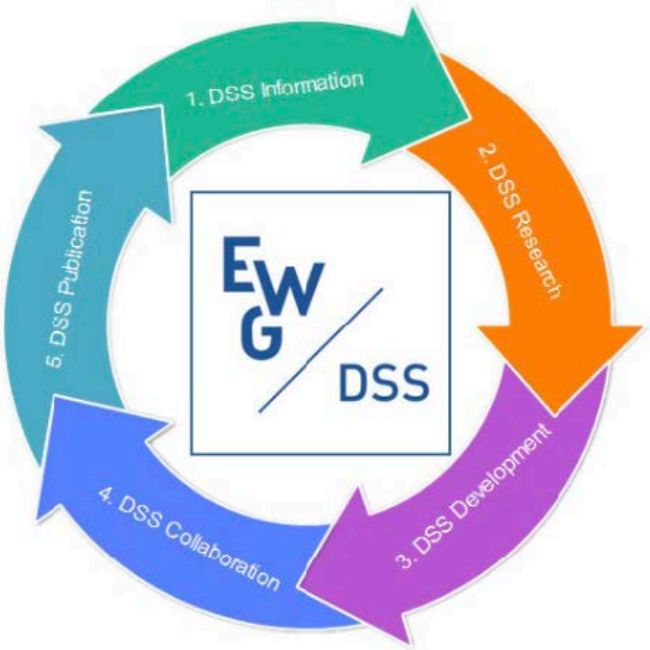
The EWG-DSS was born with 24 founding-members. Since then, the number of members has substantially grown along the years. Now we are over 300 registered members coming from various nationalities. There has also been established quite a few well-qualified research co-operations within the group members, which have generated valuable contributions to the DSS field in journal publications.

Since its creation, the EWG-DSS has held annual Meetings in various European countries, has taken active part in the EURO Conferences on decision-making related subjects; and has organized several workshops and conferences on different topics around Decision Support Systems.

The main purpose of the EWG-DSS is to establish a platform for encouraging state-of-the art high quality research and collaboration work within the DSS community. Other aims of the EWG-DSS are to:

- Encourage the exchange of information among practitioners, end-users, and researchers in the area of Decision Systems.
- Enforce the networking among the DSS communities available and facilitate activities that are essential for the start-up of international cooperation research and projects.
- Facilitate professional academic and industrial opportunities for its members.
- Favour the development of innovative models, methods and tools in the field Decision Support and related areas.
- Actively promote the interest on Decision Systems in the scientific community by organizing dedicated workshops, seminars, mini-conferences and conference streams in major conferences, as well as editing special and contributed issues in relevant scientific journals.

The process-loop shown next translates the main activities of the EWG-DSS envisaging the dissemination of DSS Information (1) and Research (2), in order to encourage DSS Development (3) and Collaboration (4) among the DSS researchers and professionals. As a consequence, Publication (5) opportunities to document the research & development processes and the end results are promoted within the EWG-DSS editions.



Specifically, to accomplish the main objectives listed above, the EWG-DSS promotes the following key-activities:

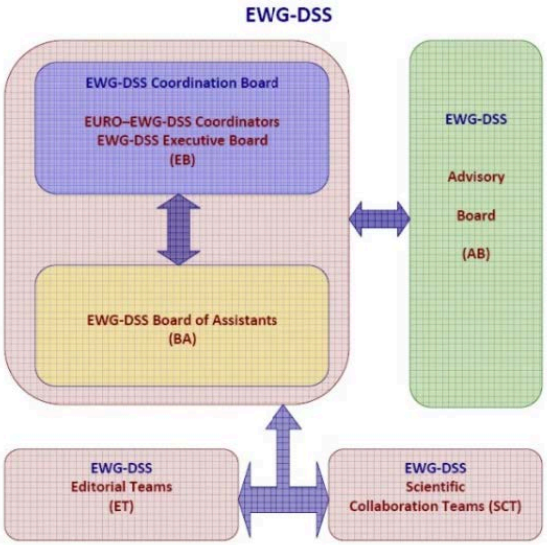
- Annual ICDSST Conference and other Conference-Streams organization related to Decision Support Systems topics.
- Annual Journal Special Issues publications, on support of the annual EWG-DSS organized Conferences, providing publication opportunities in the DSS Community.
- Annual EWG-DSS Newsletter publication, promoting the events and the research achievements of the EWG-DSS members and of the DSS Community as a whole.
- Annual EWG-DSS-Award: a motivating research initiative for young researchers to submit and present their work in one of the EWG-DSS annual organized events.
- Collaboration projects among the group members. Check about the EWG-DSS research project Collab-Net Project, as well as the R&D competences of some member-institutions listed for collaboration in European projects.

Since 2007 the EWG-DSS has been managed by a Coordination Board. One of the aims of this coordination board is to promote joint-work among the group members and to encourage more participation of the whole group in DSS related projects and events, the best way possible. The Current EWG-DSS Coordination Board counts with the assistance of seven Board Members, namely: Prof. Pascale Zaraté, Dr. Fatima C.C. Dargam, Prof. Shaofeng Liu, Prof. Boris Delibasic, Prof. Isabelle Linden, Prof. Jason Papathanasiou and Prof. Pavlos Delias.

EWG-DSS Management Structure

Since May 2015, the EWG-DSS has updated its Management Structure in order to incorporate to the Coordination Board (CB) an Advisory Board (AB), which is composed of senior members of the EWG-DSS group and of the international DSS community. The new group structure also distinguishes different teams, namely: the Scientific Collaboration Team (SCT) and the Editorial Team (ET), among the EWG-DSS Members who collaborate with EWG-DSS projects and joint–Editions, respectively. The figures below illustrate the current EWG-DSS Management Structure:

The Board of Assistants (BA) is formed by young researchers linked to the Coordination Board (CB) and Executive Board (EB) members, in order to assist them with the EWG-DSS annual tasks. Board and Team members can be in more than one of the groups of the EWG-DSS new defined Management Structure. However, the members of the Coordination Board are not supposed to be members of the Advisory Board and vice-versa.



The EWG-DSS Editorial Team (ET) is a dynamic group of researchers composed of EWG-DSS Members that have guest-edited Journal Special Issues and Springer Books with the EWG-DSS CB. The Scientific Collaboration Team (SCT) includes the researchers who are involved with EWG-DSS research projects and initiatives, like for instance the Collab-Net Project.

For more details about the EWG-DSS organized events and publications, check the homepage: http://ewgdss.wordpress.com/.

Joining the EWG-DSS

The EWG-DSS membership does not cost you anything. If you wish to join the EURO-Working Group on Decision Support Systems, all you have to do is to send an e-mail to our group at: <ewg-dss@fccdp.com>, with the following information:
Name; Affiliation; Mailing Address; Phone; e-mail; and Homepage link.

Alternatively, you can also join the EWG-DSS via our LinkedIn Group at:
http://www.linkedin.com/groups?about=&gid=1961459&trk=anet_ug_grppro
Thanks for your interest!
The EWG-DSS Coordination Board

Preface

ICDSST – the International Conference on Decision Support System Technology – is the flagship event of the Euro Working Group of Decision Support Systems (EWG-DSS). The ICDSST series of conference is relatively young and vibrant (since 2015), while its predecessor, including EWG-DSS workshops and summer schools, has a long tradition.

The EWG-DSS was formally established in 1989 during a memorable EURO (European Association of Operational Research) summer school in Madeira, Portugal. Since then, the society has successfully organised wonderful events in many countries with collaboration from fantastic organisations, institutes and communities. Given the COVID-19 crisis, the 2020 edition of the conference was held in a fully online mode, a format that we had never used for meetings of the dimensions of ours. This has meant thinking of new ways of managing the conferences, of accommodating the sessions to participants from so many places in the world and with such varied time slots, and in general of new ways of communicating and interacting with the participants in the Conference.

The ICDSST 2020 International Conference on Decision Support System Technology has been organized by the EURO Working Group on Decision Support Systems EWG-DSS in cooperation with the Zaragoza Muticriteria Decision Making Group of the University of Zaragoza (Spain) at its Faculty of Economics and Business. The Conference is hold at the University of Zaragoza, during the period of May 27th to May 29th, 2020. The purpose of this Conference, focused on the main theme of "Cognitive Decision Support Systems and Technologies - Building the future of Decision Support Systems: the Po-wer of the Mind in the Cognitive processes" is to bring together researchers, developers and specialists in the related areas of decision making, including its methodologies and technologies, as well as application oriented practitioners directed to the implementation of solutions for DSS challenges in their respective areas of applications.

In addition to the consideration of the more traditional issues of the DSS-field, the ICDSST 2020 concentrates on the development of technologies (tools and knowledge) that support the relevance of the human factor and the cognitive orientation in decision making.

Following on from ICDSST 2019 (Main Developments and Future Trends in DSS), ICDSST 2020 will examine the role that the human factor will play in the future of DSS and the technologies required to respond to the new challenges and demands of the Knowledge Society. In particular, we will look at how the affective aspects of human beings affect our preferences and decision making.

Researchers, engineers, computer scientists, OR and DSS professionals were encouraged to submit their work to the ICDSST 2020. The scientific topics of ICDSST 2020 include:

- Decision Support Systems: Advances and Future Trends.
- Multi-Attribute and Multi-Criteria Decision Making.
- Knowledge Acquisition, Management, Extraction, Visualization, and Decision Making.

- Multi-Actor Decision Making: Group and Negotiated Decision Making.
- Collaborative Decision Making and Decision Tools.
- Discursive and Collaborative Decision Support Systems.
- Mobile and Cloud Decision Support Systems.
- Applied Decision Support Systems.
- GIS and Spatial Decision Support Systems.
- Data Science. Data Mining, Text Mining, and Sentimental Analysis.
- Big Data Analytics.
- Imaging Science (Image Processing, Computer Vision and Pattern Recognition).
- Human-Computer Interaction.
- Internet of Things.
- Social Network Analysis for Decision Making.
- Simulation Models and Systems, Regional Planning, Logistics and Traceability.
- Mobility City.
- Business Intelligence and Quantum Economy.
- Machine Learning, Natural Language Processing, Artificial Intelligence.
- Virtual and Augmented Reality.
- New Methods and Technologies for Cognitive Decision Making.
- Cognitive DSS and Cognitive Technologies.
- Affective DSS and Affective Technologies.
- Cognitive Computing.
- Cognitive Applications (cognitive democracy and participation, cognitive risk management, etc.).
- General DSS Case Studies (Business Intelligence, Education, E-Government, Energy, Entrepreneurship, Environment, Health Care, Industrial Diversification and Sustainability, Innovation, Logistics, Natural resources etc).

It is a great pleasure to introduce you to the papers and posters presented at ICDSST 2020, comprising this e-version of proceedings "Cognitive Decision Support Systems & Technologies". Each paper/poster in the proceedings has been evaluated by multiple reviewers. The papers are published in two forms: a selection of high quality, long papers are published by Springer in their book series of "Lecture Notes in Business Information Processing", and short papers and posters are published electronically. Hope you will find some really interesting information/knowledge and stimulating ideas within the broad area of decision making and decision support.

The technical realization of the conference takes place in the Faculty of Economics and Business of the University of Zaragoza, in the center of Zaragoza, Spain, during the period of May 27th-29th, 2019. Every year more than 30,000 students pass through the University of Zaragoza, which has consolidated its position in international rankings and it is now among the top 2 % of the most prestigious universities worldwide. It is one of the 10 best out of the 84 throughout Spain. Its research activity is channeled through the 170 research groups, with more than 2800 researchers, and research institutes that also provide doctoral, specialization and postgraduate programs based on their specialties. They are primarily interdisciplinary in structure and activity.

We don't want to end without thanking many people who have greatly contributed to the success of these proceedings and the conference. Organizing a conference is certainly not an easy task and demands work, dedication and management efforts that we luckily find among the EWG-DSS Coordination Board members, Advisory Board members, Board of Assistants and members of the Organizing Committee of the ICDSST 2020, despite the uncertain environment we have faced this year. We sincerely wish to express our gratitude to all the helping hands that made this conference happen. The production of this volume would not have been possible without the precious support of José María Moreno-Jiménez and Maite Escobar, who worked in tandem with the Editors to perform a plethora of tasks, most of them emerging as urgent requirements. We are deeply thankful to them all! We also would like to thank the sponsorship and support from EURO and the Faculty of Economics and Business of University of Zaragoza for the support given to the realization of the conference. Last but not least, we wish to thank all authors and participants of the conference, for having trust and interest in the EWG-DSS organized conferences by submitting their work for reviewing, presentation and publication; and specially we need to warmly thank all Program Committee members for their excellent reviewing support on this conference. We have accepted 46 submissions of 170 authors from 22 countries and we had a tight schedule for supplying review feedbacks to the authors in time for the updates and videos needed for publication and presentation. We would not have achieved our reviewing goals without the highly qualified, constructive and effective cooperation of our team of reviewers. Excellent job! THANKS to ALL of YOU!

We wish all the ICDSST 2020 participants an enjoyable and fruitful collaboration time during the conference, with lots of networking for further cooperation and joint work. And finally, you have been deprived of a visit to the beautiful city of Zaragoza but, of course, we hope you can enjoy its appeal in the not too distant future. Enjoy the ICDSST 2020!

The Editors:
Isabelle Linden
Alberto Turón
Fatima Dargam
Uchitha Jayawickrama

Invited Talks

Conflict Resolution in the Era of Cognitive Multicriteria Decision Making

Prof. Dr. Luis G. Vargas

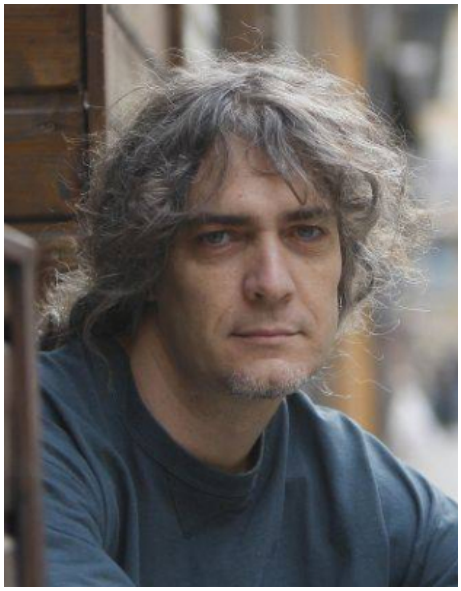
Conflict resolution is a multiparty, multicriteria and multiperiod decision-making process that involve the use of prioritization in the context of benefits, costs, perceived benefits and perceived costs. From the field of behavioral economics, that uses insights from psychology, one learns that conflict resolution is also an evolutionary process of learning to enrich the structure of factors included in the framework of analysis and the interaction and influence of these factors on the outcome with the passing of time.

Traditionally, conflicts have been analyzed quantitatively, using the normal form of a game, with payoffs, of different strategies all played at the same time, that often need to be measured in different ways. Thus, a major problem in analyzing conflicts in quantitative terms is how to deal with the measurement of intangible factors that arise in a conflict. In the past, people have talked around intangibles and have mostly decided not to include them, as dealing with intangibles can be highly subjective.

While each party can reduce the tradeoffs to a single best outcome according to its system of priorities, it remains difficult to trade off values among several parties because of their differing values and objectives. In that case one must find an abstract way to define an index for tradeoffs among the parties that would be hard to reject on grounds of equality and fairness.

Prof. **Luis G. Vargas** was the recipient of the *Juan March Foundation Scholarship,* Madrid, Spain, to the University of Pennsylvania in 1976-78. He won the *Outstanding Professor of the Year Award* in the Joseph M. Katz Graduate School of Business in 1984. He was the coordinator of the *Quantitative Interest Group* from 1987 to 1991 and the coordinator of the *Artificial Intelligence Interest Group* from 1991 to 1994. Area Director of *Decision, Operations and Information Technology* 2009-2012.

Reinventing movies: how do we tell stories in VR?



Prof. Dr. Diego Gutiérrez

Traditional cinematography has relied for over a century on a well-established set of editing rules, called continuity editing, to create a sense of situational continuity. Despite massive changes in visual content across cuts, viewers in general experience no trouble perceiving the discontinuous flow of information as a coherent set of events. However, Virtual Reality (VR) movies are intrinsically different from traditional movies in that the viewer controls the camera orientation at all times. As a consequence, common editing techniques that rely on camera orientations, zooms, etc., cannot be used. In this talk I will investigate key relevant questions to understand how well traditional movie editing carries over to VR, such as: Does the perception of continuity hold across edit boundaries? Under which conditions? Does viewers' observational behavior change after the cuts? To do so, I will rely on recent cognition studies and the event segmentation theory, which states that our brains segment continuous actions into a series of discrete, meaningful events. Our data suggests that predictions from the cognitive event segmentation theory are useful guides for narrative VR.

Prof. **Diego Gutiérrez** is Professor at the *Universidad de Zaragoza* in Spain, where he leads the *Graphics and Imaging Lab*. He's published his research on *virtual reality, perception and computational imaging* in top journals and conferences, including *Nature*. He received a *Google Faculty Research Award* in 2015, and an *ERC Consolidator Grant* in 2016. He has worked at prestigious institutions like MIT, Yale or Stanford, and collaborates regularly with NASA, Disney or Adobe, to name a few.

Decision Support Issues in Autonomous Vehicles

Prof. Dr. David Ríos Insúa

Autonomous vehicles promise to deliver major benefits to society and its individuals although they also entail certain risks. The field presents many challenges to decision support specialists some of which I shall present in this talk, including robustness, real time decisions, interactions between autonomous and non-autonomous vehicles and ethical aspects of AV decisions.

Prof. **David Ríos** is AXA-ICMAT Chair in *Adversarial Risk Analysis* and Member of the Royal Academy of Sciences.

I
Multi-Criteria Decision Making
&
Collaborative Decision Making

ICDSST 2020 PROCEEDINGS – ONLINE VERSION
THE EWG-DSS 2020 INTERNATIONAL CONFERENCE ON DECISION SUPPORT SYSTEM TECHNOLOGY
I. Linden, A. Turón, F. Dargam, U. Jayawickrama (editors)
Zaragoza, Spain, 27-29 May 2020

ICDSST 2020 on Cognitive Decision Support Systems & Technologies

Group Decision Support for agriculture planning by a combination of Mathematical Model and Collaborative Tool

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ABSTRACT

Decision making in the Agriculture domain can be a complex task. The land area allocated to each crop should be fixed every season according to several parameters: prices, demand, harvesting periods, seeds, ground, season etc… The decision to make becomes more difficult when a group of farmers must fix the price and all parameters all together. Generally, optimization models are useful for farmers to find non-dominated solutions, but it remains difficult if the farmers have to agree on one solution. We combine two approaches in order to support a group of farmers engaged in this kind of decision making process. We firstly generate a set of non-dominated solutions thanks to a multi-objective centralized optimization model. Based on this set of solutions we then used a Group Decision Support System called GRUS for choosing the best solution for the group of farmers. The combined approach allows us to determine the best solution for the group in a consensual way. This combination of approaches is very innovative for the Agriculture. This approach has been tested in laboratory in a previous work. In the current work the same experiment has been conducted with real business (farmers) in order to benefit from their expertise. The two experiments are compared.
Keywords: Mathematical Model, Optimization, Multi-objective, GDSS, Group Decision

INTRODUCTION

Each season farmers must face the difficult decision about which crops to be planted and the allocated land area to each of them. Farmers usually make this decision based on market prices of the crops in the previous season. However, market prices highly depend on the balance between supply and demand. In this context, if most of farmers decide to cultivate the crops more profitable the previous year, an excess of these crops could provoke both, a decrease in their prices and high quantities of waste. The imbalance between demand and supply is largely

due to the lack of collaboration among farmers who individually decide about planting and harvesting decisions.

With the aim of supporting farmers in this difficult task, centralized mathematical programming models integrating decisions on planting and/or harvesting for a set of farmers have been developed that provide the optimal solution for the agricultural supply chain. However, this centralized approach could produce inequalities in the profits obtained by farmers, leading to the unwillingness to cooperate and contribute to the collaborative crop planning, and to the farmers unacceptance of the obtained planning. This task is even more difficult when several objectives are taken into account. In this context, approaches exist that can be used to find a predetermined number of non-dominated solutions. However, the problem even remains difficult if farmers have to agree on one solution to be implemented.

In order to support the farmers for this complex task we combine two approaches. We firstly generate a set of non-dominated solutions based on a centralized optimization model. The number of non-dominated solutions should be defined in advance by the group of farmers. Once decided and based on the set of non-dominated solution obtained, we then used a Group Decision Support System called GRUS for choosing the best solution for the group of farmers. The combined approach allows us to determine the best solution for the group in a consensual way. This combination of approaches is very innovative for the Agriculture domain.

In [1], we combined these two approaches in order to generate a satisfactory solution for a group of human beings. First of all, we generated 10 solutions thanks to a centralized optimization model. These solutions are then explained to a group of five end-users playing the role of farmers. We, in a second step, asked to the five end-users to give their own preferences on these 10 solutions using a Group Decision Support System (GDSS), called GRUS. This GDSS allows to find the final ranking for the group based on the preferences given by the stakeholders. It was shown in this study how the GDSS GRUS is helpful to generate a group decision which reduces conflicts in a group and how it supports to find a consensus. In the GDSS we used the Borda voting procedure [2]. Nevertheless, the conclusions of this experiment have some limitations based on the fact the decision makers were researchers and not farmers. In this current paper, we conducted the same experiment with real agriculture businessmen. The main objective of this paper is to compare the results found in laboratory with results obtained with real users.

The paper is structured as follows. First, the problem under study is described. Second, the methodology to generate multiple solutions. Then, the group decision procedure to select one of them in a laboratory and real contexts and their comparison are presented. Finally, a set of conclusions are derived.

THE PROBLEM

The agricultural supply chain under study is one typical of the region of La Plata, in Argentina, for the tomato crop. The supply chain is assumed to be integrated by different farmers that are in charge of the production, cultivation, harvesting and distributing of different varieties of tomatoes to several markets. A mixed integer linear programming model (MILP) was developed to support the centralized decision making about the planting and harvesting decisions per farmer and tomato variety, the quantity of each type of tomato to be transported from the farmer to each market, the waste as well as the unfulfilled demand. Five farmers were considered with an available planting area in hectare (ha) for each farmer of 20, 18, 17, 16 and 15, respectively. The planning horizon was one year divided into months. Three tomato varieties were considered: pear, round and cherry. The planting period comprises three different months (July, October, and January) that do not depend on the specific variety. The

harvesting periods and the yield are dependent on the planting period but are also the same for all the tomato varieties (Table 1). These planting periods are the usual in the region of La Plata, that is one of the most important areas of tomato in greenhouse for sell in fresh in Argentina.

Table 1. Harvesting periods

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
July					X	X	X	X				
October							X	X	X	X		
January									X	X	X	X

From the planted date to the harvesting date, different activities need to be made to the plant in order to ensure its correct growth. Because the tomato crop matures over time, it is necessary to make different harvesting passes in the same time period whose time per plant depends on the tomato variety. Both activities require of human labor that is assumed to present limited capacity.

Once harvested the tomatoes are distributed to two different customers, a central market and some restaurants, incurring in a transport cost that depends on the farmer and the customer. The transported quantities to each market try to satisfy the monthly demand of variety taking into account the sale prices that is dependent on the ratio between supply and demand. Lack of supply to cover market demand is modelled by the decision variable of unmet demand and excess of supply as regards market demand is reflected by the waste decision variables.

The decisions made should respect limitations about the available planting area in each farm and other supply chain policies related to the planting of tomato varieties: all tomato varieties should be planted in all planting periods and all farmers should plant some variety in all planting periods. Other constraints reflected the balance equations between quantities planted and harvested and these last ones with transported quantities and fulfilled demand. The waste in each farm is calculated as the difference between matured tomatoes and those not harvested meanwhile the waste in markets as the difference between quantities transported and not sold.

When searching for a solution the three dimensions of sustainability are taken into account by incorporating them into the multi-objective model. The three objectives considered were:

- Economic Objective: Maximize the profits of the supply chain as the difference between incomes per sales and total costs.
- Environmental Objective: Minimize the total waste along the Supply Chain.
- Social Objective: Minimize the unfulfilled demand along all the Supply Chain covering human requirements and increasing the customer satisfaction.

In its current state, the experiment does not take into account the fact that side payments would be possible to make the generated solution acceptable for all group members. Instead, the GDSS GRUS is used to choose the most satisfactory solution for the group between non-dominated solutions whose generation is reported in the following section.

GENERATING NON-DOMINATED SOLUTIONS FOR THE MULTI-FARMER PLANTING MODEL

To solve the centralised multi-objective mixed integer linear programming model, we transformed it into a single-objective model by applying the ε-constraint method ([3]; [4]).The method starts optimizing the model only for one objective. The optimal value of this first objective is used to formulate a constraint for the next model execution that in this step is optimized for a second objective. The same process is made with the third objective by constraining both the first and second objective. The process is repeated now starting from

another objective and so on until all the different combinations of the objectives are solved. This provides with a set of solutions from which dominated solutions are discarded. The non-dominated solutions are analyzed to identify the best and worst values for each objective that provide the range of values used to define the grid points for which the model will be solved.

For our case study, ten values were defined for the ε_i parameter. The model was implemented using the MPL software 5.0.6.114 and the solver Gurobi 8.0.1. This provide us with ten non-dominated solutions. The detail for each non-dominated solution can be consulted in Table 2. For each solution, the value of the three objective functions for the entire supply chain are presented. Readers are referred to [1] to consult the solution for each farmer. It is necessary to find a complementary procedure to decide which non-dominated solution to implement for two reasons: 1) because of being non-dominated solutions the profit, wastes and unfulfilled demand that reports the best result for one objective is not the best for the others and 2) there are multiple farmers affected that will not base their decisions only on SC objectives but also and mainly in their own objectives. This procedure based on the GRUS system is described in the following section.

Solution	Name	SC Profits (€)	SC wastes (kg)	Unfulfiled demand (kg)
1	A	148.334.625	5.316.020	207.317.999
2	B	148.302.280	5.315.998	201.749.612
3	C	148.003.481	6.417.520	195.841.392
4	D	146.849.751	11.193.326	189.933.239
5	E	145.326.260	14.017.213	184.025.050
6	F	142.518.888	11.213.768	178.116.854
7	G	136.863.913	8.410.330	172.208.666
8	H	146.572.577	-	204.769.167
9	I	135.083.010	-	182.724.221
10	J	129.129.328	25.230.996	154.484.078

Table 2. Objective values for the non-dominated solutions generated

GRUS RESEARCH EXPERIMENT USING CENTRALIZED MODEL SOLUTIONS

We used GRUS to rank the 10 generated solutions for the multi-farmer planting model which anticipates harvesting and transporting decisions. We had five decision makers playing the role of the farmers, including the facilitator as a decision maker. This experiment was conducted in research laboratory. The adopted process was composed by the following three steps:

1. Alternatives generation: The facilitator filled in the system the 10 non-dominated solutions found thanks to the optimization model.
2. Vote: The five decision makers ranked the 10 solutions according to their own preferences. For this, the value of each objective jointly with the area planted with each tomato variety for each farmer and for the whole supply chain were provided to decision-makers.
3. Ranking solutions: The system then computes the final ranking for the group using the Borda [2] methodology.

The results of this procedure are described in the Table 3.

Research Experiment (RE)		
Solution	**Points**	**Ranking**
A	17	4 ex aequo
B	20	3
C	23	2
D	24	1
E	17	4 ex aequo
F	16	5 ex aequo
G	16	7
H	10	5 ex aequo
I	15	6
J	8	8

Table 3. Result of the Group Ranking provided by GRUS for the research experiment.

This result is given for the group of five end-users. The five farmers have the same weight (importance) for this experiment. Nevertheless, we also could choose that the importance of each farmer is linked to the number of hectares, only in Multi-Criteria processes.

We can see that on positions 4 and 5 two alternatives are ex aequo: solutions A and E for rank 4 and solutions F and H for rank 5. The best solution for the group is the one for which the five farmers have benefits and the three tomato varieties are planted, that is solution D. Nevertheless, we can notice that it is not the solution, which generates the best profit on a global point of view.

This first experiment shows that the solution obtained by a centralized optimization model that generates the highest profit, that is the solution A, is not necessarily the best one for the group of agents (humans). In order to show that this combination of approaches could be useful in real situations, we conducted again the same experiment with real businessmen in agriculture (farmers).

GRUS BUSINESS EXPERIMENT USING CENTRALIZED MODEL SOLUTIONS

We again used GRUS to rank the same 10 generated non-dominated solutions. Four decision makers who were businessmen in agriculture, including the facilitator as a decision maker, gave their own preferences. The same process composed by the above three steps was adopted but the business had a higher importance than the facilitator. For this second experiment the five end-users did not have the same importance. The facilitator had the lowest importance (1) and two of the businessmen had the highest importance (5). The two other businessmen had a medium importance (3). The results can be consulted in Table 4. We can observe that for businessmen selection, the solution with the highest profit is the best in the new ranking.

Business Experiment (BE)		
Solution	**Points**	**Ranking**
A	30	1
B	26	4
C	17	7 ex aequo
D	18	6
E	11	8
F	17	7 ex aequo
G	28	3
H	20	5
I	29	2
J	6	9

Table 4. Result of the Group Ranking provided by GRUS for the business experiment

The comparison of the final ranking between the business experiment (BE) and the research

experiment (RE) can be consulted in Table 5, where the last three columns on the right represents the difference for each objective between solutions for businessmen and researchers ranked in the same position. A positive difference for SC profits means that businessmen solution is better in profit than researcher solution because the objective is to maximize profits. On the contrary a negative difference in SC wastes and unfulfilled demand represents a better solution for these two objectives for businessmen since the objective is to minimize them.

				Business Experiment (BE)							Research Experiment (RE)		DIFFERENCES= BE-RE		
Solution	SC Profits (€)	SC wastes (kg)	Unfulfilled demand (kg)	Ranking	Points	Solution	SC Profits (€)	SC wastes (kg)	Unfulfilled demand (kg)	Ranking	Points	SC Profits (€)	SC wastes (kg)	Unfulfilled demand (kg)
A	148.334.625	5.316.020	207.317.999	1	30	D	146.849.751	11.193.326	189.933.239	1	24	1.484.874	-5.877.306	17.384.760
I	135.083.010	0	182.724.221	2	29	C	148.003.481	6.417.520	195.841.392	2	23	-12.920.471	-6.417.520	-13.117.171
G	136.863.913	8.410.330	172.208.666	3	28	B	148.302.280	5.315.998	201.749.612	3	20	-11.438.367	3.094.332	-29.540.946
B	148.302.280	5.315.998	201.749.612	4	26	A	148.334.625	5.316.020	207.317.999	4 ex aequo	17	-32.345	-22	-5.568.387
H	146.572.577	0	204.769.167	5	20	E	145.326.260	14.017.213	184.025.050	4 ex aequo	17	1.246.317	-14.017.213	20.744.117
D	146.849.751	11.193.326	189.933.239	6	18	F	142.518.888	11.213.768	178.116.854	5 ex aequo	16	4.330.863	-20.442	11.816.385
C	148.003.481	6.417.520	195.841.392	7 ex aequo	17	H	146.572.577	0	204.769.167	5 ex aequo	10	1.430.904	6.417.520	-8.927.775
F	142.518.888	11.213.768	178.116.854	7 ex aequo	17	I	135.083.010	0	182.724.221	6	15	7.435.878	11.213.768	-4.607.367
E	145.326.260	14.017.213	184.025.050	8	11	G	136.863.913	8.410.330	172.208.666	7	16	8.462.347	5.606.883	11.816.384
J	129.129.328	25.230.996	154.484.078	9	6	J	129.129.328	25.230.996	154.484.078	8	8	0	0	0

Table 5. Comparison of the Group Ranking between the business experiment (BE) and the research experiment (RE)

Based on this, it can be observed in Fig. 4 that the rankings obtained for each group of decision-makers are different. It might seem that for businessmen is more important the SC profits than the other objectives because the solution A is the 1^{rst} in their ranking. However, if we compared the 2nd, 3rd and 4th solutions for the BE and RE, it can be observed that businessmen also consider important to minimize wastes and unfulfilled demand even worsening the SC profits. In any case, the alternative with the lowest profit and maximum waste stays the worst in the two rankings (J). It seems that for them the SC Profits and Wastes criteria are much more important than the SC unfilled demand criterion.

Comparing the two rankings, it can give a good representation on the weights of criteria for real decision makers. The difference between the research and the businessmen experiments ranking can be explained by the expertise that the businessmen have on how to manage this decision problem. Therefore, it can be concluded that the best solution for a group even based on quantitative objectives depend on the subjects involved being even more difficult to predict when multiple objectives should be considered.

CONCLUSIONS

Supporting a group of decision makers engaged in a decision process is generally a complex situation. Several stakeholders may involve conflicting situations that cannot be avoided. Two main difficulties can arise for a group of decision makers: determine the alternatives and determine the weight of criteria. Each decision makers can have his own preferences for the weight of criteria but determining the weight for the whole group of decision makers is a complex task considering that some decision makers could have more experience or have more importance in the group. In order to solve these issues, we combine two approaches. We firstly generate a set of non-dominated solutions thanks to solve a multi-objective centralized optimization model by means the ϵ-constraint method. The advantage of this automatic generation of solutions is that the decision makers can have a reasoning based on shared alternatives. Based on this set of solution, we then used a Group Decision Support System called GRUS for choosing the best solution for the group of farmers. The combined approach allows us to determine the best solution (or the least bad) for the whole group in a consensual way. This combination of approaches is very innovative for the Agriculture. The experiment

was conducted twice: firstly, in a laboratory and then with real businessmen (farmers). As a result of these two experiments we can conclude that the weight of all used criteria is not the same for businessmen and researchers.

As perspective of this work and in order to avoid boring tasks to businessmen, like for example evaluate the weight of criteria, it would be interesting to calculate the weight of criteria by comparison with two experiments.

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Experimental evaluation of a solution method for bilevel knapsack problems

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ABSTRACT

We consider the class of problems with two different decision-makers. The first one, called the leader, solves an optimization problem with a constraint involving another optimization problem, solved by the second decision-maker, called the follower. Such hierarchical problems emerge in many practical applications, for instance, in revenue optimization, transportation networks and energy allocation, among others. Moreover, they provide a natural method for consideration of uncertainty in the input data in decision-making. However, most multi-level models of practical interest are very difficult to solve with the current computational techniques, especially when both continuous and integer variables are involved. Although many single-level versions of such problems can be efficiently solved with today's technology, their hierarchical generalizations usually provide a significant challenge even for the modern state-of-the-art solvers.

In this paper, we consider different variants of bilevel knapsack problem. These problems model various practical applications, as well as constitute fundamental building blocks of more advanced models. Due to their concise formulations, they are also suitable for generating benchmark instances for the evaluation purpose of solution algorithms. We apply a general bilevel optimization method based on branch and cut paradigm. The implementation of this method as an extension of mixed-integer programming solver is presented. The computational study conducted on three different variants of bilevel knapsack problem is then presented. For the comparison, a baseline algorithm with the exhaustive search on the leader level, and single-level branch and cut on the follower level, was utilized. We found the considered branch and cut method to be very efficient for bilevel problems with non-competing optimization goals. We also note, however, that the problems with competing objectives are much more challenging.

Keywords: hierarchical decision-making, mathematical programming, computational study

INTRODUCTION

Many practical applications of mathematical optimization involve hierarchical structures. It is often a modelling simplification to flatten that structure into a single level. Such reduction enables the utilization of well-known computational methods, efficient in terms of the time required to evaluate a decision. However, the associated optimization problems could be often much better modelled utilizing the concept of a hierarchy of decision-makers, with decisions at each level influencing the outcome on adjacent levels. For example, many managerial decisions involve a conflict of interest and the primary decision-maker need to predict the influence of adversarial behavior of involved parties. As another example, we note that almost any optimization problem may be affected by uncertainty of its input parameters, as they may be obtained from measurements of limited precision, a forecast, or averaging. In such case, the uncertainty itself may act as an adversary for the primary decision-maker and may greatly impact the quality of decisions.

Although general multilevel optimization problems have been considered in the literature [1], the fundamental case is the bilevel optimization, with just two levels of hierarchy, that already covers a very wide range of real-world applications. The bilevel models have been applied, among others, in: revenue management [2], network design problems [3, 4], energy allocation problems [5], chemical engineering [6].

It turns out that the introduction of the second level in the mathematical optimization models brings inherent complexity from the computational standpoint. In general, such problems belong to the class Σ_2^p [7], i.e., a set of problems that remain NP-hard to solve even if we can use an oracle that answers NP queries in $O(1)$ time. Some special cases of these problems are notoriously hard to solve to optimality. This is unfortunate, as due to the ubiquity of such problems, it is very desirable to have a general-purpose mathematical programming solver of high quality for such problems, as we have for single-level mixed-integer optimization (with industry standard software like Cplex, Gurobi, Xpress).

In this paper, we evaluate an implementation of state-of-the-art mixed-integer solver for bilevel optimization problems, based the branch and cut scheme introduced in [8]. A computational study on three different variants of bilevel knapsack problem is presented. We find that these formulations vary significantly in terms of computational difficulty. We also describe a concept of the baseline algorithm as a comparative approach to solving bilevel problems.

PROBLEM FORMULATIONS

A general bilevel mixed-integer programming problem can be stated as:

$$\max_{x \in \mathbb{R}^{n_1}, y \in \mathbb{R}^{n_2}} F(x, y) \tag{1}$$

s.t.

$$G(x, y) \leq 0 \tag{2}$$

$$y \in \arg\max_{y' \in \mathbb{R}^{n_2}} \{f(x, y') : g(x, y') \leq 0\} \tag{3}$$

where x is the vector of leader's decision variables, y is the vector of the follower's decision variables, $F(x, y)$ is the leader's objective function, function $G(x, y)$ defines the set of feasible solutions of the outer problem, while $f(x, y)$ is the follower's objective function and $g(x, y)$ defines the set of feasible solutions of the inner problem. Note that constraint-defining functions G and g may be used also to impose integrality of selected variables. Although all

the formulations considered in this paper have maximization in the inner problem, we consider both maximization and minimization in the outer problem.

The following variants of bilevel knapsack problem were considered (see [9] for the analysis of the complexity of these problems).

(1) Dempe-Richter's (DeRi) variant, stated as:

$$\max Ax + \boldsymbol{a}\boldsymbol{y} \tag{4}$$

s.t.

$$C \le x \le C', \tag{5}$$

$$\boldsymbol{y} \in \arg\max_{\boldsymbol{y}'}\{\boldsymbol{b}\boldsymbol{y}' : \boldsymbol{b}\boldsymbol{y}' \le x\}, \tag{7}$$

$$y_j \in \{0,1\}, \quad j = 1, \dots, n.$$

In this simple variant, the leader decides on the knapsack capacity, while the follower solves the regular knapsack problem with the imposed capacity. The items may have different values from leader and follower perspectives.

(2) Mansi, Alves, de Carvalho and Hanafi (MACH) variant, stated as:

$$\max \boldsymbol{a}_x\boldsymbol{x} + \boldsymbol{a}_y\boldsymbol{y} \tag{8}$$

s.t.

$$\boldsymbol{y} \in \arg\max_{\boldsymbol{y}'}\{\boldsymbol{b}\boldsymbol{y}' : \boldsymbol{c}_x\boldsymbol{x} + \boldsymbol{c}_y\boldsymbol{y}' \le A\}, \tag{9}$$

$$x_i \in \{0,1\}, \quad i = 1, \dots, n, \tag{10}$$

$$y_j \in \{0,1\}, \quad j = 1, \dots, m. \tag{11}$$

Here the item set is divided into two groups, with one group controlled by the leader, and the other by the follower. Leader decides on the choice of items first, however, the leader's outcome depends on both agents' choices. The follower fills the remaining knapsack's capacity in order to maximize his private objective function.

(3) DeNegre variant:

$$\min \boldsymbol{b}\boldsymbol{y} \tag{12}$$

s.t.

$$\boldsymbol{a}\boldsymbol{x} \le A \tag{13}$$

$$\boldsymbol{y} \in \arg\max_{\boldsymbol{y}'}\{\boldsymbol{b}\boldsymbol{y}' : \boldsymbol{c}\boldsymbol{y}' \le B, y_i' + x_i \le 1\}, \tag{14}$$

$$x_i, y_i, y_i' \in \{0,1\}, \quad i = 1, \dots, n. \tag{15}$$

In this variant, the two decision makers share the set of items, but have separate knapsacks and directly competing objectives: leader aims to choose such items that would restrict the choice of the follower in order to minimize the value of follower's knapsack. At the same time, the follower aims to maximize the value of items selected among the remaining ones. Note that the directions of optimization are the opposite in this case.

COMPUTATIONAL EXPERIMENTS

In this section, we present and discuss the results of computational experiments on the branch and cut method for solving bilevel packing problems. We test two hypotheses. The first one states that computation time needed to achieve optimal or near-optimal result is faster for the tested method than for the baseline algorithm. The second hypothesis is that the studied

approach maintains its usability (understood in terms of providing optimal or near-optimal solution) if the problem instances are scaled up to tens of thousands of items.

The general approach to solving mixed-integer bilevel problems utilizes the *high-point relaxation*, where the inner problem's constraint involving maximization or minimization is first replaced by nonlinear constraint, which is then relaxed. The bilevel feasibility is then examined in each node of the branch and cut tree by solving the inner problem for a (partially) fixed leader's decision vector. This algorithm is described in detail in [8].

In order to acquire a reference for the performance results of the studied algorithm we propose an alternative method for solving bilevel problems. We will call this approach the baseline algorithm. The concept of this method is as follows: firstly, all possible **x** values are enumerated, and for each feasible value of **x** the follower problem is solved using an existing MILP solver. While solving the follower problem all feasible solutions are stored; after all cases are finished, an objective function value is computed for each fixed pair of **x** and y values. Finally, a pair of **x** and **y** is selected for whom the objective function has the value best matching an optimization criteria.

Testbed

The computational experiments are divided into two stages. In the first stage, we compare the execution time of the considered branch and cut method and baseline algorithm. In the second stage of experiments we study the relative gap for relatively large instances of the knapsack problem. As the baseline algorithm does not provide a way to measure relative gap, the second stage of experiments was conducted with the branch and cut method only.

We obtained the data for the computational study by implementing test data generator. The generator creates values for problem instances, provided with a fixed number of items, and randomizes integer values for parameters (item value, item weight, knapsack capacity) within the given boundary values.

The testbed for the computational experiments was a Dell Inspiron laptop, with Intel Core i7 2.8GHz CPU, 16GB RAM and SSD storage. The operating system for the machine was Windows 10 (64-bit). The implementation utilized MILP solver ILOG CPLEX 12.8, with the Python API for CPLEX and the callback functionality.

Study of the computation time in comparison with the baseline algorithm

During the first stage of experiments, we determined that the studied method is considerably faster than the baseline algorithm while solving instances of knapsack problems in DeRi and MACH variants. However, when the leader and follower objective functions are competing, the advantage of the studied method is deteriorating, as the study on DeNegre variant shows.

For MACH problem five different settings of the test data generator were used to generate five groups of multiple problem instances; in each case the branch and cut method achieved an optimal solution in under 0.1 seconds, while the baseline algorithm usually finished with timeout (set to 60 seconds) returning feasible solution without the guarantee of its optimality. For one of the test data generator settings the baseline algorithm managed to provide an optimal solution, however even then the time needed to achieve the solution was about 2.5 seconds. Our study on DeRi variant has shown that for small instances of the knapsack problem (10 items to choose from) a baseline algorithm actually performs better that the studied method (execution time 0.887 seconds vs. 1.527 seconds). Increasing the number of items to 30 allowed the studied method to reduce the computation time to about

0.4 seconds. The similar time was achieved as well when there were 50, 70 and 100 items to choose from. The baseline algorithm however presents the clear tendency to increase the execution time with the increase of the number of available items – for 30 items the execution time was 7 seconds, for 50 – at least 12 seconds; for 50 items the first cases when the baseline algorithm failed to provide the optimal solution emerged. For instances where number of items were greater than 50, no optimal solution was found in given time limit.

The study we conducted on the DeNegre's knapsack problem variant has shown that when the follower and leader objective functions are competing, the advantage of the studied method over the computational algorithm is no longer clear. For five different settings of the test data generator, in two cases performance of the studied method and the baseline algorithm is comparable (execution stopped on timeout, providing feasible solution, without the guarantee of optimality). We note the exception of cases when the optimal solution was equal to 0. For those, the studied method returned the solution in under 0.4 seconds. For the remaining three settings of the test data generator the baseline algorithm performs better than the branch and cut method, as it delivers the optimal solution in about 6 seconds, while the latter method uses up all available time and finishes only with feasible solution.

The summary of the data collected during this stage of the computational study is presented in the Table 1 (SD stands for *standard deviation*).

Table 1: Summary of the study of the computation time

Problem variant	Description	Studied method	Baseline approach
MACH	All instances	Optimal – avg. 0.056s (SD = 0.033)	Mostly timeout – avg. 37.197s (SD = 25.640)
DeRi	Instances with 10 items	Optimal – avg. 1.527s (SD = 2.274)	Optimal – avg. 0.878s (SD = 0.299)
	Instances with more than 10 items	Optimal – avg. 0.422s (SD = 0.376)	Optimal for less items, timeout for more items – avg. 47.113s (SD = 31.953)
DeNegre	Instances with optimal value = 0	Optimal – avg. 0.331s (SD = 0.110)	Mostly timeout – avg. 28.348s (SD = 8.000)
	Other instances	Mostly timeout – avg. 35.934s (SD = 12.564)	Optimal in about 6 seconds or timeout – avg. 13.200s (SD = 11.730)

Study on the relative gap for large problem instances

In the second stage of the computational research we studied only the DeRi and MACH knapsack problem variants, due to the problems of the DeNegre's variant even with relatively small instances of the problems.

We conducted the study on MACH variant with instance groups with 10 000, 50 000, 100 000 and 500 000 available items. With timeout set to 90 seconds, solving of the first two groups produced the optimal solution or a solution very close to the optimal (relative gap equal or less than 0.1%) in all cases. For 8 instances of total 50 in the group with 100 000 items available the studied method retuned only feasible solution, but mean relative gap for those instances was relatively small (3.77%). Computation of the 50 instances in the last group delivered an optimal or almost optimal solution in 34 cases; the

remaining 16 cases were finished on timeout and produced feasible solutions with mean relative gap of 13.39%.

The studied method returned an optimal or feasible solution with relative gap 3% or less for all DeRi problem variant instances with 50 000 items or less. However, when we increased the number of available items to 60 000 while keeping the rest of the test data generator settings and generated another 50 instances, only 36% of them was solved with an optimal solution, with the mean time of execution of 32 seconds. In 12% of the cases no feasible solution was found, while for the remaining 52% of instances the studied method finished execution on the 90 seconds timeout, with the mean relative gap of 1865%. When we increased the number of items to 80 000, only 12 of 50 instances was solved with an optimal solution (in the average time of 30 seconds). For 10 instances no feasible solution was found and for the remaining 28 instances a feasible solution was found, with the mean relative gap of 2518%. Summary of the results of this stage of the experiments are presented in Table 2.

Table 2: Summary of the study on the relative gap for large problem instances

Problem variant	Description	Studied method
MACH	Instances with 10 000 – 50 000 items	Optimal
	Instances with 100 000 items	Mostly optimal, avg. relative gap 3.767% (SD = 2.538) when nonoptimal
	Instances with 500 000	Mostly optimal, avg. relative gap 13.387% (SD = 11.399) when nonoptimal
DeRi	Instances up to 50 000 items	Mostly optimal, avg. relative gap 3% (SD = 0.566) when nonoptimal
	Instances with 60 000 items or more	Mostly nonoptimal, some without any solution; avg. relative gap when nonoptimal: 2210.393% (SD = 2120.839)

The conducted study shows that the method maintains its usability even for instances of knapsack problem containing tens of thousands of items. However, as the study on DeRi variant shows, after a certain problem size threshold is reached, the efficiency of the method deteriorates rapidly. Applying the studied method to real-life problems should be done with this scalability limitation in mind, with constant supervision of the relative gap.

CONCLUSIONS

The presented study indicates that the considered branch and cut method could be a very efficient tool for solving bilevel optimization problems with inner-level optimization direction agreeing with the outer-level. However, the study indicates that the problems with competing objectives appear to be much more challenging. We also note that the solution method scales only up to a certain problem size of the last knapsack problem variant.

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Tool support for Generating User Acceptance Tests

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ABSTRACT

Software testing, in particular acceptance testing, is a very important step in the development process of any application since it represents a way of matching the users' expectations with the finished product´s capabilities. Typically considered as a cumbersome activity, many efforts have been made to alleviate the burden of writing tests by, for instance, trying to generate them automatically. However, testing still remains a largely neglected step. In this paper we propose taking advantage of existing requirement artifacts to semi-automatically generate acceptance tests. This paper extends a previous paper in which we use Scenarios, a requirement artifact used to describe business processes and requirements, and Task/Method models, a modelling approach taken from the Artificial Intelligence field. The proposed approach derives a Task/Method model from Scenario (through rules) and from the Task/Method model specification, all alternatives in the flow of execution are provided. Using the proposed ideas, we show how the semi-automated generation of acceptance tests can be implemented by describing an ongoing development of a proof of concept web application designed to support the full process.

Keywords: User Acceptance Tests, Scenarios, Task/Method model, Agriculture Production

INTRODUCTION

Developing software still remains a very complex process involving several actors and consisting of different steps. The testing step remains as one of the biggest problems, and it is frequently avoided. As a consequence, the resulting system can fail to meet users' expectations, rendering it useless. Our objective is to develop a strategy to make the testing step easier, generating User Acceptance Tests (UAT) in a semi-automatic way from requirements artifacts. Many software development methods use, in the early stages, steps to clarify business processes and specify requirements. These processes are often used to define the UAT. A semi-automatic generation of UAT can with few efforts support the software

engineers to elicit, to clarify and to discuss the business processes and the requirements by showing some implications of their analysis/modeling. Theses analysis can result in new modifications and developments of the model of business processes and requirements. Therefore, a semi-automatic generation of UAT constitutes a decision support for the modelling of business processes and requirements. To do this semi-automatic generation, we combine two modelling approaches: Scenarios, from the requirement engineering field and Task/Method models, from the Artificial Intelligence field, particularly knowledge-based systems [3]. A first work has been done (see [1] and [2]) which proposes to use a wiki website for describing Scenarios, and to translate these Scenarios in Task/Method model in a semi-automatic way.

Figure 1 depicts the overall proposed process. First, the users describe scenarios thanks to a website application after, the translation rules are applied to generate the corresponding task/method model. These steps were already proposed in a previous work [1]. The obtained task/method model is then executed by an execution engine which produces an Execution Tree (ET). A ET is a data structure representing all possible executions of the task/method model (hence, all possible flows of actions and tests). Test cases can be extracted from this ET. In this paper, we will focus on the last two steps: execution engine and the test cases generation.

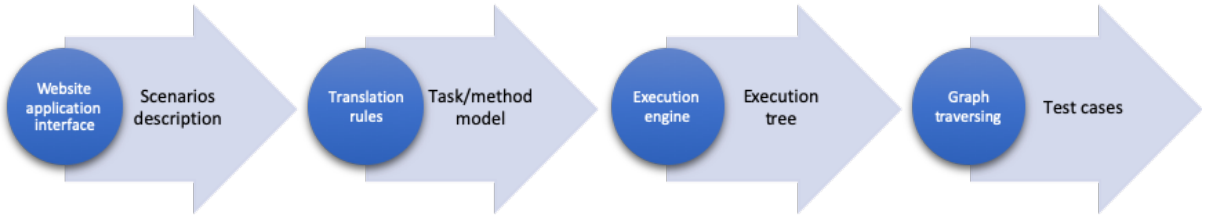

Figure 1: Test cases generation process

This work is applied to the RUC-APS project. RUC-APS is a H2020 RISE-2015 project, aiming at Enhancing and implementing Knowledge based ICT solutions within high Risk and Uncertain Conditions for Agriculture Production Systems. In this context we will use a scenario based on agriculture production. The rest of the paper is organized as follows: we first introduce related work, then present the background introducing scenarios and the Task/method paradigm. In the third part, we describe the two last steps of our approach (see Figure 1) which will be illustrated by a Task/Method model generated from a scenario based on agriculture production. Finally, we show our conclusions and future work.

RELATED WORK

Garousi et al. [4] describe six steps in test cases automations: (i) test-case design, (ii) test scripting, (iii) test execution, (iv) test evaluation, (v) test results reporting and (vi) test management and other test engineering activities. Our approach has the aim of designing test-cases. So, we provide a technique to cope with the first step (test-case design). Takagi et al. [5] describe a strategy to develop a graph that model the histories of test case execution. Although the authors deal with low level histories related to hardware testing, their proposal is similar to our proposal, since we generate a tree with all the different scenarios that need to be tested. Monpratarnchai et al. [6] propose a tool to automatically generate test cases for Java applications. They analyze the source code and derive a script using a symbolic language. After that, Junit code is generated. Our strategy is similar, since we analyze Scenarios, the source description of the requirements and Task / Method model language is used to specify criteria that allow to obtain test cases. Stoyanova et al. [7] propose a

framework for testing web app. The framework has two main parts: (i) test case generation and (ii) test case execution. Although we have to execute Task / Method model script, it is needed to obtain the test cases. That is, the tree that we obtain is the final test cases that is needed to test the application. Chatterjee et al. [8] propose an approach to automatically generate test cases from Use Cases. Bouquet et al. [9] propose a similar although they use class diagram and state machine to derive the tests. They explore all the alternatives in the flow of the dialog as well as the preconditions and they generate all the tests needed. The difference with our approach is that they rely on state while we rely on actions. We consider that every action can be success or fail, why they rely on every state of the different elements included in the situation.

BACKGROUND

Scenarios

Scenarios can be used in different stages of software development, from clarifying business process and describing requirements, to providing the basis of acceptance tests [10]. There is a distinction between application domain (the real world) and the application software (the machine) [11]: during business process modelling and requirements elicitation, Scenarios describe events in the world, while in system specification, they describe events in the machine. Scenarios are stories about people and the activities they perform to reach certain goals, parting from a setting and counting with some resources. Their description ranges from visual (storyboards) to narrative (structured text) [12]. Leite et al. [13] propose a template with six attributes to describe Scenarios in a textual way: (i) Title, it is the name of the scenario to identify it, (ii) Goal, conditions and restrictions to be reached after the execution of the Scenario, (iii) Context, conditions and restrictions that are satisfied and constitute the starting point of the Scenario execution, (iv) Actors are agents that perform actions during the Scenario to traverse the path from the context to reach the goal, (v) Resources, products and elements used by the actors to perform action, and (vi) Episodes: steps executed by the actors using the resources beginning at the context to reach the goal.

The text descriptions in Scenarios follow a fixed structure. In particular, episodes must be written with full sentences describing the subject, the action they perform, and if necessary the resource used. The following example describes partially some Scenario for farmer packing products. The example also includes the cases to consider for testing the scenario. These test cases do not belong to the original structure of the scenario:

Scenario: detect stress in crops of tomatoes and peppers
Resources: Sensors
Actors: System
Episodes:
The sensor reads the temperature
The sensor reads the level of humidity
The sensor reads the intensity of the light
The system determines if it is a stressful condition
Test cases:
If some sensor can not read the data the system do not have the input necessary to infer a prediction.
All the sensors can read the data, but the system does not have historical information to infer a prediction

Scenario: collect information
Resources: Sensors
Actors: System
Episodes:
Several sensors collects information about the temperature
The system calculates the average to determine the temperature
Test cases:
There is a problem collecting the information
There is a problem summarizing the date

Task/Method Paradigm

The task/method paradigm is a knowledge modelling paradigm (mainly from the artificial intelligence field [14], [15]) that sees reasoning as a task. Knowledge is expressed in a declarative way, making it easy to process by execution engines or planners [1]. A task/method model is composed by a ***domain model*** and a ***reasoning model***. The former describes the objects of the world being used (directly or indirectly) by the latter, similarly to an application ontology. It is often described in UML language and implemented with OO languages. The reasoning model describes how a task can be performed. It uses two modelling primitives: a ***task***: is a transition between two world state families (an action) and is defined by the following fields: *Name, Par, Objective* and *Methods*. A ***method*** describes one way of performing a task. A method is characterized by the following fields: *Heading, Prec, Effects, Control* and *Subtask.*

The task's field *Name* specifies the name of the task. The field *Par* contains the list of parameters, that is, all objects handled by the task. For example, in a task *Read*, the parameter list could be *(sensor, temperature)* which are domain objects (from domain model) used by the task *Read*. We will write *Read(sensor, temperature)*. The list of methods which can be applied to perform a task is described in the field *Methods*. A terminal task is a directly executable task (without described methods). The method's field *Prec* contains conditions that must be satisfied to apply the method. The execution order of subtasks is described in the *Control* field, and sub-tasks are recorded in the *Subtask* field. Note that, by essence, Task/Method models are hierarchical. Here we explained only the fields used in this work, see [2] for a full reference.

User Test Cases Generation

In this work, we make the following assumption. We consider that we dispose of a Task/Method model obtained in the two first steps of our approach (Figure 1, see for more details [1]). The execution of tasks in the task/method model can only succeed or fail. Specifically, only the terminal tasks succeed or fail directly, the execution status (success or failure) of the other tasks results only from the status of the terminal tasks. Under this assumption, all possible executions of a task/method model will correspond to the propagation of two possible execution status (success or failure) of terminal tasks. In the previous example (see also Figure 2), the "Read(sensor,temperature)" task has one method with two terminal tasks: "Collect information (system, sensors, temperature, data)" and "Summarize data (system, data)". These terminal tasks can succeed or fail. So if both succeed, the "Read(sensor,temperature)" task succeeds and if one of them fails, then the "Read(sensor,temperature)" task fails. In our approach, we consider that each user test case corresponds to an execution path. In the "Read(sensor,temperature)" example, two user test cases can be extracted from the following execution paths: "Collect information (system, sensors, temperature, data)" fails therefore "Read(sensor,temperature)" fails and, "Summarize data (system, data)" fails therefore "Read(sensor,temperature)" fails.

To generate user test cases, it is possible to generate user test cases directly from the task/method model, or to generate all execution paths and extract user test cases from these execution paths. We have chosen the latter option which is more flexible and separates the execution process from the extraction process. Thus, the execution engine produces all execution paths in the form of Execution Tree (ET). User test cases are extracted from the ET and possibly with some natural language processing tools. An ET contains all possible executions of one task. It is composed of two types of node: the etask nodes which represent the executed tasks and the emethod nodes the executed method. In the figure 2, an ET is

drawn for the task “Detect stress”. Boxes correspond to etasks, ovals to emethods and arrows link etasks to emethods. One task can be executed by several methods, and one method can have several emethods according to the execution status (success or failure) of subtasks. In the figure 2, the etasks and the emethods with gray background are etasks and emethods that failed.

The following algorithm describes the execution engine that produces an ET for one etask. Each etask and each emethod have a boolean attribute “failure” (true for failure and false for success). etasks and emethod are instantiated from Tasks and Methods of the task/method model. By default, the failure status is false for all etasks and all emethods. If an etask *et* is terminal, one new emethod is added with a copy of *et* in which the failure status is true. In this way, for each terminal etask, there exist two versions of this etask, one with the failure status to false and the other with the failure status to true. If an etask is not terminal, all applicable methods are instantiated and executed. A method is executed by launching the code in its control field which will rerun the Execution_engine function on some etasks in the subtasks field.

```
Execution_engine(et:ETask)
 if et is a terminal then
            set false to failure status of et;
            et_failure=Duplicate et with failure status to true;
            em_failure=Duplicate the emethod of et with failure status to true;
            link et_failure and em_failure to the parent task of the emethod of et;
else
            methods= all methods of et;
            for all m in methods do
                        em= instantiate m;
                        link em to et;
                        if em is applicable then
                                    execute control field of em
                        end if
            done
end if
return et;
```

As an ET contains all ways of executing an etask, user test cases can be extracted by traversing the ET from the failed terminal etasks (leaves of ET) to the initial etask (root of ET). The proposed process has been applied to the “detect stress in crops of tomatoes and peppers” scenario described previously. The figure 2 presents the ET obtained by the execution engine tool. For generating UAT, we simply traverse the ET from the leaves which fail to the root. Each extracted branch corresponds to one UAT. In the current implementation, UAT are generated by a direct translation from these ET branches. We obtained the following UAT.

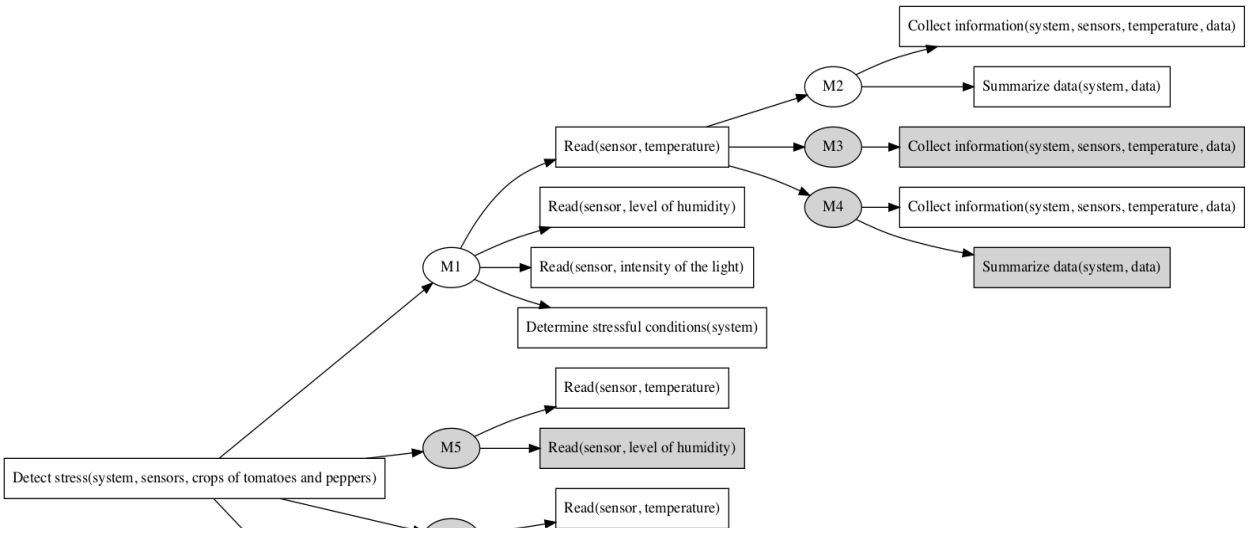

Figure 2. Execution tree for Detect stress task (success white background and failure gray background)

- Detect stress(system, sensors, crops of tomatoes and peppers) fail because Read(sensor, temperature) fail because Collect information(system, sensors, temperature, data) fail.
- Detect stress(system, sensor, crops of tomatoes and peppers) fail because Read(sensor, temperature) fail because Collect information(system, sensors, temperature, data) succeed, but Summarize data(system, data) fail.
- Detect stress(system, sensor, crops of tomatoes and peppers) fail because Read(sensor, temperature) succeed, but Read(sensor, level of humidity) fail.
- Detect stress(system, sensor, crops of tomatoes and peppers) fail because Read(sensor, level of humidity) succeed, Read(sensor, temperature) succeed, but Read(sensor, intensity of the light) fail.
- Detect stress(system, sensor, crops of tomatoes and peppers) fail because Read(sensor, intensity of the light) succeed, Read(sensor, level of humidity) succeed, Read(sensor, temperature) succeed, but Determine stressful conditions(system) fail.

CONCLUSION

In this paper we presented a way to generate UATs from a Task/method model. This work follows previous work ([1] [2]), where users describe scenarios through a web application and from this description, translation rules are applied to generate the corresponding task/method model. Our approach is to use an execution engine that generates an execution tree representing the trace of all possible executions. From this execution tree, UATs can be extracted using graph traversing and natural language processes. In the current version of the execution engine, only textual descriptions of tasks are processed. In future work, we want to study how to use a domain model in the form of object-oriented model in order to integrate UATs related to the domain model in the execution engine.

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Intelligent Decision Support System for Updating Control Plans

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ABSTRACT

In the current competitive environment, it is crucial for manufacturers to make the best decisions in the shortest time, in order to optimize the efficiency and effectiveness of the manufacturing systems. These decisions reach from the strategic level to tactical and operational production planning and control. In this context, elaborating intelligent decisions support systems (DSS) that are capable of integrating a wide variety of models along with data and knowledge resources has become promising. This paper proposes an intelligent DSS for quality control planning. The DSS is a recommender system (RS) that helps the decision maker to select the best control scenario using two different approaches. The first is a manual choice using a multi-criteria decision making method. The second is an automatic recommendation based on case-based reasoning (CBR) technique. Furthermore, the proposed RS makes it possible to continuously update the control plans in order to be adapted to the actual process quality situation. In so doing, CBR is used for learning the required knowledge in order to improve the decision quality. A numerical application is performed in a real case study in order to illustrate the feasibility and practicability of the proposed DSS.

Keywords: Decision support system, recommender system, case-based reasoning, quality control planning.

INTRODUCTION

Product and process quality control is essential for manufacturing companies in order to achieve their objectives and to meet customer requirements. According to IATF16949 standards [1], automotive manufacturers and their suppliers are required to establish quality control plans for their manufacturing processes. The control plan is a document that defines the quality control actions and methods to be performed for the product characteristics and the process parameters. The aim is to assess the compliance of these characteristics and parameters with the requirements and to minimize their variability. In order to assure efficiency, quality controls need to be focused on the critical features that are important to the customer. In this sense, the control plans optimization is a challenging issue for industrial experts. In fact, the decision concerning what to control, how and where requires considering conflicting criteria. On the one hand, the controls are essential for assuring quality as they prevent the risk of producing and delivering defective products to customers. On the other hand, controlling all products and process characteristics increases strongly the manufacturing costs as well as the time delays. In order to support the decision process for quality control planning, several research works have been developed. Considerable works are based on multi-objective optimization techniques. These models allow optimizing the control plans based on specific criteria such as total production costs, warranty costs [2], the level of risk and the inspection capacity [3]. Most of these works are subjected to restrictive assumptions and require large volumes of information and precise data. Therefore, they are not adequate to deal with early and complex decision-making issues such as the lack of information availability. To overcome these difficulties, other approaches based on multi-attribute decision-making models are proposed for the development of control plans. An intuitionistic fuzzy decision model is proposed in [4]. It aims to select the best inspection scenario based on expert knowledge and judgment. Three criteria are considered for the decision, namely the cost, the process capability and the external non-conformity rate. Nevertheless, in this work, the criteria are assumed to be independent. This may lead to unsatisfying decision because the criteria may present preferential interactions that should be taken into account [5]. In order to model the criteria interactions, we developed in a previous work a multi-criteria decision making (MCDM) approach for the selection of the best control scenario [6]. This method uses AHP [7] and the Choquet integral [5] for evaluating the performance of the control alternatives according to three main criteria. The latter are the risk priority number, the control cost and the control time. The proposed approach makes it possible to consider the decision makers 'preferences regarding the importance of criteria and their interdependencies.

Indeed, the above-mentioned approaches tackle the decision problem in the quality control planning and permit to generate optimized control plans that are implemented in the manufacturing process. However, these control plans are static and may become ineffective in case the quality circumstances change during manufacturing stage. For this reason, control plans need to be continuously updated in order to be adapted to quality situation changes. For instance, if the process becomes mastered and stabilized, then the controls must be lightened and vice-versa. According to the previous remarks, this paper proposes an intelligent decision support system (DSS) for systematically updating control plans with respect to the actual process quality state. The proposed DSS is a recommender system (RS) that permits to select the best control scenario for the actual situation based on experts' knowledge. Case-based

reasoning (CBR) technique is used in order to continuously update the knowledge and improve the decision quality. We present, in the next section, the basic concepts of the DSS, the RS and the CBR. In section 3, the proposed DSS for updating control plans is presented. Sections 4 and 5 are dedicated for the numerical application and the conclusions, respectively.

BACKGROUNDS

In this section, we briefly introduce some basic knowledge of the related works.

Decision support and recommender systems

Decision Support Systems (DSSs) are popular tools of computerized systems that support the decision-making processes. They are widely used for solving decision problems in different domains e.g. energy, manufacturing, etc. [8]. DSSs have greatly progressed since their appearance. As they are enriched by artificial intelligence techniques, DSSs has evolved from aiding decision makers to perform analysis to providing automated intelligent support. In this sense, Recommender Systems (RSs) are DSSs that are capable of analyzing previous usage behavior and making recommendations for the most suitable items [9]. There are three main types of RS depending on the used approach for the recommendation: The content-based RS, the collaborative RS and the hybrid RS. The content-based RS learns to recommend items that are similar to the ones liked by the user in the past. The collaborative RS makes recommendations to the active user based on items that users having similar tastes liked in the past. The hybrid RS is a combination of the content-based and the collaborative recommendations. Furthermore, several research works used different artificial intelligence techniques for developing personalized RS. We can cite ontology [10] and CBR [11]. In this work, CBR technique is adopted for elaborating the proposed RS.

Case based reasoning

CBR is a technique for solving new problems based on specific past experiences that are represented and stored as cases. A case is a set of problems and their associated solutions. A "source case" is a case from which we draw inspiration to solve a new problem called "target case". CBR is a cyclic process that has four main steps: (1) retrieve the most similar cases from databases, (2) reuse the case solutions trying to solve the problem, (3) revise suggested solutions, and (4) retain useful parts of this experience for future problem solving. CBR has been widely used in recommendations. Recently, in [12], CBR is combined with collaborative filtering for elaborating a hybrid RS. The use of CBR approach makes it possible to overcome the cold start problem of the collaborative filtering recommendation and therefore increases the system performance.

In today's highly competitive environment, it is crucial for manufactures to continuously make the best decisions in the shortest time. In this context, developing intelligent techniques for decision-making is a key factor to optimize the efficiency and effectiveness of the manufacturing systems. The decision process in the field of quality control planning is a complex task due to the conflicting criteria and the lack of information availability. The development of an intelligent DSS for quality control planning is then needed in order to enhance the decision-making process.

PROPOSED DSS FOR UPDATING CONTROL PLANS

In this section, we present the proposed DSS for updating control plans. This DSS is an RS that assists the decision maker (DM) to select the most suitable control scenario for a given quality situation. To do this, CBR technique is used to enable the learning of the required knowledge for the resolution of new cases. The designed methodology is described by the flowchart (Figure 1). We explain the steps of the methodology with respect to the CBR cycle.

-Case representation: A case is a piece of knowledge representing an experience and typically a problem and a solution. Cases are usually represented as attribute value pairs that represent the problem and solution features. In this work, the problem represents the quality situation of a given process operation and a given product characteristic. The solution consists of the quality control scenario (S_i) that is suitable to deal with this situation while considering the efficiency issue. A quality situation is characterized by four attribute values pairs that represent four process and product quality indicators. The latter are the process capability (Cp), the process capability (Cpk) [13], the internal non-conformity rate (NCR) and the external non-conformity rate (ENCR).

-Case retrieval: This phase consists in searching in the cases base for a similar case (source case) that will be used to solve the new case (target case). In this work, similarity between the target case (C^t) and the source case (C^s) denoted Sim(C^t, C^s), is calculated using the Minkowski distance as follows:

$$\text{Sim}(C^t, C^s) = |Cp^t - Cp^s| + |Cpk^t - Cpk^s| + |NCR^t - NCR^s| + |ENCR^t - ENCR^s|$$

The source cases stored in the cases base are prioritized according to their similarities. The DM defines a threshold. Thus, the source case that has the smallest distance inferior to the threshold is selected to be used. However, the cases base may be initially empty or similar cases may not be found. Therefore, the solution for the target case is chosen manually by the DM according to his knowledge and preferences. In this case, the proposed MCDM method in our previous work [6] is used for the selection of the best control scenario.

-Case adaptation: The phase of adaptation in the CBR cycle is the process of proposing a solution to a new problem from solutions belonging to the recalled source cases. In this work, the system automatically recommends the solution of the source case to solve the target case. However, the DM has to validate the recommended control scenario to be used. If the he estimates that the recommended solution is not suitable, then the manual option is used.

-Case revision: During the revision phase, the selected solution is evaluated. For doing so, the DM defines the objectives (Cp^*, Cpk^*, NCR^* and $ENCR^*$) to be reached using the proposed solution. The latter is applied in the manufacturing process. After a T period defined by the DM, the obtained results are compared with objectives. If objectives are reached, the solution is then judged satisfactory and therefore the case (problem-solution) is considered relevant. However, if the results are not acceptable, then the case have to be repaired. In this work, two types of revision are performed: The revision of the manual choice and the revision of the automatic choice. In case the solution is manually chosen, then the DM revises his evaluations in the decision-making process. In fact, the pairwise comparisons in the AHP matrix are adjusted. However, in case the solution is selected automatically by the RS and if the obtained results of Cp, Cpk, NCR and ENCR are not satisfactory, then the case

is not sufficiently similar. Therefore, the similarity threshold should be adjusted.

-Case retaining: The retaining or learning phase consists in incorporating what is useful in the cases base and synthesizing the new knowledge that will be reused later. Therefore, the storage of new relevant cases enriches the cases base and increases the system experience.

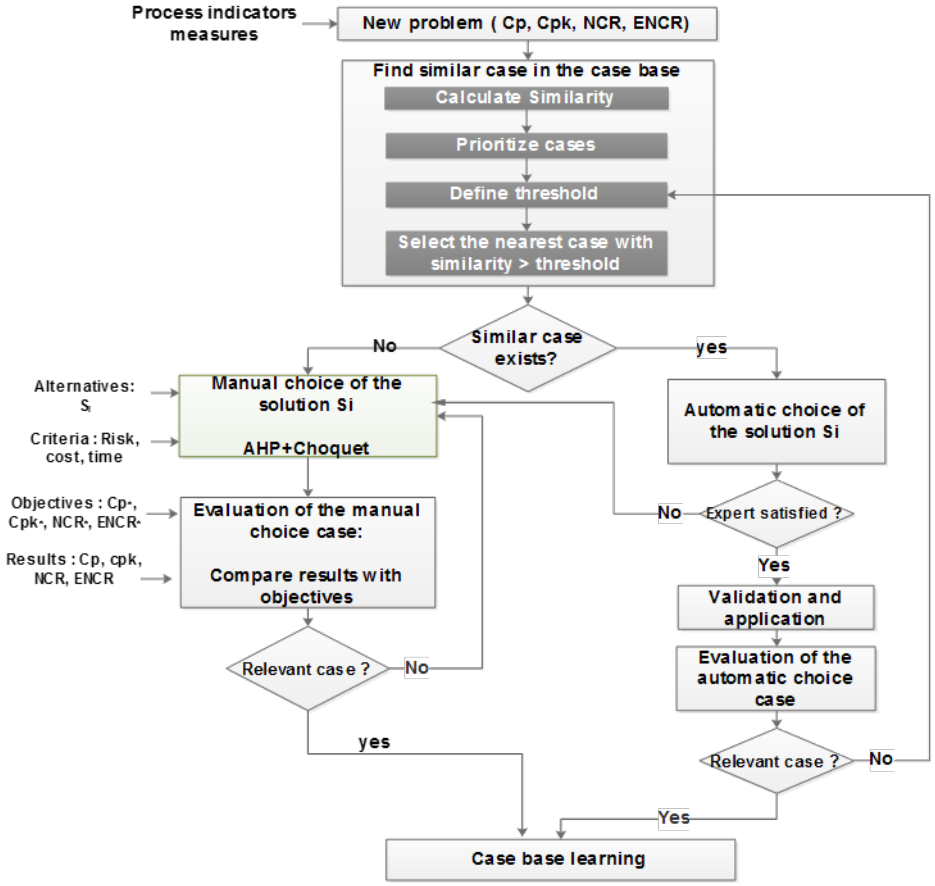

Figure 1: Flowchart of the proposed methodology

NUMERICAL APPLICATION

In order to illustrate the proposed methodology, we perform a numerical application in a real case study. The latter is an enterprise of automobile components, which manufactures different wires to command airbags [6]. We present, in what follows, the decision process for the quality control plan selection concerning a process operation (Splitting/Crimping) and a product characteristic (crimping height). The problem attributes are entered by the DM in the DSS (Figure2). Given this quality situation, the DM performs the manual evaluation of the control scenarios according to the considered criteria. The evaluations of the alternatives and the selected control scenario are presented in Figure 3. According to the manual evaluations performed by the DM using AHP method and Choquet integral, the selected control scenario is S2 ”Sampling control by measure (simple plan)”. Therefore, the DM agrees the choice and S2 is applied for the considered process operation. Otherwise, the DM repeats the manual evaluations. In order to illustrate the automatic choice, some relevant cases are added to the cases base. The DM enters new target case attributes. The system finds similar case in the cases base. Thus, the solution S3 is recommended by the system for solving the target case. At this step, the DM can display the details of the source case and agree the recommendation

or disagree and perform the manual choice (see Figure 4).

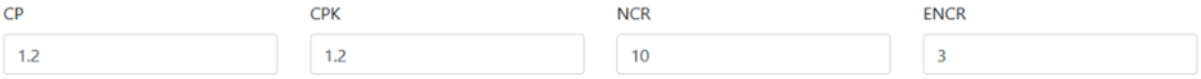

Figure 2: entering the quality situation in the DSS

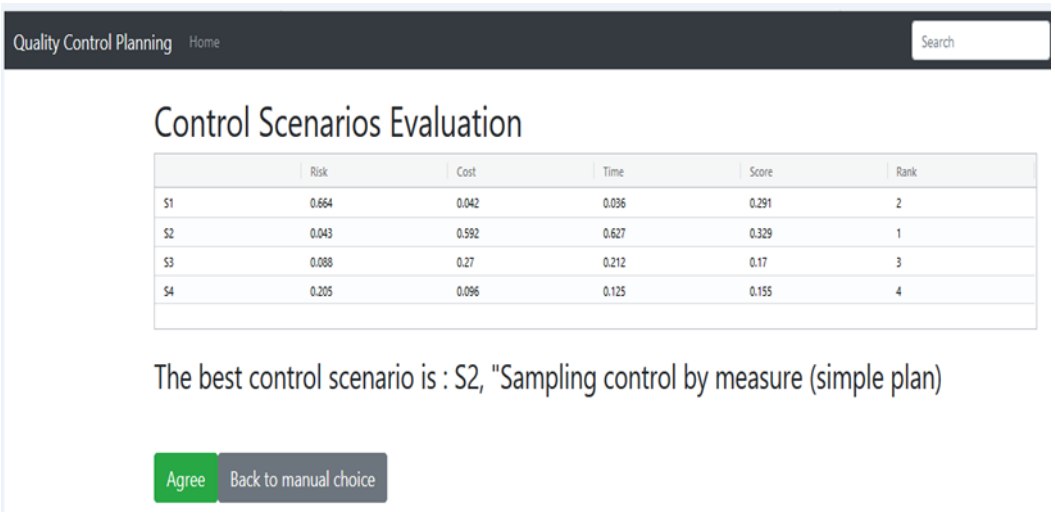

Figure 3: The obtained alternatives evaluation using the manual choice option.

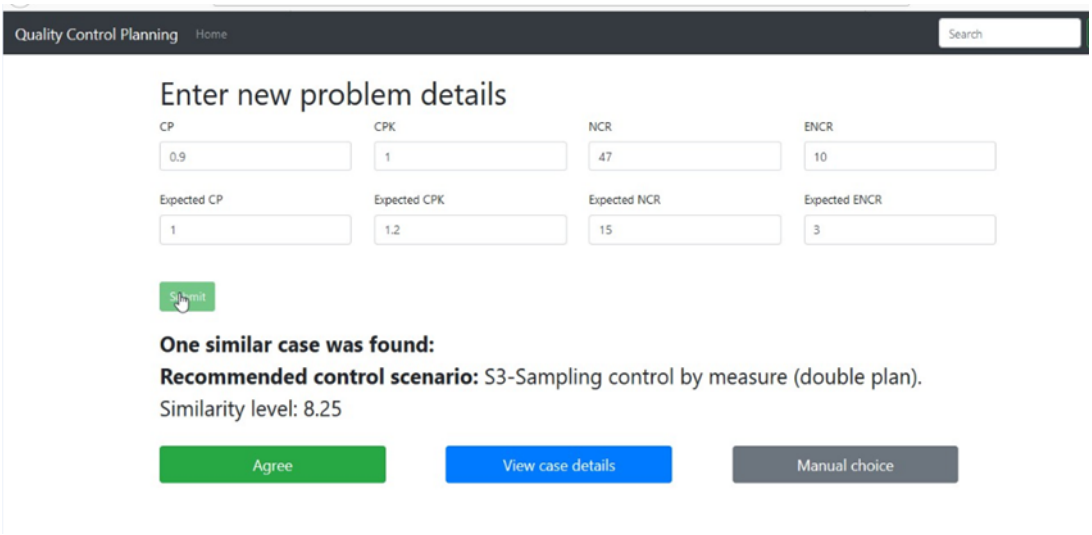

Figure 4: The automatic choice illustration.

CONCLUSIONS

This paper presents an intelligent DSS for updating quality control plans. The proposed DSS is an RS that makes it possible to select the best control scenario for a given quality situation using two different approaches. The first is a manual choice based on an MCDM method. The other is an automatic recommendation using CBR. The effectiveness of the DSS to improve the decision process is illustrated by its application on a real case study. In future work, we are interested in optimizing the process of calculating similarities in order to improve the accuracy of the decision.

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ICDSST 2020 on Cognitive Decision Support Systems & Technologies

The Multi-Actor Multi-Criteria Analysis (MAMCA): New Software and New Visualizations

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ABSTRACT

The Multi-Actor Multi-Criteria Analysis has been a successful methodology to integrate multiple stakeholders in the decision-making process. Because MAMCA evaluates different alternatives based on the objectives of the stakeholders, decision-makers can increase the support for the alternative they will choose. Still, the application of the methodology can be complex to popularize this approach. The MAMCA software was therefore published in order to facilitate the use of the methodology. The development of that tool offers also new opportunities. Currently, the goal is to extend the MAMCA software as a mass participation tool, hence maximizing participation involvement.

In order to facilitate the application of the methodology, the new MAMCA software was published. This contribution highlights how the MAMCA methodology was integrated into the software and how the data is being visualized. We focus on enhancing the concept of "Participation" in the development. A new data structure has been developed and an easier user interface makes the tool more accessible. An easy-understand evaluation method is integrated into the software. The interaction experience between participants is improved. Overall, the new MAMCA software is aimed to have a better performance in workshop settings.

Keywords: MAMCA, MCDM, Data Visualization, Human-Computer, Interaction

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An exploratory guide to identifying the preferences for territorial attributes in households housing choose

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ABSTRACT

Housing is a particular type of commodity with different values and representations among households. A vast range of characteristics need to be managed and comprehended, namely its physical properties, territorial attributes and environmental amenities, plus the individual conceptions on the importance assigned to each feature. Thus, housing preferences and choices in the housing market becomes a key research topic.

This paper acknowledges the contribution of revealed preferences approaches through an explicitly embedding of socio-cognitive dimensions on research devices design. Moreover, the research is not only motivated by research questions concerned with a better understanding of the role of territoriality on housing choice criteria, as, also, will try to contribute to developing market mediation mechanisms that enhance usual assumptions to the societal adoption of market mechanisms as the key housing allocation mechanism on western societies.

Through a combined briefly literature review and exploratory tool design, this work contributes to the debate on the role of multicriteria methods to study territorial housing choice and as a valid tool to help house seekers obtaining more informed location choices.

Keywords: housing, territorial preferences, choice, multicriteria, decision support tools

INTRODUCTION

Houses represent the most valuable single asset owned by most individuals. Different economic studies pointed out the market value of a housing unit is typically several times an occupant's income and the value of a nation's housing stock is traditionally a significant proportion of its total capital stock. In fact, as an economic good, the direct costs with a house, in the EU, represented, in 2013, 18% of the total final consumption expenditures of households and housing contributes about 30% to the EU's GDP[1].

[1] Contribution measured on the category of national accounts defined as "gross fixed capital formation". Data source: C. Gerstberger and D. Yaneva, "Statistics in focus 2/2013 - Analysis of EU-27 household final consumption expenditure" Available: https://bit.ly/2KWUyMq

The conditions by which the exchanges (transactions) of goods and services between different individuals occur are usually assumed as general mechanisms of (socio-economic) development. As pointed in standard economics literature, the market can be described as a collective device that allows compromises to be reached, not only on the nature of the goods to produce and distribute but also on the value assigned to them. The general socio-political arrangement of western societies gives the market an important institutional role in the housing allocation. Unfortunately, as it has been known for a long time (at least since Coase), as market face relevant transaction costs, inefficiencies emerge and, therefore, undesirable socio-economic outcomes can be produced. The analysis of transaction costs on housing markets highlights information flows as one primary source of market inefficiencies, with many pitfalls identified as related to search costs linked to the geospatial characteristics of housing units.

This paper aims to contribute to the debate on the development of decision support tools that can help to reduce search costs in housing markets, following a scientific research effort which was claimed to be important on housing studies and which remains open both in literature debates and policy challenges in particular. This work is structured in four parts to address this challenge. First, is outlined the standard methodological and theoretical frameworks for housing preferences and choices. It follows with a reflection on the cognitive dimension that should integrate decision-making tools, useful for dealing with households' residential preferences. A couple of structured methods are considered, and then a conceptual and exploratory tool is presented. Finally, the paper ends with some considerations and future work ambition.

STUDY HOUSING CHOICE: MAJOR APPROACHES

The process through which decisions on residential location occur is complex as it deals with a wide range of housing and location attributes and its multiple assessments and importance for different types of households [1]. The research on this field has proven useful to discuss spatial levels of attractiveness and explain household or individual behaviour attitudes and intentions, by using stated and revealed preference approaches [2].

Stated preferences are grounded mostly on statistical models, with econometric approaches extensively used to measure the housing choice and preferences. The hedonic pricing mechanism, purposed by Rosen [3] and grounded on Lancaster Consumer Theory remains as a significant framework on the study of stated preferences, despite the challenges to couple territorial attributes on those models ([4], [5]).

Despite the quantitative approaches focused on information codified on market data, different authors have been trying complementary approaches based on devices that capture de revealed preferences of house seekers. For example, Jansen et al. [6], grounded on a set of theories that embodied a precise cognitive dimension on it: the life-cycle models, the theory of planned behaviour, between others. However, frameworks such as the life cycle and life-course introduced assumptions to the empirical works resulted in concerns about the interdependence of demographic, economic, institutional, and social environment. Moreover, these relations have multiple meanings for households with different characteristics, as students, young or older adults, or as Jansen et al. [6] organize it through the educational, the labour, the family, and the housing or residential careers. At the same time, external conditions and allocation rules imposed by the balance between demand-supply also influence preference and choice structures. The revealed preferences approach lead us to other scientific fields, focused at understanding and explaining human behaviour, according to individual expectations, beliefs, norms, and utility functions (see, for example [7], [8]). Even though it finds application to the

housing preferences – as presented by Jansen et al. [6] – some criticism needs attention (see, for example [9]).

COGNITIVE DECISION MAKING AS A FRAMEWORK TO ANALYZE THE TERRITORIAL DRIVERS OF HOUSING CHOICES

This paper adopts the revealed preferences approach as a) it will target the research objectives through a deep understanding of housing choice criteria and b) it allows to manage the strong assumption of a perfect market, usually in the standard stated preferences approaches. Moreover, it will contribute to the development of house seekers decision-making tools that will assess its individual choices.

Previous insights on literature should be part of the design of the decision process tool that processes individual preferences. Dealing with the heuristics and cognitive dimension of the decision process produces an enlighten on how people make choices and how that process influences the residential choice outcomes.

A first step on individual preferences is to identify relevant dimensions to consider in the setup of this framework. Kim et al. [1] divide this analytic framework concerning two stages, one regarding the residential mobility and another delimited to the housing choice stage, and analytically introduce concepts such as bounded rationality, to sustain the model in which the choice process is based on sequential tradeoffs between housing price, accessibility and neighbourhood amenities. However, as concluded by the authors [1], the extensive analysis they provide would gain if alternative methodologies would be matched or compared (e.g. land use and transport interaction models, mixed revealed preference and stated preference bid-choice models, hedonic pricing models and land value impact studies). The experiment data in the study fed relevant conclusions on residential location choice. Similar approaches, but using a public participation GIS survey is found in the research work of Hasanzadeh et al. [4], but with a different type of attributes, namely individual profile characteristics. It allowed comparing land areas matching the revealed preferences of the respondents. The authors outline a mismatch between stated and revealed preferences outcomes, as a consequence of different issues related to assumptions and design, and underline that choice of where to live can be determined by factors "*such as housing supply and stochastic events (e.g., new job opportunity) that limit the time for rational search choice*".

As proved in the literature on housing research, there are many plausible approaches. Common to these studies is a value-focused and goal-oriented behaviour. Typically, stated and revealed preference data is circumscribed in time, and replication or update is time and price consuming. Thus, the implementation of real-time decision tools, based on ranking and/or comparison of a variety of housing characteristics based on preferences constitutes an alternative approach to assess how geographical and spatial aspect (location of housing, jobs, schools, and other activities) matches the (stated and revealed) preferences. Besides the traditional spatial econometric tools and assumptions, social interactions modelling, as well as socio-cognitive decision-making research, are also essential to combine and aggregate. In addition, lessons learned from multicriteria decision support systems applied for housing evaluation should be actively considered. The transition from preferences and choices underline different understandings of rationality or different decision-making mechanisms. Thus, a preference housing model must be able to encounter discernable choice contexts, housing and households' characteristics, capacity to capture perceptions and identity, and ideally evidence consequences of decisions (e.g. scenario building, housing stock, housing price, urban structure). The next sub-section discusses preference strategies based on

multicriteria methods, as it consists of a core feature of the housing decision-making models presented in the next section.

Choice strategies and structured methods to assess housing search decision making

Without exception, all multicriteria methods provide an evaluation framework based on crucial factors carefully outlined. Almost intuitively, is assumed that this framework will be tuned based on objectives, adequate criteria to assess or measure them, scores to link each criterion to objectives or alternatives, and a step for defining weights (to differentiate and prioritize criteria and alternatives). As Valerie Belton [10] states "the extent to which, and how, these key factors are elaborated in the model structure differs between the methodologies (or "schools" of MCDA [Multi-Criteria Decision Aiding])". In a schematic and non-extensive description, a couple of features are in mind while designing decision aiding tools for dealing with preference stating. The value function will ensure the linking of the concept to higher-level goals, embedding understandable concerns, for such that concepts are broadly comprehensive to be used by all users during analysis. The way criteria or attributes are defined can arise different headings, involving either framing or cognitive issues, as well as interdependency (or independence) functions. Thus, the meaning and performance of alternatives against criteria bring measurability challenges and judgmental, analytical factors. Decision problems are highly complex, and the context in which support tools are designed is critical for successful outcomes. The consideration of different perspectives involves constant tradeoffs along the process, as sometimes available information is not enough, or, in turn, information might place excessive demands on users. Describing and structuring the value tree recalls certain degrees of detail, compromising the operationally of the model.

It is therefore essential to realize that in real life decision contexts, evaluating all possible combinations of attributes, criteria and alternatives is almost impossible, highly time-consuming and cognitively demanding. For that reason, most multicriteria evaluation methods are designed for the evaluation of independently defined alternatives. Yet, value functions and outranking methods share different characteristics in the way hierarchy, ranking, ordering, and final constructs derived from the criteria structure.

Besides criteria selection, weighting and evaluation, aggregation procedures are also essential to discuss because individual preferences (describing a person's perception or relative importance of each criterion) can contrast with the collective (a combination of) preferences outcomes across criteria. The work of Borges et al. [11] uses real decision-making data to prove at what extent individual weights when using different aggregation metrics deviate from collective decisions, and compares different multi-criteria methods. Lessons learned from this study are extensible in the context of this paper. Regarding preference aggregation, careful attention goes for the different mean calculation assumptions, as well as the aggregation of preferences based on ordinal, pair-wise or cardinal choice. However, the decision between one method or another must combine the robustness of comparisons, as well as the cognitive effort and decision heuristics that each involves. A more content-oriented input is related to the subjectivity or tangible level of each attribute or criteria. What the authors conclude is that as lower the decision tree (and therefore, the sub-criteria become more refined) individual and aggregated preferences evidence more significant disparity [11].

Regarding multicriteria decision methods, the most commonly used are the AHP – Analytic Hierarchy Process, the ELECTRE – elimination et choix traduisant la realite, TOPSIS – Technique for Order of Preference by Similarity to Ideal Solution, SAW – Simple Additive Weighting, and PROMETHEE – Preference Ranking Organization METHod for Enrichment of Evaluations ([9]–[11]).

Due to both its theoretical and application simplicity, AHP can be considered a prevalent rank order weighting method. Originally developed by Saaty [12], this method is ruled by the hierarchical composition of criteria and sub-criteria for the comparison of pairs of options and assessment of relative importance of alternatives. A comparative research for assessing the sensitivity and robustness of the ranking results when using different methods (AHP, SAW, TOPSIS, ELECTRE), conducted by Borges et al. [11], concluded that all tested methods resulted in similar results for the most and least ranking positions.

HOUSEARCH: A CONCEPTUAL AND EXPLORATORY TOOL TO UNDERSTAND THE IMPORTANCE OF TERRITORIALITY IN HOUSING CHOICES

The overview presented in previous sections shows the complexity of choices that will be needed to take in account, by researchers, in order to configure a device to study housing choice process and its major territorial drivers. In literature it is possible to identify various attempts to develop decision support systems to the housing choice process concerned to a) answer research questions about the drivers of housing choice, b) debate how to use and combine the multi-criteria decision making approaches to housing choice research and c) develop mechanisms that help public policy and/or stakeholders in the housing sector.

Following these attempts, this work is a first step for these efforts and its debates. The last section will summarize the major guidelines on the under-development tool, which attempt to combine all this knowledge. Two primary objectives are pursuit: 1. Provide, to individuals, a useful support decision tool which will be able to reduce the cognitive effort required for making housing choices (on its territorial dimensions); 2. a tool able to collect data on the housing choice process for territorial dimensions, for further scientific research of drivers on territorial housing choice process.

House Search and the role of information and communication technologies

Transaction costs are high in the housing market, which opens the market to mediators agents. ICT have a potential to lower the transaction costs: as Sawyer et al. [13] shows, ICT has been adopted focusing the development of tools to ensure data assembling and process information on search mechanisms. It is well-documented that individuals housing search process makes extensive use of commercial web-based tools which provides that functions, despite the debate on its useful role on the market, namely to lower the recognized high information asymmetries between supply and demand, and, by this way, lowering transaction costs.

Housing search processes which involve a search within territories that are not well-known by individuals, the in-loco prospection is complemented by geographic information systems available on the web (services dedicated to housing listings or more general, dedicated to geographic information). Tools, such as google maps and google street maps, or enable geographic criteria embedded on multiple listing services, have been increasingly used in individuals autonomous demand search (see, for example, Bader et al. [14] for a general overview). The important value share of territorial attributes on housing price had been demonstrated in inumerous studies which follows stated preferences approaches.

HouSearch. The guidelines to build a housing choice decision support system

The seminal works of Golledge and Timmermans ([15], [16]) will be adopted here as the main inspiration to design our device on housing choice. Four essential elements will be accomplished in the final tool. In briefly it will comprise:

- ***Define the set of available data to obtain summarized variables and territorial clusters built from them.***

Taken in account the n-dimensionality of territoriality, the variety of data to describe it and the recognized time-consuming of AHP algorithms, a previous data mining approach will be applied, with a focus on algorithms that ensure significative feature reduction and produces unsupervised classification of big datasets of spatial data (including georeferenced socio-economic data).

Previous works of the research team [17] will guide this element of the HouSearch DSS: a target set of 6 composite territorial attributes and a maximum of 16 clusters for a medium Portuguese urban – system will be desirable to ensure consistency of individuals responses.

- ***Association between territorial units' clusters, streetscapes and cluster territorial attributes.***

To provide a decision mechanism on territoriality features reasonable familiar to individuals, in addition to a text description, google street streetscapes will be used as a proxy for territoriality visual environment. Several works point the usefulness of this approach to enhance the valuation of different sophisticated territorial features.

Here, for each territorial cluster and each exercise, random streetscapes will be retrieved from the Google service; streetscapes pictures will be taken randomly from the major transportation network nodes inside the territorial cluster.

- ***Setup an AHP type algorithm, adopting the pair-wise evaluation mechanism at each stage, to obtain the hierarchical order of territorial unit's clusters***

The AHP algorithm will start with the pair-wise comparison of all selected representative streetscapes of the territorial units clusters. One of them is randomly assigned as a fixed comparator. The following steps are similar and, as illustrated in Figure 1, will configure a hierarchical iterative process, designed to found the order of an individual's preferences.

- ***Link the territorial preferences with available houses in each location on public housing multiple listing web services to provide an ordered list of houses.***

Finally, to ensure the engagement of users with the HouSearch tool, a key element to incorporate on this device is the capacity to provide an automatic collection of available houses (ads), from public multiple listing services. This mechanism will identify the geographic location of each house (when provided) and match them with the territorial units incorporated on the tool. This mechanism is used to sort the retrieved set of available houses through the user territorial preferences defined before, giving an add-value result for house seekers.

It should be highlighted that the preliminary user tests of the AHP framework described above reveal some shortcomings that should be taken into account on the next development phase. Two most cited are the requests for a) reduce the time-consuming of the process and b) enable a repeat / modify previous choices mechanism.

Figure 1 *Schematization of the different iterations of the AHP algorithm through pair-wise evaluation.*

CONCLUSIONS

The study of the role of territorial features in housing valuation is a classical challenge in urban studies and a permanently open question to public policy. Stated preferences approaches have shown incredible developments across the years, with increasingly sophisticate techniques to mining the significant amounts of data provided by market operations (big data). However, stated preferences rely, by its nature, on the adoption of behavioural assumptions, which requires other techniques to verify its reasonability in each context securely. Moreover, stated preferences are focused on descriptive (or predictive) tasks, which makes them less useful to ensure an active human – interaction mechanism, usually pursued by the setups of decision support tools.

Although, revealed preferences approaches can be useful complementary tools (despite, some authors adopted them, in certain circumstances, as valid alternatives). Revealed preferences will open the debate on the cognitive processes of decision making, rather than on each outcome. Cognitive dimensions are a valuable feature in domains dominated by the complexity and multi-dimensionality of its subjects. Housing and housing choice process are one of these domains, especially when looked from territoriality criteria. An additional lesson learned during this exploratory development phase is that it should be considered additional cognitive dimensions to improve the user-perceived usefulness of this tool. Improvements on the user interface (design, enable action correction tools, between others) should be considered.

In this exploratory work, we will present a brief review of the challenges associated with the embeddedness of cognitive reasoning in housing choice studies. Multi-criteria decision-making tools are not only valuable complementary or alternative methodologies to describe the value of territorial features associated with housing, but an important mechanism that potential offer to housing seekers a more rational (structured) decision-making mechanism.

HouSearch is an attempt to combine the multiple benefits of revealed preferences tools mentioned here. At the same time, it contributes to meet the needs of a research program focused on the territorial drivers of housing choice and the cognitive processes that inform it. Also, HouSearch can be able to contribute to a better and efficient housing market through the results it offers to its users: the hierarchization of the available house in public web-based multiple listing services.

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Collab-Net as a DSS for the Identification of Potential Partners and the Creation of Research Consortia

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ABSTRACT

Few demanding research issues can be addressed by a single researcher. Many advanced topics require huge sets of competences and transdisciplinary approach. Finding the right partners for a research project has always been a challenging task. Nowadays, competition for excellence and scarcity of funding make the search for adequate partners a critical element from the very beginning of a project definition, as the project consortium has to show the balanced qualification and experience needed to run the project in a fit-for-purpose and cooperative way among all partners.

The present paper presents the on-going development of a decision support system to support project leaders in identifying potential partners within the registered EWG-DSS members. Built on top of the long-term Collab-Net research project, the proposition is presented here under the form of three scenarios that are typical examples of how the new features are used and involved in use cases.

Keywords: DSS, EWG-DSS, Research Projects, Consortium, Partners-Search, Collab-Net

1 INTRODUCTION

Many research questions involve intrinsic difficulties that very often require multi-disciplinary or transdisciplinary approaches, which can only be carried out by diversified and complementary groups of researchers. Many research funding organisms are pushing project leaders into building international consortia, involving different partners from different sectors and different countries in order to bring the complementary capacity needed for a cross-sector multidisciplinary project. Finding the right partners for a research project has always been a challenging task. Nowadays, competition for excellence, scarcity of funding and the internationalization of research networks, make the search for adequate partners not only more difficult, but also more critical from the very beginning of project definition.

One way to help researchers in this context is academic social networking sites (ASNSs), which are social media platforms designed to support the dissemination of research and social interactions among researchers [1].

An assessment of motivational factors of use; impact; quality of information and ease of finding peers on these platforms has been the subject of several recent studies [1-5] discussing the importance and complexity of the theme. An example of a successful network used by project coordinators for partners-search in ICT when applying for EU research projects is the "Ideal-IST" network.[1]

Concerned by the described challenge and aiming to support its members in the appropriate partner-search for research and development tasks related to topics related to Decision-Making, the EURO Working Group on Decision Support Systems (EWG-DSS) started to develop means to facilitate the identification of the needed research/development partners among its associates and collaborators.

On the one hand, the proposed DSS is willing to offer support to project leaders on the search for the most appropriate partners for his project consortium. On the other hand, the EWG-DSS aims to offer visibility of its associates current areas of research to any of the members. The long-term Collab-Net research project that serves as basis for the DSS proposed here, has been initiated with the intention to analyze relationships among members and encourage new research and academic cooperation [6-9]. Consequently, it is a convenient background platform to support this new project and integrate pieces of answer to the following research question: how to support the EWG-DSS members search for research partners while offering each member good visibility and strengthening the links in the group.

In the current paper we present the definition of new features, currently under development, introduced in the Collab-Net Platform in order to offer support to the identification of potential project partners. The structure of the paper is as follows: Section 2 briefly presents the existing Collab-Net Platform; Section 3 defines the extensions supporting partner selection. Limitations and Future work are discussed in Section 4; and Section 5 draws some conclusions.

2 BACKGROUND: The COLLAB-NET PLATFORM

The Collab-Net project was initiated in 2008 by the EWG-DSS coordination board members [6]. The main aims of the Collab-Net project were "to evaluate the group's collaboration dynamics since its foundation (in 1989), in order to encourage new research and promote further collaboration among the academic members of the group in common projects and joint-publications". A complete history of the project can be found in technical report [10] and books chapter [11,12].

[1] https://www.ideal-ist.eu/

The current version of the Collab-Net project has been deployed in a web platform, so that it can be easily and effectively accessed by all EWG-DSS associates. It involves the respective bibliography of the EWG-DSS members, automatically collected from their Google Scholar individually maintained pages. The current platform aims to enable the affiliated members to investigate the publication relationship of the collaborative interaction among papers' authors within a publication database.

3 NEW FEATURES DEFINITION FOR THE COLLAB-NET AS DSS

3.1 Methodology.

In order to define the features to be supported by the system, our initial step was to interview the senior board members (the three founding members) of the group and collect scenarios as user stories. The synthesis of this task results in three scenarios that were then formalized as use cases and are presented in subsection 2.2 of this paper. Then, a prototype interface was designed for the DSS, which is presented in subsection 2.3.

It is worth noticing that we are interested in supporting projects that need Decision Support Systems and related tools in their solutions. The writing of scenario enhanced the distinction between two concepts relative to the project in question: *application domain* and *DSS scientific domain* (*scientific domain* in short)

3.2 Scenarios: Consortium Building for a Project including a DSS in Oncology

Context: *A member of the group is targeting to compose a consortium for project attending a healthcare call for proposals of the European Commission current research program. She is willing to propose a project on the development of a DSS platform to support oncology practitioner in their diagnoses. Preparing this proposal, she is searching for partners interested in healthcare system applications and with experience in various DSS domains, in particular MCDA. She needs at least four partners from three different countries in Europe with consolidated competence on the required areas.*

Scenario 1.

Agents:	Action Description
User	1. The user connects to the system
System	2. The system presents the menus
User	3. User selects the menu "partners identifications"
System	4. The system presents: - the lists of members (with their nationalities, scientific domains and application domains), - the list of application domains and - the list of scientific domains.
User	5. User selects the application domain "healthcare"
System	6. The system presents: - the lists of members (with…) restricted to the ones associated to the application domain "healthcare", - the selected application domain "healthcare" - and the list of scientific domains
User	7. User observes the scientific domains of the selected members.
User	8. User selects the scientific domain "MCDA"
System	9. The system presents: - the list of members (with…) restricted to the ones associated to the application domain "healthcare" and scientific domain "MCDA". - the selected application domain "healthcare" - the selected scientific domain "MCDA"
User	10. User asks for the network analysis involving the identified members and other researchers
System	11. The system presents: - the graph of the members involved in application domain "healthcare" and scientific domain "MCDA".

	- the selected application domain "healthcare" - the selected scientific domain "MCDA"
User	12. User selects a member and requests for his Google Scholar page
System	13. The system provides access to the Google Scholar account of the selected member.

Scenario 2.

Agents:	Action Description
User	1- 4. Steps 1 - 4 as in Scenario 1.
User	5. User selects the scientific domain "MCDA"
System	6. The system presents: - the list of members (with…) restricted to the ones associated to the scientific domain "MCDA". - the list of application domains - the selected scientific domain "MCDA"
User	7. User asks for the networks análisis involving the selected members and other researchers
System	8. The system presents: -the graph of the members having "MCDA" in their scientific domains. - the list of application domains - the selected scientific domain "MCDA"
User	9. User selects a member and asks the system for his registered detailed data
System	10. The system provides for the specific member: - his affiliation - his email address - and hyperlink to his Google Scholar profile

Scenario 3.

Agents:	Action Description
User	1- 6. Steps 1 - 6 as in Scenario 1.
User	7. User asks for the networkanalysis involving the selected members and other researchers
System	8. The system presents: - the graph of the members involved in application domain "healthcare". - the selected application domain "healthcare" - the list of scientific domains

3.3 System Interface

To support the DSS, a prototype interface has been conceived, as shown in Figure 1, depicting the step 4 of the above presented scenarios. At the stage 4, the system presents (i) the lists of members (with their nationality, scientific domains and application domains), (ii) the list of application domains and (iii) the list of scientific domains. Note that the button "Show List" is currently activated and the “Show Network” is enabled.

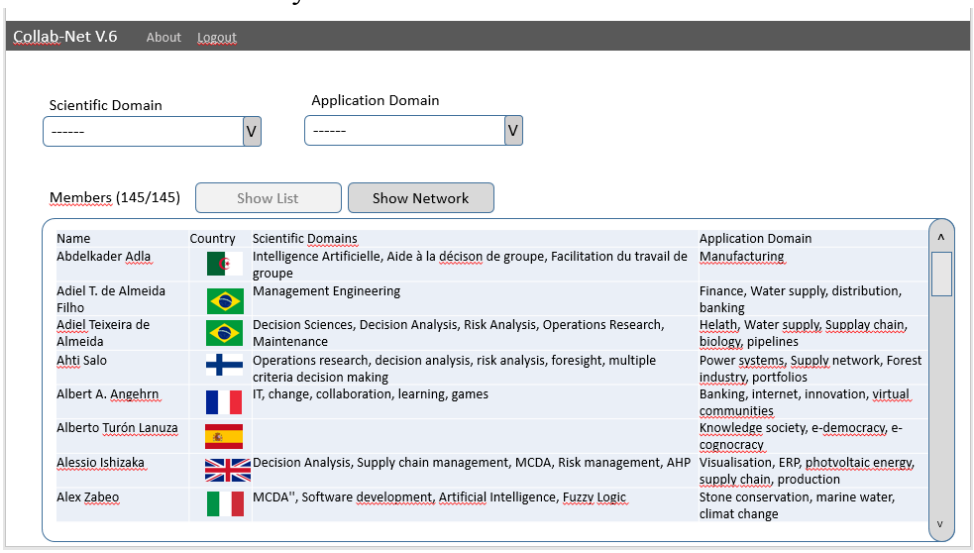

Figure 1. Prototype Collab-Net DSS Interface - Scenario 1, Step 4

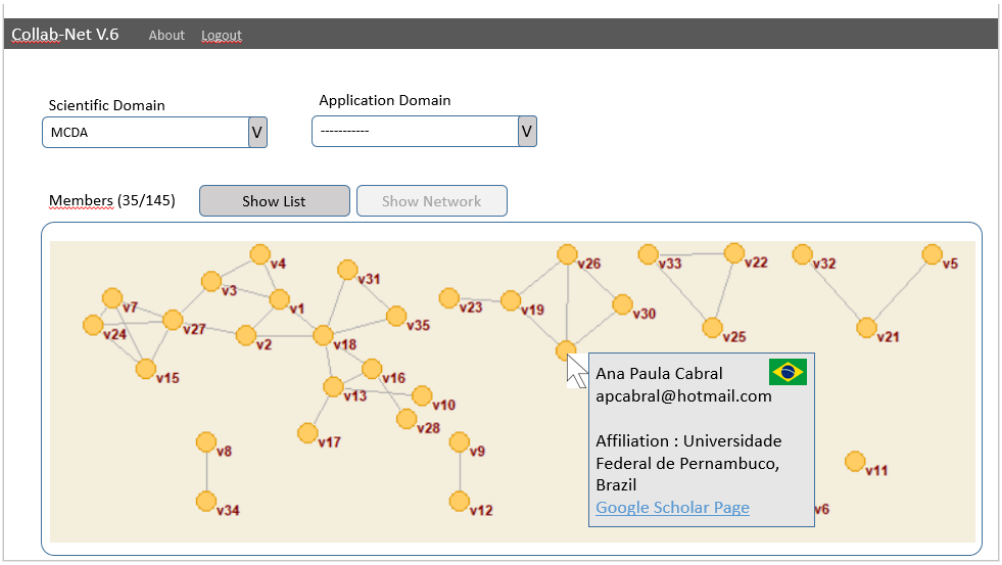

Figure 2. Prototype Collab-Net DSS Interface featuring Scenario 2, Step 10

Figure 2 presents the interface illustrating Scenario 2. At this stage, the system presents: (i) the graph of the members having "MCDA" in their scientific domains (as in step 8), (ii) the list of application domains, (iii) the selected scientific domain "MCDA". Moreover, given the selection of a specific member (at step 9), the system presents now (i) his affiliation, (ii) his email address and (iii) a hyperlink to his Google Scholar profile, as shown in the displayed window of the interface in Figure 2. The "Show Network" button is activated, whereas the “Show List” is enabled for further member selection. Note that the "vxx" labels displayed on the network nodes are used here for the purpose of the prototype. They will be replaced by the actual names of members taking part in the selected subnetwork. Figure 3 illustrates the general concept of the use of the Collab-Net as a DSS for appropriate identification of project partners among the EWG-DSS members.

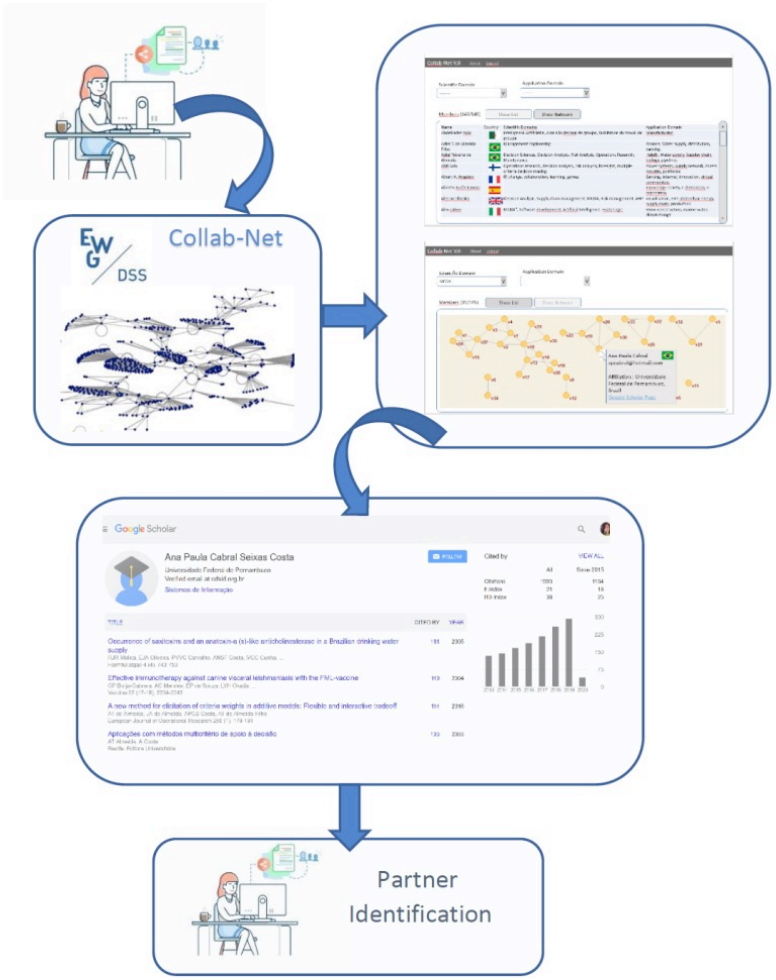

Figure 3. Collab-Net DSS General Concept

4 LIMITATIONS AND FUTURE WORK

At the time of writing this paper, our DSS proposition is still a prototype design. However, the database that will support the application is already ready and tested. The data collection relies on the data involved in the current Collab-Net platform, which are extracted from Google Scholar. Currently, 145 authors among the 250 officially registered EWG-DSS members have identified public Google Scholar accounts that can be used by Collab-Net. Most of the currently scientifically active members are among the 145 identified authors. Among the missing ones, we observe mainly: (i) old members of the group, probably not willing to engage in new social network application, (ii) young researchers and Ph.D. students, whom we really want to push them to create and open their profiles; and (iii) members from the industry having a low engagement with scientific publications.

Regarding members engaged in the industrial sector, it would be highly relevant to find another way to involve them in the platform, in order to enrich the search of the DSS not only with publication evidences, but also with consolidated work experience. Indeed, companies are often rich partners in consortium and their participation is requested by different funding agencies. Including existing partnership in research project into the network would be an added-value and a solution to this issue. However, finding a data source where to collect automatically this information is still an open challenge. Similarly, co-authorship is not the only important existing relation among the members of the groups. Other relevant ones like: experience in being partner in research projects, scientific visits in renown institutions and organizations, Ph.D. thesis co-supervisions, etc., also exist, to mention only the main obvious ones. Again, the question of the data source for acquiring this information is here a challenge to overcome.

The scenarios described in this paper have mentioned the notion of scientific domains and application domains. Scientific domains will be retrieved based on the topics declared by members in their Google Scholar profile. This data collection is already done. However, the existing topics are user-defined outside any typology. A matching procedure has to be defined between them and a more standardized list. This is a topic for further exploration on the project.

Regarding the application domains, a typology has to be selected. We plan to use text mining technique on the list of publication, in order to associate the relevant domains with each of the members of the group. Reports on future developments in this direction will be made available as soon as results are obtained solving this issue.

5 CONCLUSIONS

Selection of appropriate partners for research project consortia is a demanding and critical task in the definition of research project proposals, based on the requirements of the associated research for funding. Offering support to this task is among the challenges that the EWG-DSS Coordination Board is willing to face. The long-term Collab-Net research project offers an opportunity for inclusion of features related to this task. The current paper presents a designed prototype in this perspective and discusses the open challenges and future work.

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II
West Zone Papers

ICDSST 2020 PROCEEDINGS – ONLINE VERSION
THE EWG-DSS 2020 INTERNATIONAL CONFERENCE ON DECISION SUPPORT SYSTEM TECHNOLOGY
I. Linden, A. Turón, F. Dargam, U. Jayawickrama (editors)
Zaragoza, Spain, 27-29 May 2020

ICDSST 2020 on Cognitive Decision Support Systems & Technologies

Artificial Intelligence Based Decision Making for Venture Capital Platform

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ABSTRACT

Venture Capital as an industry forms the backbone of innovation today. However, despite investing in high technology startups, most of the venture capital firms face a variety of challenges in its day to day operations which lack the adoption of technology. In this work, we introduce a platform aimed at automating some extremely crucial portions of the overall workflow of such firms that ranges from automating the sourcing of opportunities to analyzing and predicting their likelihood of success.

Keywords: Venture Capital, Artificial Intelligence, Platforms.

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ICDSST 2020 on Cognitive Decision Support Systems & Technologies

DSS, BI, and Data Analytics Research: Current State and Emerging Trends (2015-2019)

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ABSTRACT

Over the past several decades, DSS has progressed toward becoming a solid academic field. Nevertheless, since the mid-1990s, the inability of DSS to fully satisfy a wide range of information needs of practitioners provided an impetus for a new breed of DSS called business intelligence systems (BIS). This paper examines the major differences among decision support systems (DSS), business intelligence (BI), and data analytics (DA). These three systems are different in terms of data, analytical environment, analytical tools, their focuses, and others. Next, the paper briefly describes the major characteristics of each. Third, A survey of DSS, BI, and DA is conducted covering the period of January 2016 through December 2019 to report publication trend of each system. The final section summarizes the findings and discusses their implications. This research provided a picture of what has happened over the past several years. The biggest accomplishment the DSS community achieved is that it provided the foundational concepts such as the DDM paradigm and the definitions of DSS. The DSS area has given the fruits of the DSS research to numerous other fields. Further, DSS and BI have a mild level of increased publications, while there is very sharp increase in DA (349%).

Keywords: Decision Support Systems, Business Intelligence, Data Analytics, BigData, Data Warehouses.

ICDSST 2020 on Cognitive Decision Support Systems & Technologies

An Automated Corpus Annotation Experiment in Brazilian Portuguese for Sentiment Analysis in Public Security

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ABSTRACT

This paper aims to present an experiment developed in order to produce a corpus with automated annotation, using pre-existing annotated corpus and machine learning classification methods. A search for pre-existing annotated corpora in Brazilian Portuguese was applied, founding 6 corpora of which one has been selected as training dataset. A set of tweets was collected in a specific area of Recife (Pernambuco-Brazil) using some keywords related to kinds of crimes and reinforcing some places on that area. Preprocessing tasks were applied over the pre-existing corpus and the collected tweets' set. Latent Dirichlet Allocation was applied for topic modeling followed by Multinomial Naïve Bayes, Linear Support Vector Machines and Logistic Regression for the sentiment polarity classification. Experiment cross-validation results indicated Linear Support Vector Machines as the most accurate classification method among the three, and by using it, the new specific annotated corpus about the selected topic related to public security was created.

Keywords: Corpus annotation, Sentiment analysis, Public security, Brazilian Portuguese, Machine learning classification.

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Selection of an Integrated Security Area for locating a State Military Organization (SMO) based on group decision system: a multicriteria approach

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ABSTRACT

Over the past few years there has been growing concern among authorities over crimes committed worldwide. In Brazil it is no different. High crime rates have encouraged government authorities involved in public safety to identify solutions to minimize crimes. In this context, one way to plan and manage security is in the division of neighborhoods in ISA (Integrated Security Areas). Each ISA has a neighborhood conglomerates taking into account their geolocation. From this it becomes possible to maximize security management and combat crime. Based on that, one of the main points that generate great discussion at the governmental level is the choice of a certain integrated security area for the installation of a certain police battalion. This choice involves multiple decision makers since several hierarchies are involved. Thus, this paper aims to identify the best ISA to deploy a police battalion using group decision techniques and tools. For this work the Group Decision Support System (GDSS) called GRoUp Support (GRUS) was used from two main Vote techniques: Condorcet and Borda. With this it was possible to identify the best ISA taking into account the pre-established criteria.

Keywords: Public Safety; Multicriteria; GRUS

INTRODUCTION

Public safety has received special attention in many countries, especially regarding lack of security. Particularly in Brazil, there are several problems that contribute to a lack of security. Low investment in technologies, inefficient integration between the various public safety departments, and low salaries are among the points that have the greatest impact on the effectiveness of public policies for the fight against crime [1][2]. The state of Pernambuco,

Brazil, uses an index that identifies the number of victims, the Violent Lethal and Intensive Crimes (VLIC), and this index shows worrying data. The Social Defense Department of Pernambuco (SDS PE) integrates actions of the Pernambuco government aimed at guaranteeing public order to minimizing the VLIC index, considering the population's feelings towards the actions that are carried out, as well as the sense of security of each individual.

One of the points that have the biggest effect the individual sense of security is violence against life. These crimes have particularly strong effects on the daily life of people in developing countries, as is the case of Brazil [2]. Most of these crimes are some form of theft followed by murder, which causes profound impacts in both social and cultural terms. Specifically, in social terms, it is evident that the sentiment of the population is affected by a new crime. This feeling is characterized by the fear that people have about the possibility of suffering a similar crime [2][3]. Thus, programs for the promotion of public safety must both minimize crime and increase the sense of security in the population.

In this context, in order to manage public security, the state government of Pernambuco, together with the social defense department, divides neighborhoods and cities from integrated security areas (ISA). Each ISA is responsible for a set of neighborhoods enabling greater management of public safety. From this division it becomes possible to expand the offer of actions that aim to minimize violence and, consequently, increase the sense of security.

However, one of the most critical points of public security management is the installation of new police stations, as there are several criteria that need to be analyzed, as well as multiple decision makers with different profiles, as well as taking into account political and social factors.

Thus, this paper aims to identify the best ISA to deploy as a police battalion using group decision techniques and tools. For this work we used the GRUS software from two main Vote techniques: Condorcet and Borda. With this it will be possible to identify the best ISA taking into account the pre-established criteria.

BACKGROUND

Integrated Security Areas (ISA)

In Pernambuco there are 26 integrated security areas (ISA). These are smaller areas that are used to define how the police should work, allowing for greater level of cooperation and integration between the parties involved (Figure 1). From this integration it becomes possible to establish actions aimed at minimizing the occurrence of crimes, such as homicides.

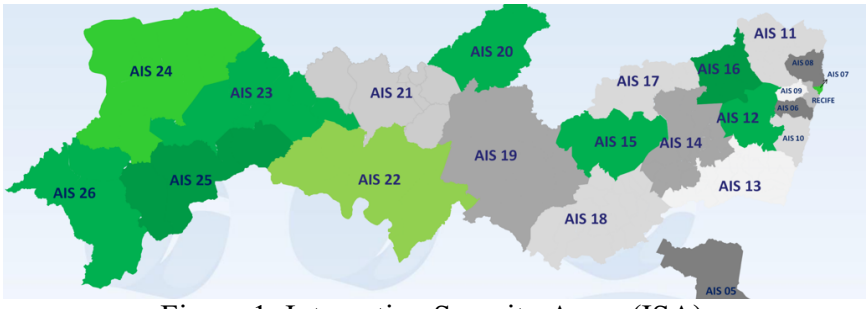

Figure 1: Integration Security Areas (ISA)

These 26 areas are distributed into three Regional Directors. The first group is subordinate to the Director of the Metropolitan Region and is composed of police stations located in the state capital and cities of the metropolitan region; The second group reports to the Director of Interior Area 1, which involves cities in the central region of the state. and the third group reports to the Interior Area Director 2, who considers cities in the western state. Although these 26 ISAs exist, the crime rate per population, which is above reasonable limits, is a major problem in some municipalities in the state of Pernambuco.

Police Station location problems

According to [4], localization problems are fully associated with geography, in which the division of an area by a police force is fundamentally a geographical problem. Generally, a city is divided into police command and patrol areas. [5] According to the author, the boundaries of an area are based on expert knowledge of the areas to be patrolled and police resources.

As stated earlier, optimizing the number of police stations and the allocation decision making problem should consider a different set of criteria. Based on the literature [4] [6] there are several suggested criteria that can be considered, such as the crime rate per population (one of the important criteria for police station optimization); population and unemployment rate; identification of a potential crime center; road accessibility and land availability; population density; Size of territory an agent should patrol; potential growth; density of police stations; political considerations; and environmental impact.

The State of Pernambuco is divided into Integrated Security Areas in a manner similar to that defined by [10], in a real scenario, decisions to define the location of an State Military Organization (SMO) are based basically on political and / or financial issues and without support for a formal procedure (subjective analysis). Thus, the contribution of this paper is to support this kind of decision problem, considering a relevant set of decision maker criteria and preferences.

That works and others present in the literature show the importance of multicriteria decision, as well as group decision in public security scenarios taking into account the various existing techniques. Several problems can be solved using these techniques, such as the allocation of police vehicles; choice of location for battalions; and vehicle routing. These problems are solved based on the identification of the existing criteria and alternatives, as well as from meetings that aim to support the group decision-making process. Considering software, as is the case with GRUS, it is possible to connect different decision makers to establish a single decision analysis process, as in this study.

GRUS System (Condorcet and Borda)

GRUS software is equipped with various collaborative tools and can be used in various decision-making processes by defining steps that make up this process, such as Brainstorming - Categorization of ideas - Establishment of consensus that is part of a group decision process. If there is no consensus, voting processes are required [7]

For the Borda process, the candidates are sorted according to the preferences of each voter. A count is then proceeded follows: each position in the ranking is given a score: 1 point for the

last ranked, 2 for the second to last, 3 for the second to last etc., ie the distance between each preference should be only one point. In the end the points are added to decide which alternative wins. This system takes into account not only each voter's first choice, but all others, so the winner is not always the first-placed candidate [8]

Regarding the Condorcet methods, or parity methods, are a class of ordered voting methods that follow the Condorcet criteria. These methods compare every pair of options, and the option that beats every other option is the winner. One option outperforms another option if most votes rank it better on the ballots than the other option. These methods are often referred to collectively as Condorcet methods, because the Condorcet criterion ensures that they all give the same result in most elections, where there is a Condorcet winner [8].

METHODOLOGY

The evaluation matrix is available thanks to a previous work [9]. In this paper the authors organized the questionnaire and a workshop where three stakeholders were involved. Based on interviews and the consolidation of opinions, the financial, social, criminal and political aspects were highlighted by the experts as important for achieving better and more compromising solutions. These four aspects were also fragmented into more specific issues: intentional lethal violent crime (ILVC), heritage violent crime (PVC), hotspot analysis, territorial extension, commercial presence, number of prisons, significant presence of communities, area with presence of flow, population, number of schools, risk assessment area. From this we identified the weights based on the importance of preferences among the stakeholder criteria (Table 1).

Table 1: Criteria

Criteria	***Scales***	***Weights***
CVLI (c1):	Total amount of intentional lethal violent crimes	0.30
Population (c2):	Population	0.20
Number of prison (c3):	Number of prisons in the area	0.10
Presence of another (SMO) (c4):	Number of SMO in the area	0.10
CVP rate (c5)	Total amount of patrimonial violent crime	0.15
Perceived risk level (c6)	5-point Likert scale (from very low risk to very high risk)	0.15

Table II illustrates the evaluation matrix considering 26 alternatives (representing 26 ISA) as well as the values of each alternative for all criteria.

Table 2: Evaluation Matrix

Alternative \ Criteria	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*
ISA_1	62	78.097	0	1	8420	3
ISA_2	90	337.983	0	1	7308	2
ISA_3	162	402.419	0	1	8182	4
ISA_4	176	421.291	2	1	9262	4
ISA_5	150	375.081	0	1	4711	3
ISA_6	416	751.002	0	2	9145	5
ISA_7	170	380.556	0	1	8372	4
ISA_8	269	618.090	5	1	7617	5
ISA_9	126	267.570	0	1	3073	3
ISA_10	226	307.271	0	1	2511	5
ISA_11	324	576.958	0	2	3019	3
ISA_12	235	418.012	1	2	2596	3
ISA_13	318	493.076	1	2	1804	5
ISA_14	408	676.723	1	1	7242	4
ISA_15	145	322.263	1	2	1508	3
ISA_16	123	355.549	1	2	1206	4
ISA_17	194	278.246	0	1	2467	4
ISA_18	217	509.005	1	1	1592	3
ISA_19	122	348.158	2	1	500	2
ISA_20	35	186.421	0	1	170	1
ISA_21	71	186.091	0	1	262	2
ISA_22	51	171.471	0	2	228	1
ISA_23	42	146.341	1	1	258	2
ISA_24	121	329.483	0	2	620	2

From these values it was possible to perform a simulation process in the GRUS software to identify which ISA will be chosen for the implementation of a new battalion. As previously stated, the software establishes a voting system where the parties involved can express their preferences taking into consideration the established criteria. The voting process is in according to the borda and Condorcet techniques, where decision makers assign a score for each alternative considering a scale of 0 to 10 points. After completing the voting process, the

software makes a comparison between the two methodologies (borda and condorcet) and establishes the final result.

Thus, we have as final result (the first five placed) (Table 3):

Table 3: Final Result

Integrated Security Area	Final Classification
AIS 02	1°
AIS 05	2°
AIS 24	3°
AIS 18	4°
AIS 04	5°

Thus, it was found that AIS 02 was the winner taking into consideration the determined criteria, as well as the preference of the decision makers (which in this case were three).

Figure 2: Integration Security Area 02

This ISA belongs to the city of Recife and is responsible for the conglomerate of three neighborhoods: Santo Amaro, Boa Vista and Soledade. In Recife, these neighborhoods represent a high crime rate considering the CVLI and CVP data of the state of Pernambuco.

CONCLUSIONS

Ensuring the public safety of the population is not an easy task and constantly needs actions to ensure greater efficiency in this process. In this scenario, government agencies, daily, need to make decisions that will impact the life of the population.

In this context the choice of a certain integrated security area becomes a determining factor to ensure a higher level of security in the locality and, consequently, in the state. However, this becomes a challenge as there are several criteria and decision makers who have different views of the same goal.

Thus, this work, based on the GRUS software, established a voting process taking into consideration the Condorcet vote procedure for the selection of a certain integrated security area where a new police battalion will be deployed. Thus, the purpose of this paper is to help governmental agencies decide to install a new battalion taking into account various criteria and decision makers.

For future works, besides dealing with geographical aspects (the second step of the problem location), probably using GIS, we suggest considering other set of criteria.

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Cognitive Decision Support Systems & Technologies

Design of portfolio investment DSS for the purchase and sale of assets

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ABSTRACT

Many people do not invest in stock exchanges due to lack of interest, information or fear. In fact, due to its volatility, the capital market can be considered high risk. However, there are ways to reduce risk and the most used method is to diversify the investment portfolio. In order to make the decision to buy or sell quotas of assets in a diversified portfolio, it may take a long time as the number of companies increases, in addition to the price variation of each one. Based on this problem, this article aims to propose the design of a system to support the decision to buy and sell assets within a diversified portfolio, in order to optimize the process and reduce the time and analysis for this. The investor is the one who will decide what his portfolio will be like, but he must provide some data (Input) to be processed (Processing Data) and then generate a decision (Output), which guarantees the great flexibility of the system for different investor profiles. The proposed DSS proved to be effective, returning the values necessary to align the portfolio with the predefined strategic model of the investor and indicating the right number of shares to buy or sell according to the available capital.

Keywords: decision support system; financial management; analytics; financial assets; big data.

INTRODUCTION

Fear is common among all stock exchange investors, since due to market volatility, investing becomes a risky task. For O'Sullivan and Sheffrin [1], one of the ways to circumvent fear and mitigate the risk of investing in exchanges is to diversify the investment portfolio. This diversification consists of pluralizing companies and sectors and not concentrating their capital on only a few segments. However, due to diversification, the more companies you have in your investment portfolio, the more difficult it is to process how much to buy from each [1].

Thus, the decision-making process becomes extremely complex, since decision-makers (DMs) must take into account, in addition to risk, a large amount of assets to define an investment portfolio. DMs need, then, efficient tools to achieve better and safer decisions. Within this context, they can use Decision Support Systems (DSSs) to increase consistency of the decisions . A DSS can be defined as a computer-based information system that supports decision-makers in using data and models to solve semi-structured and structured problems. It helps decision-makers to define better decisions and answer complex questions [2,3].

As in Industry 4.0, the economy needs not only real-time data, but also the ability to analyze them, so it is important that Decision Support Systems are integrated into the data analysis in order to facilitate decision making by the decision-maker [4]. Thus, taking the problem of the time it takes to decide the purchase or sale of assets in a diversified portfolio, we propose the design of a Decision Support System to reduce the decision time, creating an optimization model, integrated it into Google Spreadsheet® and used Google Finance as a database to search for model information.

To do so, we performed a simulation, mainly based on data from the Brazilian financial market, to verify the applicability of the proposed DSS, since, in 2018, 42% of Brazilians invested in some way, and of these 88% invested in savings [5]. However, most investors have a profile to invest in investment funds or the stock exchange. They do not do so due to lack of interest, information or fear. Part of this fear may be due to 45% of the population believing that to start investing in shares, you must have a minimum value of R$ 1,000.00, which is false, since asset prices vary a lot for another, when it could started with R$ 5.11 in 2018 [5]. Therefore, the use of a DSS could minimize lack of interest, information or fear from DMs.

METHODOLOGICAL PROCEDURES

The methodology starts with the identification of the problem to be solved, which in this case, consists of the difficulty in calculating the exact number of shares to be bought or sold, when having a diversified investment portfolio. The investor is the one who will define his investment portfolio. In the literature, the most common model used is the Markowitz theory of portfolio selection [6]. There are other portfolio investments models, such as computational methods [7], Robust Portfolio Optimization methodologies [8] and etc.

Since the focus of this paper is the design of the DSS, we proposed an optimization model, based on the DM preferences and the literature, to define an investment portfolio. To

define the system, we used the Google Spreadsheet® interface to analyze and interpret the results. Figure 1 shows the methodology structure used to design the DSS.

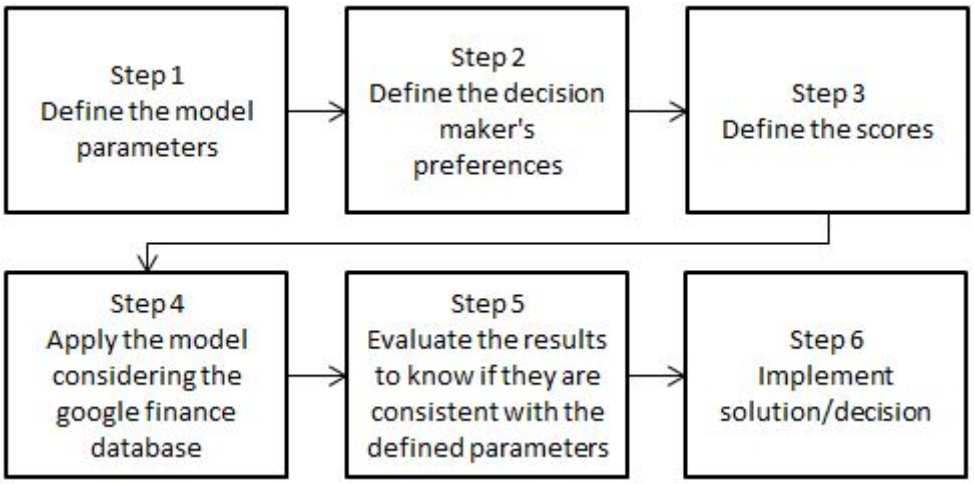

Figure 1: Methodology Structure.

Mathematical model proposed

As already said, the aim of the proposed model is to support the buy and sell assets within a diversified portfolio, in order to optimize the process and reduce the time and analysis. For this modeling, we consider a set of *n* Assets, where $A_i = (A_0 ; A_1 ; A_2 ; \ldots ; A_n)$, divided into *m* Group of assets, where $C_j = (C_0 ; C_1 ; C_2 ; \ldots ; C_m)$, which the assets in each asset group are mutually exclusive, that is, $m \leq n$.

So, each group of assets must have a certain percentage (K), which will be defined by the investor, in the investment portfolio, where $K_j = (K_0 ; K_1 ; K_2 ; \ldots ; K_m)$ is given as a percentage, and $K_0 + K_1 + K_2 + \ldots + K_m = 1$. In addition, each asset will also have a percentage (parcel of importance) within the group that belongs.

After, we used a concept of scores to evaluate the degree of importance of an asset, assigning a score from 0 to 5, being able to follow the following criteria: 0 - “I don’t want to invest now; 1 - “To invest very little money”; 2 - “To Invest a little money”; 3 - “Average investment”; 4 - “To invest more money”; 5 - “To invest much more money”.

Thus, is defined a set of Scores, where, $\alpha_i = (\alpha_0 ; \alpha_1 ; \alpha_2 ; \ldots ; \alpha_n)$. Next, to this model is necessary to calculate the ideal percentage of each asset within the investment portfolio. The following equation should be used:

$$ideal\ \%\ of\ the\ asset\ = \frac{K_j \alpha_i}{\sum_{i=0}^{n} \alpha_i} \quad (1)$$

In sequence, our model require the percentage of the portfolio that the investor already owns. Thus, the investor must provide the amount invested in each asset and then, through Equation 2, is calculate the percentage. If the investor does not have any investment, the amount will be null.

$$\%\ that\ has = \frac{v_i}{\sum_{i=0}^{n} v_i} \quad (2)$$

Where, the amount already invested per asset $v_i = (v_0 ; v_1 ; v_2 ; \ldots ; v_n)$.

Here, with these calculations performed, it is already possible, through Equation 3, to

obtain the price per asset to normalize the portfolio so that it is in accordance with the ideal percentage and scores.

$$Price\ to\ settle = (ideal\ \%\ of\ the\ asset\ (total\ amount\ invested + total\ value\ to\ invest)) - value\ that\ has \quad (3)$$

Thus, it is possible to calculate the number of shares to be bought or sold for settlement, which can be defined as the price to settle divided by the price (B_i) per share of the asset. In the next topic we present and discuss the design of the spreadsheet-based DSS for this model proposed.

Design of the spreadsheet-based DSS

The design of the system basically consists of 3 process macros: Input, Data Processing and Output, gathering information that can be seen in Figure 2. The input process gathers the preferences of the investor-decision maker, in this case, how is the investment portfolio. In this step, the investor needs to award scores for the portfolio's assets, (according to the criteria in Figure 2. With these scores, it will be possible to perform data processing and read the strategic plan. Then the first calculations to be carried out in Processing are the ideal and real percentage of each asset in the portfolio (which can be 0). The ideal percentage can change as the scores change, this gives flexibility to the decision-making process, since the real will be calculated based on how much has already been invested in each asset.

The database will be the most agile tool, which will provide the stock price in real time, depriving the investor from having to search one by one and then perform the calculations. The database used will be the one available through Google Finance®, a tool from Google Spreadsheet®. Containing information from 52 stock exchanges spread across the Americas, Europe, Asia, the Middle East and the South Pacific. The end of day prices are provided by Morningstar. Corporate Actions data provided by Thomson Reuters and intra-day data may be provided by ICE Data Services [9]. It is important to note that some assets have the same name (called TAG) in different exchanges.

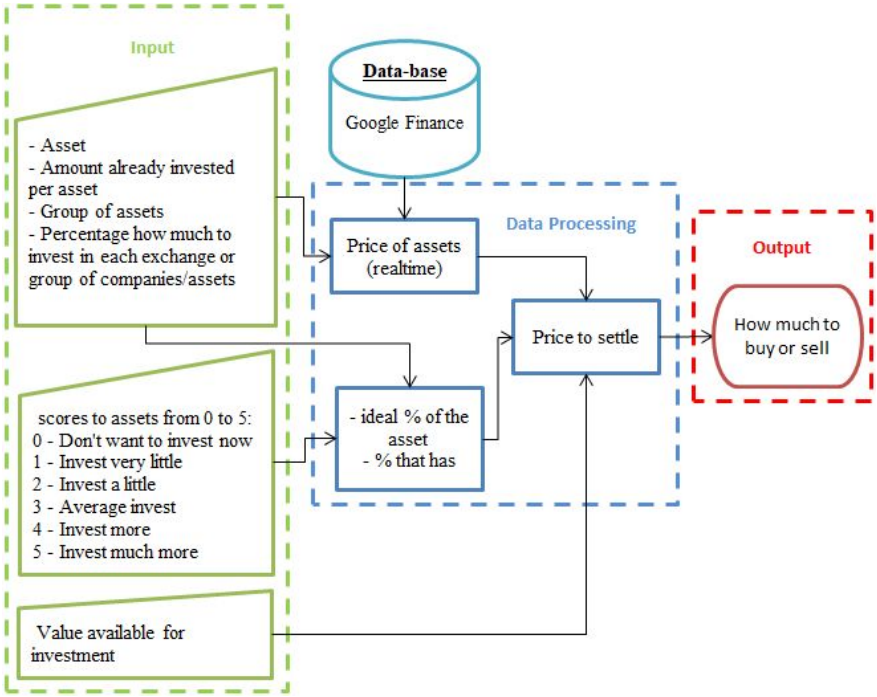

Figure 2: Structure of the DSS.

Figure 3 shows an example with the steps followed and applied in the spreadsheet. The ballots where asset prices go uses an equation that accesses the Google Finance database (= GOOGLEFINANCE (asset_code)). However, the value is returned in the computer's local currency (if you are in Brazil, it will be returned in BRL, in the USA in USD), therefore, if the asset to be invested is traded in a currency other than the local currency, the conversion of the currency traded with the local currency should be added to the equation. For example: = GOOGLEFINANCE (asset_code) * GOOGLEFINANCE ("CURRENCY: USDBRL").

For the "% I have" and "% Ideal" it is possible to place a conditional (IF function) in case the value is null, it does not return a mathematical non-conformity (0/0). With the percentages calculated and the share prices of the assets provided by the database, it is possible to calculate how much to buy and how much to sell so that the portfolio is close to or equal to the pre-defined strategic plan (proportions and scores). To calculate how much to sell, simply multiply the ideal ratio by the sum of the capital already invested with that available for the entire portfolio, and then subtract how much has already been invested in the asset and divide by the share of the asset.

	GROUP	PERCENTAGE	ASSETS	SCORE	% Ideal	HAVE	% I Have	To Settle
BVMF	50%	BVMF:FLRY3	R$ 23,60	5	15%	R$ 3.000,00	6%	R$ 5.602,94
		BVMF:EGIE3	R$ 48,19	3	9%	R$ 1.500,00	3%	R$ 3.661,76
		BVMF:WEGE3	R$ 34,53	3	9%	R$ 5.000,00	9%	R$ 161,76
		BVMF:ITSA4	R$ 10,20	5	15%	R$ 8.000,00	15%	R$ 602,94
		BVMF:MGLU3	R$ 42,00	1	3%	R$ 1.000,00	2%	R$ 720,59
NYSE	10%	NYSE:KO	R$ 235,63	5	5%	R$ 2.000,00	4%	R$ 659,09
		NYSE:T	R$ 167,57	3	3%	R$ 2.000,00	4%	-R$ 404,55
		NYSE:GE	R$ 38,16	3	3%	R$ 2.000,00	4%	-R$ 404,55
BME	10%	BME:BBVA	R$ 16,41	5	4%	R$ 3.000,00	6%	-R$ 562,50
		BME:AIR	R$ 391,14	2	2%	R$ 1.000,00	2%	-R$ 25,00
		BME:SAN	R$ 12,20	5	4%	R$ 3.000,00	6%	-R$ 562,50
FIIs	30%	BVMF:XPML11	R$ 106,65	2	6%	R$ 5.000,00	9%	-R$ 1.490,00
		BVMF:BRCR11	R$ 95,35	3	9%	R$ 7.000,00	13%	-R$ 1.735,00
		BVMF:BCFF11	R$ 89,70	5	15%	R$ 10.000,00	19%	-R$ 1.225,00

Figure 3: Example with the steps followed and applied in the spreadsheet

RESULTS AND DISCUSSION

We performed a simulation to verify the applicability of the proposed design of the spreadsheet-based DSS. Thus, we created a hypothetical scenario, which is:

- Scenario 1: a former investor, who already has capital invested in 3 different locations (BVMF, NYSE and Real Estate Investment), has an additional R$ 8,000.00 for investments in the portfolio and has decided to change his investment strategies by filling out the spreadsheet as shown in Figure 4.

GROUP	PERCENTAGE	ASSETS	SCORE	HAVE	PRICE	% Ideal	% I Have	To Settle
BVMF	40%	BVMF:FLRY3	5	R$ 3.000,00	R$ 29,76	20%	11%	R$ 4.300,00
		BVMF:EGIE3	3	R$ 1.500,00	R$ 47,53	12%	5%	R$ 2.880,00
		BVMF:WEGE3	2	R$ 5.000,00	R$ 43,15	8%	18%	-R$ 2.080,00
NYSE	30%	NYSE:KO	5	R$ 2.000,00	R$ 239,26	19%	7%	R$ 4.843,75
		NYSE:GE	3	R$ 2.000,00	R$ 48,67	11%	7%	R$ 2.106,25
REI	30%	BVMF:XPML11	2	R$ 5.000,00	R$ 130,45	9%	18%	-R$ 1.871,43
		BVMF:BCFF11	5	R$ 10.000,00	R$ 98,17	21%	35%	-R$ 2.178,57

Figure 4: Strategic table in a hypothetical scenario

The calculation for purchase and sale of shares of assets

From the “To Settle” column, we created two other columns with conditional equations, one containing the values greater than or equal to 0 and the other with values less than 0, “To buy” and “To Sell” respectively. With that, it is possible to take the proportions of purchase and sale of each asset. So, when you put how much you have to invest, just multiply it by the percentage of purchase of each asset and you will have the amount you should buy. By dividing this value by the price offered by the database, you have the number of shares to buy. The sales calculation process is simpler, just take the negative values provided by the table and divide by the price of each share.To make a decision on how much to buy or sell, we considered that the investor has R$ 8,000.00 available to make his contributions. Figure 4 shows these examples.

Figure 4: Table with the shares of assets to buy and to sell.

	Invested capital	R$ 28.500,00	Value to invest	R$ 8.000,00	
To buy	% To buy	Shares to buy	To sell	% To sell	Shares to sell
R$ 4.300,00	30%	82	0	0%	0
R$ 2.880,00	20%	34	0	0%	0
0	0%	0	-R$ 2.080,00	-15%	-48
R$ 4.843,75	34%	11	0	0%	0
R$ 2.106,25	15%	25	0	0%	0
0	0%	0	-R$ 1.871,43	-13%	-14
0	0%	0	-R$ 2.178,57	-15%	-22

Figure 4 shows the system suggestions to buy and sell shares. If we add the values of

the decision with what has already been invested, it shows that the resulting percentage is very close to the ideal percentage stipulated by the parameters previously provided. We believe that the ideal percentage was not reached for 2 reasons: the first because there is not much capital to be invested to buy additional shares of some assets and the second, because it is not possible to arrive at an exact amount of how much can be bought or sell, since the unit price of the quota is fixed at a value.

CONCLUSIONS

With the calculations and analyzes performed, it is possible to visualize the effectiveness of the proposed decision system, reducing the decision time to just a few seconds after structuring the spreadsheet. It can even serve to monitor stock prices in real time. In addition, the investor can see how much money he needs to regularize his portfolio according to his strategic plan, which can change as the market also changes, which demonstrates the flexibility of decision making. When someone has a very diversified investment portfolio, it is necessary to look for the price of each share and then calculate how many shares are necessary to buy within the strategic plan, with the new system proposed in this article, the model showed that it is possible to carry out the entire decision-making process automatically and practically in real time.

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Management Information System to Police facility location

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ABSTRACT

It is well known to society that crime rates in Brazil have been increasing a lot in recent years. The Northeast region of Brazil comes in second in the ranking of crime, in which the state of Pernambuco, in the last two years, had considerable increases in their investments towards public safety and their crime rates have not reduced. In fact, several factors make difficult the decision of Prioritizing investments, such as the lack of a system to support management decisions. Considering that the location of police installations influences crime rates, specifically in police response time, this research aims to propose a Management Information System (MIS) that presents different location arrangements, with their respective performance indicators, to support decisions regarding the installation of police units. The MIS model for locating police facilities uses two methods, the first to find potential locations, called K-means, and the second to select optimal locations, called the Maximum2 Covering Location Problem (MCLP). The results obtained when using MIS in a Brazilian city, based on crime occurrences, to identify police units, demonstrated a better performance of the service when compared to the current configuration of the units.

Keywords: Facility Location Problem, Public Safety, Management Information System, K-means, MCLP.

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Supporting Operational Decisions on Desalination Plants from Process Modelling and Simulation to Monitoring and Automated Control with Machine Learning

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ABSTRACT

This paper describes some of the work carried out within the Horizon 2020 project MIDES (MIcrobial DESalination for low energy drinking water), which is developing the world's largest demonstration of a low-energy system to produce safe drinking water. The work in focus concerns the support for operational decisions on desalination plants, specifically applied to a microbial-powered approach for water treatment and desalination, starting from the stages of process modelling, process simulation, optimization and lab-validation, through the stages of plant monitoring and automated control. The work is based on the application of the environment IPSEpro for the stage of process modelling and simulation; and on the system DataBridge for automated control, which employs techniques of Machine Learning.

Keywords: Operational Decision Support; Desalination Plants; Process Model-ling; Process Simulation; IPSEpro; Plant Monitoring; Automated Control; Ma-chine Learning, Horizon2020 Project, MIDES, Microbial Desalination Cell, MDC, Low-energy Process, Treated Wastewater, Drinking Water, Climate Change Adaptation, Sustainability.

III
East Zone Papers

ICDSST 2020 on
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Determinants of recommendation in the airline industry: An application of online review analysis

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ABSTRACT

This study explores key determinants of airline recommendations by integrating scores reviews and text comments scraped from online sources. Numerical review scores were used to characterize features on how passengers decide to recommend others. Text analysis technique provides information of service attributes that differentiate positive and negative comments. Using generated WordCloud, the results suggested that positive recommenders are satisfied with human dimensions such as personality and friendly services, while negative comments suggested frequent complaints on poor operational dimensions such as on-time performance and seat comfort.

Keywords: Web scraping, text mining, airline recommendation, online review, WordCloud.

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An E-government procurement Decision Support System Model for Public Private Partnership projects in Egypt

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ABSTRACT

The use of Decision Support Systems (DSS) has become a successful approach over the past years as it relies on the use of knowledge rather than information. Moreover, the tremendous increase in communication and information technology applications is encouraging decision-makers to incorporate the extensive analysis of previous transactions and historical experiences, along with the computer applications, to take the critical decisions related to procurement. However, the are several challenges that face the procurement decision-making process in any organization, especially, the governmental entities, such as how to choose the best suppliers to deal with. In this sense, this paper aims to present the impact of using DSS to help facilitate a better e-procurement cycle, which will involve better decision-making in the selection of the most convenient suppliers based on the previous historical record on the nominated suppliers. To achieve this aim, a DSS tool that uses decision trees named Expert System Builder (ES-builder) has been used. This paper will be specific to a case study on the new Public-Private Partnership (PPP) law number (#) 67 in Egypt, which is a law concerned with the cycle that any governmental entity engaging in projects with the private sector.

Keywords: E-Government Procurement, Private Public Partnership (PPP), Decision Support Systems (DSS), Egypt, ES-builder.

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THE IMPACT OF BIG DATA ANALYTICS ON PROCUREMENT IN EGYPT

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ABSTRACT

The use of big data has recently become a successful approach for companies seeking to make better decisions. Supply chain (SC) is considered an incredible source of data, as it includes data about customers, suppliers, and operations, capitalizing on these data can create a substantial competitive advantage. Furthermore, SC big data analytics (BDA) contributes to better customer service levels, better product quality, and higher revenues. This paper aims to present a model that overcomes the common challenges of BDA faced by companies working in the field of procurement. A Survey was applied in Egypt where the survey focused on four major pillars; the importance of BDA to the procurement activities and SC decision-making, the current status of BDA implementation in the organizations, benefits of BDA implementation in procurement, and challenges of BDA implementation in procurement. Based on the data collected and analyzed, the findings revealed everyday challenges that face companies operating in Egypt while implementing BDA in SC decision-making. Academics and practitioners should refer to findings and insights from this paper when conducting procurement functions to enhance SC decision-making .

Keywords: Big Data Analytics, Supply Chain decision-making, Procurement, Supply Chain analytics, Egypt.

INTRODUCTION

The vast advancement that is taking place in information technology (IT) has changed the concept of competition in many industries. Among the several technology novelties is big data (BD), which is characterized by variety, volume, velocity, and value [1]. Alongside with the development of BD analytics (BDA) age, the BDA has drawn the attention of several researchers and practitioners, after realizing the significant value generated to any business [2]. Furthermore, procurement function tends to rely heavily on data management, as procurement managers need to dispose of, clean, and analyze data of different types to match the operation performance of suppliers and increase their cost savings [3]. Nevertheless, given the importance of data management, the procurement sector was relatively slow to recognize the potential role of new technologies in research and practice [3, 4]. Additionally, [5] stated that when it comes to BDA, procurement is behindhand development and exploration when compared to other supply chain (SC) functions, although significant revenue goes to procurement. Certainly, in order for a company to succeed in implementing BDA, all of its functions should keep up with each other. For this reason, this research attempts to underline the significant importance of BDA in SC and procurement in order to help companies to have more visibility over the supply market, improved negotiating position, improved risk management, and better decision-making. In order to achieve this aim, the following research questions have been developed:

1. What are the required elements of BDA implementation in SC and procurement?
2. What are the benefits and challenges that may face BDA implementation in the procurement process?
3. How can BDA adoption improve the performance of procurement process?
4. What are the obstacles and barriers to implementing BDA in Egypt?

The remaining sections of this research are organized as follows: first, the present literature on BDA from the SC management and procurement viewpoint; then, the subsequent sections explains the methodology, empirical results, discussion, and ends with the conclusion and recommendation of the research.

LITERATURE REVIEW

BDA can be leveraged in the control of the entire SC, where massive information is generated in each process in the chain from upstream to downstream. This information provides accurate and real-time insights to help SC managers to continually recognize SC issues and respond to them [6]. Furthermore, [2] argued that by increasing transparency, durability, and robustness, BDA could benefit SC by creating enormous cost savings and better SC decision-making. Likewise, there is a collection of capabilities in business analytics that use statistical techniques that adopts descriptive, predictive, and prescriptive analytics to accelerate informed decision-making. As a result this helps companies gain competitive advantage among their rivals [7]. The descriptive analytics is used to determine behaviors and model past habits, while predictive analytics uses both qualitative and quantitative methods to improve productivity by predicting the past and future levels of business process orientation [8]. Likewise, Prescriptive analytics use the predictions to recommend actions in future situations, whether to take advantage or avoid occupational hazards [6, 9]. [2, 10] argued that BDA helps make SC operations more efficient by strengthening and connecting all SC partners through a data-driven system. However, SCs are not owned by one specific company; there are multiple numbers of participants; each has its fragmented system, which requires standardization efforts. Many stakeholders do not understand the value that can be gained by BDA, even though

sharing information creates value, firms can be hesitant in this regard, especially if they are concerned about losing competitive advantage [11].

Setting analytics to work for procurement requires a comprehensive understanding of the function of sourcing. Sourcing is a strategic tool because a substantial amount of a company's revenue is dedicated to sourcing. Thus, companies have realized that it can no longer be a function in a silo. Alternatively, it needs to be structured and coordinated with all other roles as its duties are more than just buying goods. Consequently, it has become more complex to apply analytics to sourcing [5]. The situation with procurement analytics is that they use analytical techniques to support decision-making, but the burden is the ability to manage data. The Challenges companies face in managing their data are; inaccurate information about suppliers, and consumption patterns. Besides, there is a vast volume of data in dispersed systems, which makes its management even more difficult [10, 11] Table 1 summarizes the success factors, benefits, and challenges of implementing BDA in SC and procurement.

Table 1: BDA in SC and procurement success factors, benefits and challenges.

BDA Success Factors	BDA Benefits	BDA Challenges
• SC system integration • Improved forecasting/decision making • Security and governance • Operational efficiency • One version of the truth	• Increased visibility • Enhanced bargaining position • Ability to respond faster to change • Greater power in relationship with suppliers and customers • Operational efficiency • Accuracy of information • Better risk management • Informed decision-making	• Needle in a haystack (where to start?) • Islands of excellence (uncoordinated functions) • Measurement minutiae (too many metrics) • Analysis paralysis • Data quality • Dispersed systems • Lack of standard data format

Although [5] explained the benefits and hurdles of BD across a company's entire supply chain and all of its functions, he briefly touched the procurement and the exploratory studies addressing BDA in procurement especially in Egypt where he revealed that no studies addressed the challenges associated with BDA implementation in procurement.

METHODOLOGY

To find answers to the research questions discussed earlier, a questionnaire was designed and distributed to collect empirical data. Four constructs were measured in this study: importance of BDA to procurement activities and SC decision-making, BD implementation status, perceived benefits of BD implementation in procurement, and challenges of BD implementation in Egypt. All constructs were measured by multiple items that were adapted from previous studies with appropriate modification. A five-point Likert-type scale anchored from 1 (“strongly disagree”) to 5 (“strongly agree”) was used in the questionnaire. In order to ensure the reliability, the suggestion of [12] was adopted to use a minimum of three items to construct the content of each construct. At first, the original version of the questionnaire was reviewed by three professors who had experience in the field of procurement and BDA. Then a pilot test was conducted with four SC consultants and industry practitioners. The modifications were minor, based on the received feedback. Nonetheless, most of the remarks were related to the wording of the questions. Accordingly, they were re-phrased to be easily interpreted to avoid any misunderstanding. A purposive sampling technique was used to choose respondents who were relevant to the research topic. The sample was selected based on their awareness of BDA or their experience of being involved with BDA implementation. The data

was collected from Egypt; an online questionnaire was distributed to 100 firms operating in different sectors, such as food, fashion, communication, automotive, and agriculture. Among the 100 questionnaires, the authors received 95 valid responses. The validity rate is 95% of the respondents; 40% were SC directors, 30% were procurement managers, and 30% were IT managers.

ANALYSIS AND DISCUSSION

For the purpose of this research, a mixed-method analysis has been selected for data analysis. On completion of the data collection, statistical manipulations were conducted using SPSS software, and the results were presented using pie charts, graphs, and tables. Furthermore, thematic analysis was used to add a descriptive flesh to the skeleton provided by quantitative data. These methods facilitated a systematic analysis of the data from which the research findings and conclusions were pinpointed.

As shown in Table 2, respondents were asked to rate the importance of BDA to the procurement activities and the SC of an organization. Nearly 69% of respondents confirmed BDA as extremely important to their organization's SC and to their procurement and sourcing department, 29% confirmed BDA as important and 2% confirmed that it is neither important nor unimportant. Moreover, there are five stages of BDA implementation: nascent, pre-adoption, early adoption, corporate adoption mature/visionary adoption. In the nascent stage there's low awareness of BDA and its value across the organization, in the pre-adoption stage the organization starts to be more aware about BDA and study it's value if implemented, in the early adoption stage the company starts implementing BDA, in the corporate stage the end-users get more involved and transform how do they do business and finally in the mature/visionary stage the organization uses highly tuned infrastructure. Out of the mentioned five stages of big data levels, the majority of the respondents (72%) are at the beginning stages (pre-adoption 37% and early adoption 35%) 13% are at corporate adoption and 2% considered themselves to be at a visionary level. Likewise, maximizing overall performance and utilization emerged as the most influential benefit, followed by dealing with suppliers more efficiently, saving costs and minimizing risks. Despite acknowledging the benefits and importance of BDA, the responses also indicated that BDA implementation has been lagging. Finally, the respondents indicated that organizations face many challenges and obstacles in the implementation of BDA, especially in Egypt as most companies in Egypt have poor quality of data, lack of skilled employees with a good understanding of data analytics, lack of capital/funding and problems in system integration. Based on the mean values, the lack of skilled employees with a good understanding of data analytics is the most common challenge faced by organizations, followed by the poor quality of data, the lack of capital/funding and problems in system integration

Table 2: Summary of results from the questionnaire.

Themes	**Importance of BDA to the procurement activities & SC**	**Current status of BDA implementation in the organization**	**Benefits of BDA in procurement**	**Challenges of BDA implementation in procurement**
%/Mean Value	Extremely important: 69%	Nascent: 13%	Maximizing overall performance & utilization (mean value = 3.9)	Lack of skilled employees with good understanding of data analytics (mean value ≃ 3.71)

	Important: 29%	Pre-adoption: 37%	Dealing with suppliers more efficiently (mean value ≃ 3.86)	Poor quality data (mean value = 3.6)
	Neither important nor unimportant: 2%	Early adoption: 35%	Saving costs (mean value ≃ 3.81)	Lack of capital/funding (mean value ≃ 3.56)
	-	Corporate adoption: 13%	Minimizing risks (mean value ≃ 3.75)	Problems in system integration (mean value ≃ 3.52)
	-	Mature/visionary:2%	-	-

Respondents were asked to state any additional comments or suggestions in the last part of the questionnaire. Some respondents stated that recently companies are becoming more aware of BDA and applications of Internet of Things (IoT) and they are looking further to overcome the challenges associated with implementing them. Other respondents suggested that companies should first invest in training the existing workforce to put digitization into place then can move further by developing an IoT platform to ease the assimilation of data from different sources and explore the possibility of using Artificial Intelligence (AI). AI machine learning is learning from every input of data and uses these inputs to generate new rules for future business analyses. Thus, implementing AI in procurement function will result in smarter procurement processes, better decision making, better forecasting, managing risks more effectively, better supplier evaluation through monitoring suppliers' performance, greater automation of menial procurement tasks and better identification of opportunities that deliver bottom-line impact.

As depicted in Figure 1, the procurement function is highly impacted by big data, the inner part of the model which is presented in the gray area shows the impact of BD on procurement in organizations based on the literature findings. It indicates that lack of employee understanding of data analytics, besides lack of capital funding, issues with system integration, and human errors are the major challenges accompanied by BD.

On the other hand, the outer part of the model which is presented in the yellow area shows the impact of big data on procurement in organizations based on the data collected from surveys. It indicates some findings that are actually dependent where the survey results revealed manual work and duplication of work and this results in taking a lot of time to get the needed data, resulting in poor data quality, and finally, wrong decisions are made.

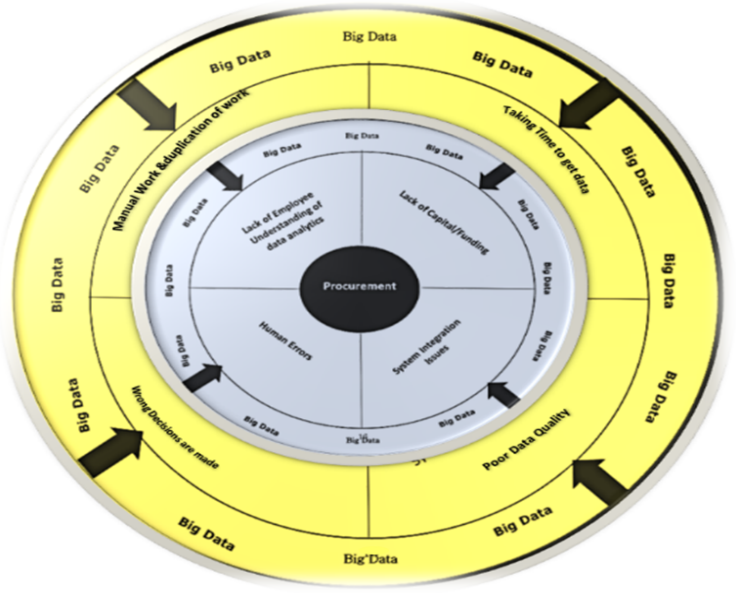

Figure 1: BDA challenges in procurement model.

CONCLUSION

Reliability of using data is quite an important pillar in carrying out procurement functions. BDA impacts decisions about which suppliers to select and which to avoid and many more aspects when it comes to decision-making. This paper contributes to building better reliability on BDA based on the literature findings as well as, information collected from surveys. These findings were used to create a model that helps avoid common challenges accompanied by using BDA in the procurement and SC decision-making process in Egypt. In conclusion, it is highly recommended to avoid the issues/challenges indicated in the model in order to have a much precise decision making besides, the time wasted in analyzing the wrong data. The model ends at false decision making which is a major drawback in reliability on BDA.

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A Gateway for Technology Adoption in Agriculture: a Design-Thinking Approach for a Compliance Decision Support System

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ABSTRACT

Globally, consumers are becoming more conscious of unsustainable farming practices. The appetite for safely produced, compliant and pesticide free crops is increasing. In response to these demands, the Argentinian government has issued new regulation to govern the application of *good agricultural practices* affecting production, storage and selling activities. This legislation is an opportunity to incentivise farm owners to adopt technology for recording mandatory information which has previously proven difficult. This project aims to test whether compliance software is an effective gateway for shifting farmers decision-making to technology, and from intuition-based to evidence-based, improving agricultural productivity. Understanding and integrating technology into their existing practices is a substantial challenge for many farms. Consequently, the authors prototype a decision support system (DSS) for greenhouse farmers in Argentina that can trace batches of crops and their treatments to reduce compliance risk. Incorporating lessons learned from previous DSS projects, the authors utilise design-thinking strategies to include end-users in the development of the system. Through such a tool, the authors can trial innovative features to test receptiveness of farm owners to utilise information technology solutions for decision-making and identify barriers to data collection and technology adoption.

Keywords: Agricultural Compliance, Decision Support System, Technology Adoption, Design-Thinking, Agriculture

INTRODUCTION

Background

Over the past five decades there has been a global shift in agriculture from resource-driven growth to productivity-driven growth [1]. Previously, farms have increased agricultural output through expansion of land, water use, and other inputs. Most farms now prioritise improving resource and labour efficiency alongside better farming practices and technology [1]. Agricultural productivity is lower in developing countries compared to advanced economies, impeding their convergence. Technology and innovation are fundamental to drive improvements and acceleration in the sector, embodying state-of-the-art practice and "knowledge capital" that can transform farm owners' businesses [1]. Improving farm productivity not only involves efficiency and yields improvements, but also raising quality of food for higher-value and exportable products [1] . This can be an important growth opportunity for small-holder producers to meet the standards of other markets, ultimately improving their impact on economic prosperity, environmental protection and social well-being.

Compliance certifications are one method of raising the bar on food quality, yet many farms lack the existing processes to reliably track their crops from seed to harvest along with pesticide applications. As multigenerational farms are sometimes slow to innovate, they may collect such data by hand or through using spreadsheets. Understanding the barriers to technology for farmers, as well engaging with them to improve their confidence in information technology (IT), is crucial in order to remove cultural constraints on technology adoption and catalyse their economic growth. Many software solutions have struggled with low adoption rates [2] and lessons learned from previous agricultural decision support systems (DSS) identified compliance as an effective way to deliver decision support [2].

Scenario

In October 2018, the Argentinean government issued new regulation [3] to govern the application of good agricultural practices (as defined by FAO) in the context of fruit and vegetable production. This regulation affects production, storage and selling activities that take place in the confines of the farm. In relation to chemicals used in the farm, regulation states that farmers must comply with the recommendations and restrictions of use stated in the product label by the manufacturer, and that all applications must be recorded (article 2.2.1). Farmers can only use chemicals, fertilizers, and soil additions that have been registered at SENASA, the National Agri-food Health and Quality Service (article 2.2.2 for chemicals, article 2.6.1 for the case of fertilizers and soil additions). Compliance with this regulation is mandatory from January 2020 for fruits, and from January 2021 for vegetables. [3]

The approach described in this paper aims to seize the opportunity to test whether a compliance DSS addressing new legislative changes can shift farmers processes to incorporate technology whilst embedding expert advice. The project is developed in collaboration with several horticultural greenhouse farmers in La Plata, Argentina, a farming area of approximately 6000 hectares with over 1000 farms that provide fresh vegetables to a large part of Buenos Aires province [4]. Based on conversations with local farmers, many farms do not use software tools to assist with decisions and farm management. Some have begun to actively seek research and development opportunities such as RUC-APS [5] to improve their farming practices to deal with the multitude of challenges they experience such as traceability, a volatile market, manual labour requirements and pest management. Adopting technology and IT systems can help to mitigate risks that the challenges pose and ensure farming practices are compliant to help secure trade deals with supermarkets or for international exports [1].

Aims and Objectives

The authors propose a prototypical DSS, GAP-A-Farm, to incrementally integrate technology into a farm's compliance processes using a design-thinking approach for continuous end-user feedback and incorporating lessons learned from previous DSS projects [2, 6]. The authors aim to demonstrate the effectiveness of whether an accessible compliance software is an effective gateway for shifting farmers decision-making to technology, and from intuition-based to evidence-based, improving agricultural productivity. The objectives of this project are as follows: (i) review the literature and existing software tools for similar functionality and guidelines, (ii) apply design-thinking principles for software development to develop a minimum viable product (MVP) DSS for compliance and traceability, (iii) prototype features with decision support and (iv) acquire end-user feedback during the development cycle with farm owners and managers in La Plata, Argentina. The paper addresses the objectives in chronological order and is concluded in the last section with plans for a pilot study.

RELATED WORKS

DSSs are designed to aid users to make better decisions by guiding users through decision stages and presenting the likelihood of various outcomes resulting from different option [2, 7]. These can be dynamic software provide suggestions according to the user's inputs and record data for analysis to provide data-driven insights [8]. Despite wide availability of DSSs for agriculture, studies show that uptake has been disappointingly low [2]. One study, looking at lessons learned from previous DSSs and their reasons for low uptake, identified key factors for effective DSS design and delivery including usability, relevance to user and compliance demands [2]. Guidelines suggest focusing on time-consuming processes with substantial risk for the farmer to justify the use of technology [2]. Software is available to support record keeping from seed to harvest for compliance, in the form of enterprise resource planning (ERP) tools in industry such as Farmbrite and Artemis [9]. These tools can be expensive and are a leap for the technologically illiterate, especially when they are only available in English.

Several major reviews have been conducted on agricultural DSSs, two of which do not mention DSSs to support compliance [8, 11]. A review from 2019 on apps for sustainable agriculture identifies some apps for compliance-related inspection but found that they do not integrate farmer knowledge [11]. It concluded that DSSs lack emphasis of knowledge exchange to identify evidence-based practices that improve indicators of sustainability, as well as involving end-users early and throughout the software development [11]. Finally, a review of farm management information systems (FMIS) in 2015 found that few FMIS software had features for tracking traceability and providing best practices, and these were in their infancy commercially [12]. There remains an opportunity to develop a DSS as a vehicle for improving the confidence of farmers to use technology solutions.

APPROACH

A design-thinking approach was taken to involve end-users in the development of the DSS to assist farm-owners that are typically technology averse. Design-thinking is generally defined as "an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign" [13]. It encompasses a set of strategies which can be broken down into initial divergent phases and convergent phases which are iterated. The approach starts with "emphasising" through journey mapping and interviews to understanding some of the core challenges that the farmers encounter regularly. The problem-solvers then "define" the challenges and decisions that need to be supported, enabling objectives of the system to emerge. The "ideate" phase consists of sharing ideas, thinking of

possible solutions and prioritising viable concepts. The "prototype" phase involves a MVP that is evaluated by the end-user through mock-ups or storyboards in order to get rapid feedback to validate the software. The MVP mitigates the risk of a software that has unnecessary features or is not suitable for the market. The last step, "test", allows the developers to find what works and what does not so that unnecessary features can be removed, and the useful features can be improved/added. This approach was iterated over four two-week sprints with several greenhouse farm owners, a senior software developer and a junior developer.

EMPHASISE/DEFINE – INTERVIEWS AND SURVEYS

In order to determine the best-fit solution for greenhouse farmers in the region, the authors conducted a short survey with ten participants owning farms between 0.5 hectares to 30 hectares in La Plata. The aim of the survey was to determine the challenges local indoor farmers experience, the compliance schemes they follow, their key performance metrics and their current technological capacity (no. of computers and internet access). The results showed that all participants thought technology would be helpful in their processes and most participants were underprepared to deal with regulatory changes. All participants agreed that a software would be useful for "recording traceability" and "planning". Although all farms were accustomed to using their smart phones to access the internet on their farm, 70% of farms did not have access to a desktop computer. 50% of the farms do not track any key performance metrics (indicating intuition-based decisions) and all farms wanted to compare their performance to other farms. The authors concluded that the best solution would be a web-based group DSS to support existing compliance processes, providing decision support around authorised substances, premature harvest warnings and comparison metrics.

Interviews were then conducted on several greenhouse farmers that follow compliance schemes proceeding a journey mapping session which highlighted pain-points in tracking crops and their treatments [14]. These interview sessions enabled a clear definition of the software requirements in order to adequately record the data necessary for SENASA and GAP. The following user requirements were agreed: (i) plots can be entered with a history log, (ii) plant batches can be sown or harvested within a plots (iii) issues like pest outbreaks can be reported for batches, (iv) treatments like pesticide applications can be reported for batches. Concerns were raised about being able to retrospectively change the dates of treatments, indicating mistakes may be made whilst back-dating compliance. Therefore, additional features were suggested such as a warning system to ensure that pesticide is only applied to approved crops by SENASA and that crops are not harvested prematurely once pesticide has been applied.

IDEATE/PROTOTYPE – BRAINSTORMING AND PROTOTYPING

After identifying the core functionality of the DSS, and ideation phase followed which resulted in a set of prioritized ideas. Concepts that were discussed through a series of workshops included risk management, baseline graphs for metrics (yields and pesticide use) utilising group decision support system mechanics, harvest estimation (date and yield) and incorporating a database of SENASA's accepted treatments. The MVP of each of these functions was discussed to see whether they would assist users with decisions they make and determine their benefit. Simple features were then incorporated into a dashboard mock-up and a user journey-map illustrated in Fig. 1 to get end-user feedback.

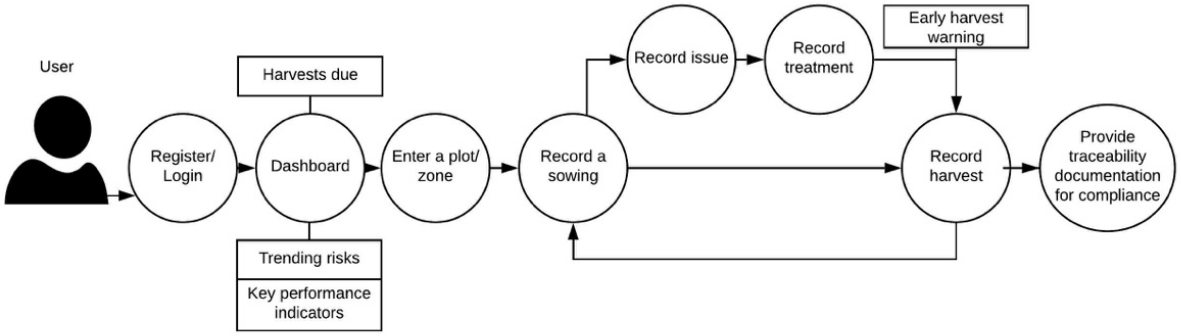

Figure 1 User journey (farmer) for Gap-A-Farm developed with the end-users

A prototype was developed for evaluation. Gap-A-Farm foresees two user profiles: experts and farmers. Experts access the system mainly to align the shared catalogue of crops and authorised substances with the information obtained from product labels, and from SENASA. Farmers access the system to record when they plant, when they discover issues in the farm (e.g. pests), when they apply chemicals and fertilizers, and when they harvest. In this sense, the system replaces the paper forms or spreadsheets they currently use. Moreover, as farmers use the system, they discover support for decision making focused on GAP compliance.

After an initial phase where the farmer registers the plots in farm, most of the interaction of the farmer with the system involves recording relevant events. Events are connected to plots (the unit of analysis). Four types of events are currently available: Planting, Issue reporting, Harvesting, Application. In all cases the date and time are recorded. When planting, the farmer records crop type (selecting from the shared catalogue) , quantity (no. of plants/kg of seeds), time to harvest, harvest duration, and expected yield. This information is processed as alerts on the dashboard such as upcoming harvests and to compare expected vs. actual yield. When recording an issue, the farmer provides a short description and a classification from a predefined taxonomy (i.e. Infestation, Disease, Nutrients deficiency, Other). Reported issues are currently used to offer targeted news to farmers whilst collating "trending" issues to be summarised on the dashboard (in the future additional advice could be offered upon logging). Recording the application of chemical products and fertilisers is central for compliance. When an application of a substance to a plot is recorded, it is cross-referenced with the shared catalogue to ensure its authorization by SENASA for the crop type in that plot (note: substances are applied under the advice of the farm's agronomist who can consult the catalogue). If a minimum waiting time prior to harvest after an application is required, the system marks the plot as "not to harvest before". Once the harvesting period begins, every harvest is recorded from each plot in the form of events (including the quantity, both in kilograms and/or in a customized unit). Whereas the latter is used to reflect on common practices, the former is used to update the dashboard, comparing expected to actual yield.

As a result of an explicit decision, driven by agility and in pursual of a MVP, the design has been limited to the data pieces that farmers need to record for compliance certification. The only exception to this rule is the "Planting" event where additional information regarding time to harvest, harvest duration, and expected yield is requested. Although farmers do not normally record this information, it is included to assess the willingness of farmers to provide extra information, evaluating how it may prompt decision advice. Finally, Gap-A-Farm transparently learns from many farmers and turn this into group decision support (e.g., showing trending issues or comparisons of a farm's yield performance to averages of other farms using the DSS).

To ease its deployment and maintenance, the system has been implemented as a web application, limiting its use to farms with internet access. It was built using responsive technologies to enable compatibility for both from desktop and from mobile devices. However,

initial discussion with the farmers from the pilot study suggest that the DSS will be primarily accessed via desktop computers.

TESTING

Gap-A-Farm went through a series of testing cycles to ensure alignment to end-users' objectives and usability requirements (efficiency, effectiveness and satisfaction). This meant bringing interactive user-interfaces and mock-ups of additional features to conduct role-play sessions with the end-user. These sessions highlighted challenges in user-flow and additional fields that would be useful (i.e. a notes section for event and customisable units). The tests were necessary to determine whether record keeping with the system clearly outperformed paper handwritten forms and spreadsheets. Assessing this contribution is the first goal of the pilot studies to be conducted in the next phase of the project. The systems also offer advice (alerts, warnings) to help farmers recognise and avoid the most frequent causes of non-compliance, namely: using a substances that was not approved by SENASA, and harvesting before the mandatory waiting time after an application has elapsed. A second goal of the pilot study will be to assess the tools contribution to reducing the risk of non-compliance. The third goal of the pilot will be to assess the farmer's stance towards the provided decision support, and towards the (anonymous) use of the information they provide to benefit other farmers. In order to evaluate the user-experience and how well the software solves the problem intended, the authors will conduct user-experience testing such as the system usability scale questionnaire.

CONCLUSIONS

The introduction of new agricultural regulation by the Argentinian government is an opportunity to test whether a compliance-based DSS, Gap-A-Farm, can increase technology adoption rates by integrating into required record keeping. The authors use design-thinking strategies to develop Gap-A-Farm prototype that supports farms that follow the GAP compliance scheme with the aim to help other farms more widely when legislation is enforced for vegetable growers in 2021. Four iterative two-week cycles have been completed, gathering feedback on the prototype system from several farmers. This approach of combining learnings from the agricultural DSS literature and design-thinking to take advantage of recent legislative changes may be a crucial opportunity to prompt agricultural practices in developing countries to evolve into the digital age. The pilot study with five farmers to formalise end-user feedback on DSS is now underway and will demonstrate whether Gap-A-Farm achieves its objectives. Features found to hinder the usability can be removed. If successful, the authors plan to scale the software for farms nationally. A follow-up study is then needed to evaluate if farms begin using other IT solutions as a consequence of using this DSS to see if Gap-A-Farm acted as a gateway to improve technology adoption rates.

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A systematic approach to data-driven process diagnostics

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ABSTRACT

While considerable work exists on the application of data analytics on process data to generate insights about process designs, performance, etc., very little has been done on leveraging process data to obtain contextual diagnostic insights. We offer a comprehensive method of the process diagnosis problem (what/who/how we can blame if a process went wrong) and describe the general principles underpinning our approach to the data-driven diagnosis. We then offer an evaluation using synthetic data, which suggests that the approach is potentially promising.

Keywords: Process mining, Process diagnosis, Data-driven diagnosis

1 INTRODUCTION

Things can go wrong in the course of executing a business process. A process might fail to deliver on the intended functionality. It might deliver on the intended functionality, but fail to meet performance targets, or service-level guarantees. Understanding the root cause of the failure –i.e., generating a diagnosis is a critical first step to deciding (and sometimes computing) the remedial actions that might redress the problem. The business process diagnosis problem is therefore an important one, with significant practical implications. The diagnoses that one might arrive at can take multiple forms. We might conclude that the root cause is structural non-conformance where the sequence of actions executed in the current instance fails to conform to any of the sequences mandated by the process design. Alternatively, we might conclude that the root cause is semantic non-conformance [1] where the process instance structurally conforms to the process design but deviates in the effects or post-conditions achieved (i.e., the observed effects do not conform to the intended effects). Other explanations could involve incorrect resourcing or context mismatch where the wrong process design or resourcing policy is applied for the process context. The identification of the correct explanation is an essential first step in computing the appropriate remedial action. Some of the remedial actions might involve design-level interventions, such as re-designing the process, modifying resourcing policies (which help decide which

resource, or set of resources, to allocate to each task) or selecting a process design that is more appropriate to the current operating context.

A design-level intervention does not help for the currently executing process instance that led to the problem being diagnosed. Instance-level interventions can involve computing compensations [1] which are alternative completions of the currently executing process instance. Our approach to the problem takes the literature on model-based diagnosis [2] as the starting point. We offer a data-driven conception of process diagnosis. The key intuition that we leverage is that past process execution histories can be mined for explanations of process faults. In particular, common features of process and contextual data associated with previous process instances associated with a given fault often represent the best explanation for the fault. Our proposal is particularly appropriate for process diagnosis given that large amounts of past process execution data (typically in the form of process/event logs) is routinely available in most enterprise systems. This approach, like most data-driven approaches, is reliant on the volume, diversity and quality of the available data. We need a relatively large number of past instances associated with a given fault to be able to generate reliable explanations for the fault. In this paper, we outline the overall approach to data-driven process diagnosis in some detail. We then present an evaluation, with a synthetic dataset on phone repair event log. The paper is organized as follows. It continues with related works in section 2. It will then present the approach by running an example and its evaluation results in section 3. The paper ends by remarking conclusions in section 4.

2 Related Work

The idea is to compare a business process model with its real behaviour. It generates a good understanding that helps a domain expert redesign/repair a process model in many different and useful point of views. Our work generally leverages two new aspects of the problem (process post-conditions and contextual information) to generate new understating. We propose a framework to encode the historical data to study new aspects of data behaviour. The framework comprehensively computes all types of failure and diagnosis on ad-hoc that have not been covered previously. There are similar studies focused on self-healing systems, diagnostic and repair based on model-based approaches [3,4]. There are also other similar researches which worked on the process diagnosis problem described here [5,8-9]. However, we leveraged a semantic process model to generate task contextual-independent and contextual effects. It extracts the effect of any particular task in any stage of the process execution. It has been failed to study on previous researches regarding process diagnosis.

3 Determining the Diagnosis

Our approach main concern is to detect and diagnose a fault in an executed process model. Given a process and effect log, as well as a process model, the purpose here is to mine the immediate effect of each task associated with the event log. Cumulative effect or context-dependent effects are obtained by annotating the event log. However, immediate or context-independent effects may not be complete in the practice of running a process model

and are disappeared due to consistency. Let's explain the consistency: consider a task α with a single postconditions given by {p,q} which is followed by task β in which its outcome is to make r →*True*. If we have a single rule r → (¬p ∨¬q), the final execution would generate two distinct outcomes: {p,r} and {q,r}that is, either p or q is missing in the final set. Therefore, we leverage the method proposed by [6] to generate a complete annotation set of a process model. One may refer to section 4 in [6] for further understanding the above method. We categorize each fault into either functional or non-functional fault. Functional faulty behaviours are detected by comparing the traces in the event log that we obtain using the above method with the normative trace that consists of (expected) effect scenarios. Basically, for extracting the highest frequent features on both functional and non-functional categories we use BIDE: Efficient Mining of Frequent Closed Sequences [10] in the *Effect/Performance miner* section as shown in Figure1.

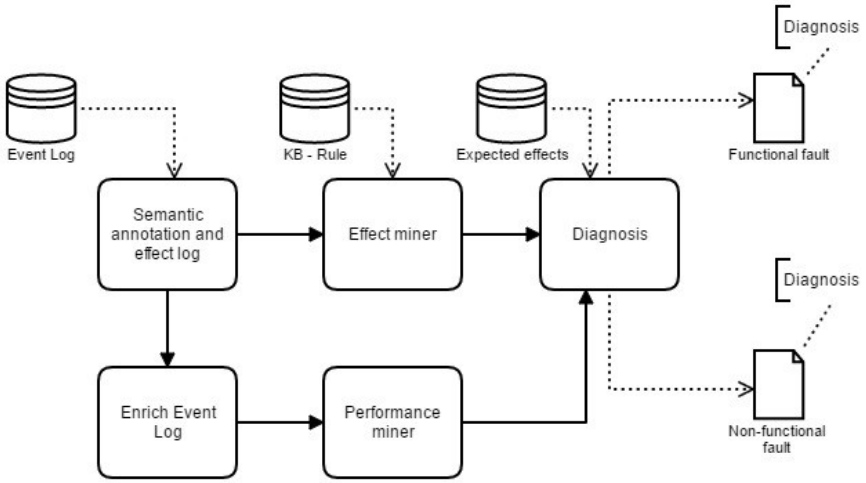

Fig.1: The evaluation procedure

For diagnosing non-functional faulty behaviours, we need to enrich the event log with contextual attributes related to a process model. For the sake of simplicity, we choose to enrich all the event logs that are used in this paper with two contextual attributes called "preference and competence". We adopt the contextual definitions as well as its measurement in [7]. Preference is described as an attitude toward doing a certain type of task. So, the frequency of doing a kind of task by a resource called preference. Therefore, preference here is defined as the number of tasks of task type α that has been completed by a resource divided by the total number of the same type of task completed by all resources. Competence is defined as the amount of time an engineer spent doing a certain type of task (e.g. complex repair). That is, the lesser the spent time is, the higher the competence is. The proposed approach by this paper determines the non-functional faulty instances by looking into instances that exceed a pre-defined threshold (QoS). It will then look for the most frequent attributes among faulty instances. The approach is illustrated in Figure 1. We use a synthetic business process log in a telephone repair company to present the approach. The log is available in processmining.org. In this case, α could be either a complex task or a

simple task. It consists of eight tasks, i.e., Register, Analyse Defect, Repair (Complex/Simple), Test Repair, Restart Repair, Inform User, and Archive Repair.
In the telephone repair company, a customer sends a telephone to be repaired. It is registered as a new case. The telephone is then analysed, and its defect is categorized. Based on the defect, the telephone is categorized as having a simple or a complex defect, and it will be sent to be repaired. Once the repair is done, it will be tested to check whether the defect has been fixed or not. If the defect remains, the telephone will be sent back to be repaired, otherwise it will be sent to the customer and the case will be archived. Table 1 presents the expected outcome of each tasks represented as cumulative effects.

Table 1: Expected outcome of the process model

Task name	Cumulative effect	Outcome description
Register (T1)	{*p*}	new case is registered
Analyze defect (T2)	{*p,q*}	defect is analysed and categorized
Repair (Simple) (T3)	{*p,q,r*}	simple defect is repaired
Repair (Complex) (T4)	{*p,q,s*}	complex defect is repaired
Test repair (T5)	{*p,q,r,t*} {*p,q,s,t*}	repair work is tested
Restart repair (T6)	{*p,q,r,t,v*} {*p,q,s,t,v*}	repair work is restarted
Inform user (T7)	{*p,q,r,t,v,w*}{ *p,q,s,t,v,w*}	user informed, telephone sent back
Archive repair (T8)	{*p,q,r,t,v,w,z*}{*p,q,s,t,v,w,z*}	the case is archived

Based on the process model, there are several normative traces (i.e., possible paths and effect scenarios), including *Register,* {*p*}, *Analyse defect,* {*p,q*}, *Repair(Simple),* {*p,q,r*}, *Test Repair,* {*p,q,r,t*}, *Inform user,* {*p,q,r,t,v,w*}, *Archive repair,* {*p,q,r,t,v,w,z*} and *Register,* {*p*}, *Analyse defect,* {*p,q*}, *Repair(Complex),* {*p,q,s*}, *Test Repair,* {*p,q,r,t*}, *Inform user,* {*p,q,r,t,v,w*}, *Archive repair,* {*p,q,r,t,v,w,z*}.
Figure 2 shows two process instances of the telephone repair with instance id 2 and 3.
From the event log, the process instance with id 3 is *Analyse defect, Register, Repair (Complex), Test Repair, Inform user, Archive repair*. Therefore, it does not conform to any normative trace, since all normative trace must have *Register* before *Analyse defect*. So, we categorize it as *structurally faulty*, and

Instance Id	Task Name	Start Time	Completion Time	Resource
2	Register	2012-01-04 11:27	2012-01-04 11:28	System
2	Analyze Defect	2012-01-04 11:28	2012-01-04 11:36	Tester4
2	Repair (Complex)	2012-01-04 11:52	2012-01-04 12:09	SolverC1
3	Analyze Defect	2012-01-04 11:59	2012-01-04 12:04	Tester2
3	Register	2012-01-04 12:04	2012-01-04 12:05	System
2	Test Repair	2012-01-04 12:09	2012-01-04 12:18	Tester1
2	Inform User	2012-01-04 12:19	2012-01-04 12:20	System
2	Archive Repair	2012-01-04 12:20	2012-01-04 12:28	System
3	Inform User	2012-01-04 12:30	2012-01-04 12:31	System
3	Repair (Complex)	2012-01-04 12:33	2012-01-04 13:14	SolverC3
3	Test Repair	2012-01-04 13:14	2012-01-04 13:24	Tester6
3	Archive Repair	2012-01-04 13:24	2012-01-04 13:30	System

Fig.2: Example of an event log showing two traces

the diagnosis is {Register, Analyse defect}. Actually, the diagnosis is {q,p}, and the proposed approach by this paper maps any immediate effect with its known task. {T1/ p} and {T2/ q} As a semantic fault sample, let's assume the end result of instance 2 trace is {p,q,s,t,v,¬w,z}. We notice that the end result does not entails any end effect scenario of any normative trace, therefore we categorize this trace as semantically faulty. We need to find the minimal set where the process instance is inconsistent with the normative trace. The end effect scenario from the normative trace is {p,q,s,t,v,w,z}, thus the minimal set is {w}, which is the immediate effect of Inform user (we can further diagnose that in this instance, the case has been archived but the user has not been informed or the phone has not been sent back). To detect and diagnose a non-functional fault, the event log must be enriched with contextual information from task execution histories. As an example, we use contextual features, preference and competence of a resource as described previously. Figure 3 presents a snapshot of the enriched event log.

In this case, the company defined a set of quality of service standards and their thresholds. To present the running example as simple as possible, we tie our setting to this QoS (threshold): "The overall repair process must not exceed one working day or eight hours". One can change the setting and select different or multiple thresholds. We consider any case that exceeds the aforementioned threshold as a fault, or more specifically, non-functional fault (although the telephone is repaired, and the end result conform to a normative trace). We leverage the task execution histories to help with the diagnosis of non-functional fault. For example, we have an instance with id 4, where the process takes 32 hours to finish, thus we consider it as a non-functional faulty behaviour because it exceeds the threshold of resolution time (8 working hours). We categorize the traces into two groups; successful and otherwise (underperformed). Successful is the ones that meet the threshold and the underperformed is the ones that exceed the threshold. Then we search in all the previous traces where similar underperformed or successful behaviour occurred. We look for either design flaws, executions flaws, flawed resource allocation, and/or context mismatch.

						Enrich with contextual info	
						Preference	Competence
instance ID	Task Name	Start Time	Completion Time	Resource	Time on task	Complex repair	Complex repair
2	Register	2012-01-04 11:27	2012-01-04 11:28	System	01:00	N/A	N/A
2	Analyze Defe	2012-01-05 11:28	2012-01-05 11:36	Tester4	08:00	N/A	N/A
2	Repair (Conp	2012-01-06 11:52	2012-01-06 12:09	SolverC1	17:00	0.37	0.06
3	Analyze Defe	2012-01-07 11:59	2012-01-07 12:04	Tester2	05:00	N/A	N/A
3	Register	2012-01-08 12:04	2012-01-08 12:05	System	01:00	N/A	N/A
2	Test Repair	2012-01-09 12:09	2012-01-09 12:18	Tester1	09:00	N/A	N/A
2	Inform User	2012-01-10 12:19	2012-01-10 12:20	System	01:00	N/A	N/A
2	Archive Repa	2012-01-11 12:20	2012-01-11 12:28	System	08:00	N/A	N/A
3	Inform User	2012-01-12 12:30	2012-01-12 12:31	System	01:00	N/A	N/A
3	Repair (Conp	2012-01-13 12:33	2012-01-13 13:14	SolverC1	41:00	N/A	N/A
3	Test Repair	2012-01-14 13:14	2012-01-14 13:24	Tester3	10:00	N/A	N/A
3	Archive Repa	2012-01-15 13:24	2012-01-15 13:30	System	06:00	N/A	N/A

Fig.3: A snapshot of an event log enriched with contextual information

In another word, we look for the common attributes in the faulty traces in compare to the successful class. The highest frequent attributes that are different in compare to the successful category, becomes the diagnosis of the fault. Let's assume we discover that in all traces where similar fault occurred, *Analyse defect, Register, Repair (Complex)* is the most frequent tasks where "Analyse defect" followed by "Register". However, and according to the successful traces, the task "Register" should always occurred first. In this case, the diagnosis is *design flaws* meaning the process model allows the defect being analysed without any registration action. To diagnose the execution flaws, let's consider that the previous execution history of underperformed instances includes a set of effects that does not comply with any normative trace in the successful class. The effect of the task "Test Repair" is either successful or failed. Based on the effects, the process proceeds either to inform user or restart the repair tasks respectively. Let's assume that a tester decides to log a failure for the test task, and accordingly the repair task needs to be restarted. However, in the next round of the repair, it appears that actually the 'Test' task effect was false, and the real effect is successful. So, in this case, the diagnosis is *executions flaws* which the tester failed to test the repair properly.

For diagnosing flawed resource allocation, let's assume, we found that in all cases where similar fault occurred, the *Repair (Complex)* task is handled by a resource with lower competence than the one in the all successful instances. Thus, the diagnosis for why the process exceeded the threshold is *flawed resource allocation*. That is, the resource who handled the *Repair (Complex)* does not qualified for this task. Let's assume that in all underperformed traces, the *Repair (Simple)* task is handled at the evening (i.e. after 18:00) in most of the time. On the successful category, however, the same task handled during daytime. Therefore, the diagnosis for why the process exceeded the threshold is *context mismatch*. That means, running the task *Repair (Simple)* after evening would fail to meet the threshold. The diagnosis also can be a combination of the aforementioned causes or on ad hoc. For instance, it is likely that, the underperformed process history is conformed structurally and semantically and handled by adequate resources. However, like the above latest sample felt into the context mismatch category.

4 CONCLUSIONS

The goal is to detect and diagnose a faulty (functional and/or non-functional) behaviour of a process model. We use a method to annotate and extract a complete set of immediate effect of each task based on event logs. The proposed approach by this paper then finds a delta set which is the difference between the real observation and an expected behaviour. The delta set which is the immediate effects will be mapped to the tasks. Those tasks are considered as the diagnosis. We aim to extend this work to a comprehensive formulation based on non-synthetic data.

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Decision Support for Project Management by using Diagnostic Inference and Explaining-Away in Bayesian Networks

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ABSTRACT

Risk and uncertainty are natural elements of projects. A project manager has to manage these elements effectively to improve the chance of project success. Yet, well-known biases and heuristics about decision-making under uncertainty limit a project manager's ability to deal with these elements, especially for complex projects, and decision support tools can be helpful for this task. This paper focuses on building a decision support model for reasoning with uncertainty in project control. We propose a Bayesian Network (BN) model that uses the notions of diagnostic reasoning and 'explaining-away' to infer the effort requirements, progress and risks of project tasks. The proposed model aids the project manager in reasoning with uncertainty and risk factors when monitoring project progress. We use a project example to demonstrate the model structure, its use, benefits and limitation compared to conventional project control tools.

Keywords: Project Management, Bayesian Networks, Probabilistic Decision Support, Earned Value Management

INTRODUCTION

Measuring project performance and progress is a key element for successful projects as it enables project managers to take actions to avoid or mitigate risk factors. A widely accepted decision support tool for project control is Earned Value Management (EVM) [1]. EVM evaluates the schedule and cost performance of a project by comparing the Earned Value (EV) of a project to the Planned Value (PV) and Actual Cost (AC). EV and PV are respectively the budgeted cost of the completed work and the budgeted cost of the planned work until the moment of project evaluation. EV is calculated by the product of PV and the Completion Rate (CR) of the project. AC is the cumulative amount of resources spent for the project. EVM uses Schedule Performance Index (SPI) and Cost Performance Index (CPI) to measure project performance. SPI and CPI values less than 1 respectively indicate time and cost-overruns.

$$SPI = \frac{EV}{PV} \tag{1}$$

$$CPI = \frac{EV}{AC} \tag{2}$$

EVM measures project progress without errors if all three parameters are precisely and accurately defined. However, this often is not possible as there is a great deal of uncertainty with the project plan and therefore PV may include inaccurate estimates. Moreover, it is often difficult to precisely estimate the CR of an activity unless it is completed or not yet started. For example, it is challenging to consistently distinguish the difference between whether an activity is 30% or 40% complete, especially for complex and uncertain project activities. In other words, when SPI and CPI indicate a time or cost overrun, it may simply be due to an inaccurate PV or CR estimate rather than a problem encountered in the project. EVM, or its derivations such as Earned Schedule Management (ESM) [2], cannot provide useful decision support in this case as they can only signal deviations from the project plan but they cannot infer the cause of this deviation.

In this paper, we present a probabilistic decision support model based on Bayesian Networks (BNs) for project control. BNs are graphical probabilistic models that can be used to make diagnostic reasoning to infer the cause of an observed event or 'explaining-away' type of reasoning to make 'what-if' scenario analysis. These types of reasoning are particularly suited for project control as they can enable a project manager to estimate the total cost and completion rates of ongoing activities based on observed costs, and to analyse the impact of risk scenarios on the project progress. Hybrid BNs [3] that contain both discrete and continuous variables are suitable to represent the parameter uncertainty of PV and CP. The proposed tool is based on a hybrid BN model that exploits 'diagnostic' and 'explaining-away' types of reasoning of BNs for project control. In the remainder of this paper, Section 2 gives a recap of BNs and an overview of the proposed BN model for project control, Section 3 applies the proposed model on a project example, and Section 4 presents our conclusions.

BAYESIAN NETWORKS FOR PROJECT CONTROL

Bayesian Networks (BN) are composed of a graphical structure and conditional probability tables that represent the joint probability distribution of a set of variables [4]. The graphical structure of a BN is a Directed Acyclic Graph (DAG) consisting of nodes representing random variables and arcs representing direct relations between variables. When two nodes X and Y are directly connected, as in X → Y, X and Y are respectively called the parent and child of

each other. When a set of nodes in a BN are observed, the posteriors of the unobserved variables can be calculated. This can be used to make predictive inference, i.e. observing a parent node revises the probability distribution of its descendants, and diagnostic inference, i.e. observing a child node revises the probability distribution of its ancestors. When a node Y has multiple parents as shown in Figure 1a, observing X alone does not revise the probability distribution of Z. However, when X is observed after observing Y, it provides us information to revise Z. This type of reasoning is called 'explaining-away' and is particularly suited for making 'what-if' analysis on the causes of an observed event. For example, suppose Z represents a failure of car's engine, X represents a dead battery and Y represents a blocked fuel pump. Without observing a faulty engine, dead battery and blocked fuel pump are independent. However, if the car is not working, observing that the battery works increases the probability of a blocked fuel pump.

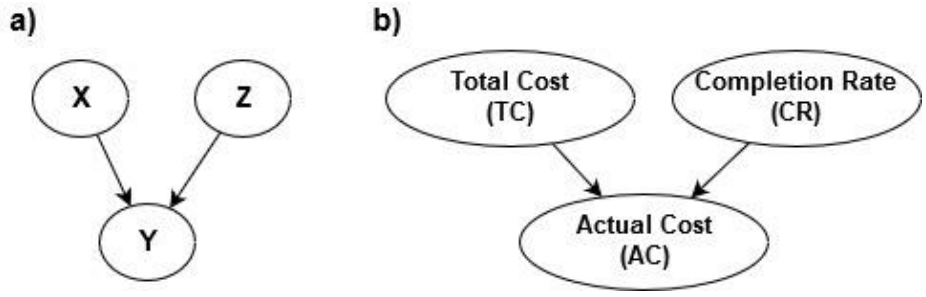

Figure 1. BN Model for Project Example

We propose a similar BN model for project control to exploit especially diagnostic and 'explaining-away' types of reasoning to evaluate project performance. Figure 1b shows the core of the proposed BN structure. The costs incurred in an ongoing project, i.e. AC, depend on the Total Cost (TC) and CR of the project. The budgeted cost of the project, i.e. PV, is an estimate of the total cost but the true total cost remains uncertain until the project is completed. Similarly, CR reflects the project manager's prior belief about the rate of completion. Evaluating completed activities in clearly defined milestones can give an estimate of the rate of completion of a project. However, the true completion rate of ongoing activities remains uncertain until the activities are close to completion. The only observed value with certainty is AC in Figure 1b. PV and CR parameters from EVM are respectively used as prior distributions for TC and CR in the BN model.

The proposed model enables project manager to estimate the TC and CR by using AC observations throughout the project. Rather than assessing project performance indices, the project manager can directly estimate TC and CR of the project. The proposed model also estimates the degree of uncertainty of these measures. The BN model can be expanded with risk factors that can affect the total cost and completion percentage of the project. These risk factors can be instantiated to make 'what-if' analysis on the impact of different risk scenarios.

APPLICATION OF THE PROJECT CONTROL BN

The proposed model can be used to evaluate the progress of individual project activities and the whole project. We demonstrate the use of the model by using a small project composed of 4 activities and 3 risk factors. Figure 2 shows the BN model of this project. Table 1 shows the expected value and 95% Credible Intervals (CI) of CR and AC of each activity when the project is being evaluated, and their TC. We used Beta and Normal distributions to model the priors

of CR and TC in the BN respectively. The parameters of these distributions are shown in italics in Table 1.

Table 1. Completion Rates, Actual Costs and Total Cost Estimates given Risk Factors

	Activity			
	1	**2**	**3**	**4**
CR	80% CI: 66% – 91% *Beta(32, 8)*	70% CI: 49% – 88% *Beta(14, 6)*	40% CI: 23% – 58% *Beta(12, 18)*	30% CI: 7% – 60% *Beta(3, 7)*
AC	22.4	14.0	14.0	2.4
TC	22.5 CI: 16.6 – 28.4 *Normal(22.5, 3)*	15.0 CI: 12.1 – 17.9 *Normal(15, 1.5)*	18.0 CI: 12.1 – 23.9 *Normal(18, 3)*	8.0 CI: 4.1 – 11.9 *Normal(8, 2)*
TC | RF1	26 CI: 21.1 – 30.9 *Normal(26, 2.5)*	17.0 CI: 13.1 – 20.9 *Normal(16, 3)*	–	11 CI: 6.1 – 15.9 *Normal(11, 2.5)*
TC | RF2	–	16.0 CI: 10.1 – 21.8 *Normal(17, 2)*	–	–
TC | RF3	–	–	21.0 CI: 14.1 – 27.8 *Normal(21, 3.5)*	9.0 CI: 5.5 – 12.5 *Normal(9, 1.8)*
TC | RF1, RF2	–	20 CI: 13.7 – 26.3 *Normal(20, 3.2)*	–	–
TC| RF1, RF3	–	–	–	12 CI: 6.1 – 26.3 *Normal(12, 3)*

The posteriors of TC and CR can be calculated by using the BN. We used AgenaRisk [5] to build the BN model and calculate the posteriors. AgenaRisk uses the dynamic discretisation algorithm to compute the posteriors of hybrid BN models. It is beyond the focus of this paper to describe the steps of this algorithm; the readers are referred to Neil et al. [3] for a thorough description. The sum of activity TC posteriors provides an updated estimate of the TC of the project. In this example, the total cost of the project is predicted as 78.9 thousand dollars (95% CI: 70.8 – 88.4). The CR of the whole project can be estimated by dividing the sum of AC values to the predicted total cost. This project is estimated to be 67% complete (95% CI: 59% – 74%).

The model could be used to make ‘what-if’ analysis by instantiating risk factors. Suppose both RF1 and RF2 realised in the project. In this case, the project’s total cost is predicted as 81.8 thousand dollars (95% CI: 73.8 – 90.8), and its CR is estimated as 64% (95% CI: 58% – 71%).

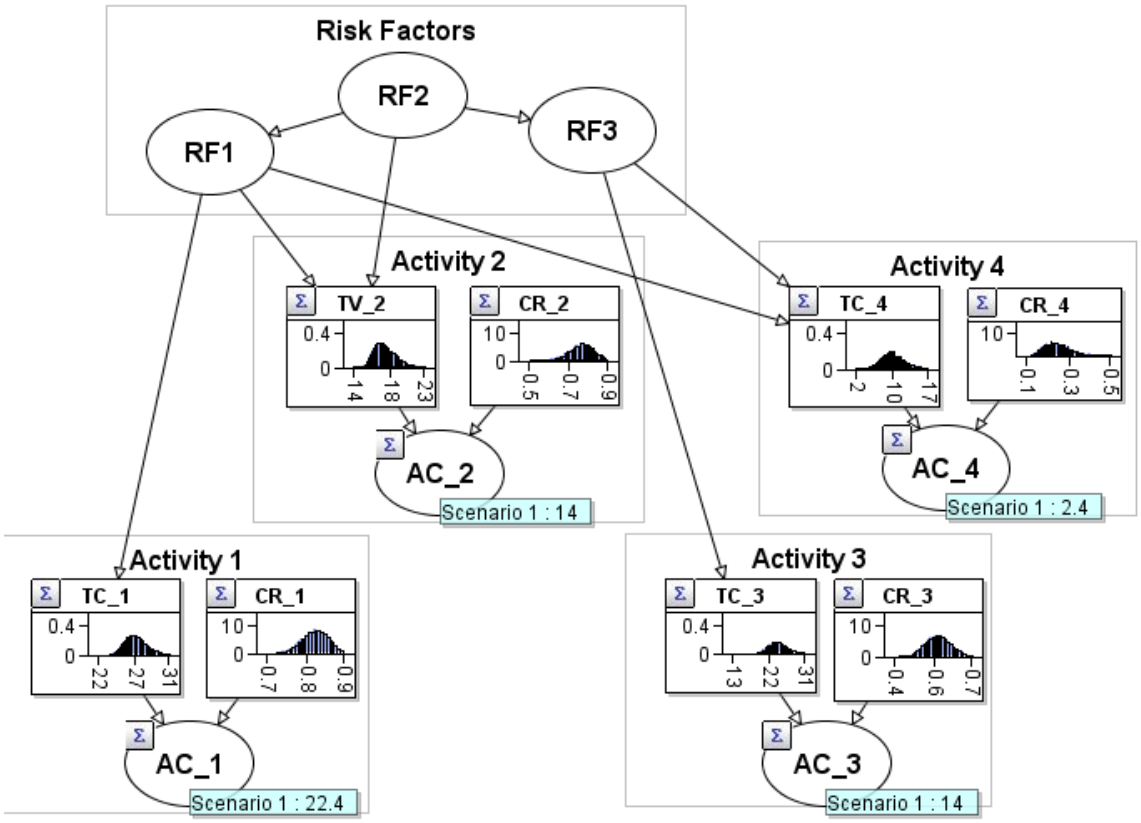

Figure 2. BN Model Applied to the Project Example

CONCLUSIONS

We presented a decision support tool based on a hybrid BN model to aid monitoring of project progress, and illustrated its use by a simple project example. The BN model uses diagnostic reasoning to infer the completion rate and total cost of a project based on observed costs and risk factors. It is able to reflect the uncertainty regarding cost and completion rate estimates, and it revises these estimates as more cost data is collected. Moreover, the model provides richer decision support by enabling 'what-if' analysis of risk scenarios. The main advantage of the model compared to EVM is its ability to handle uncertainty and use probabilistic reasoning for project control. Its main limitation currently is its parameter and software requirements. The proposed model, however, requires a large number of parameters including the probability distributions of CR and TC values, and it is computed by BN software such as AgenaRisk. In future studies, we plan to integrate the model with project management software to enable a wider use of the model, and design an interface for defining the parameters.

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Knowledge mobilization crossing boundaries for decision support: Insights from agri-food supply chains of Chile

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ABSTRACT

The current world business environment is characterized by increasing uncertainties, complexities, and risks, which requires agri-food supply chain (AFSC) managers to respond and act quickly in a context full of instability and unpredictability. Increasing pressure placed on AFSC managers intensifies the need to combine knowledge management (KM) and decision support that rapidly overcome knowledge boundaries. It has been recognized that the research issue related to the knowledge mobilization crossing boundaries in the AFSC needs to be addressed. This paper investigates knowledge boundaries and boundary-spanning mechanisms with the data collected from experienced AFSC practitioners. Results from the empirical study verified that knowledge boundaries such as syntactic boundaries, semantic boundaries, and pragmatic boundaries could be effectively tackled by four specific boundary-spanning mechanisms: boundary spanners, boundary objects, boundary practices, and boundary discourses. Furthermore, an efficient knowledge mobilization process helps to increase the economic benefits and social benefits, as well as helps to improve operation management and efficiency of AFSC companies. This study advances existing literature on identifying factors of knowledge boundaries and boundary-spanning mechanisms, and defining the role of boundary-spanning mechanisms in tackling different knowledge boundaries. The results of this study have the potential to help AFSC managers to tackle knowledge boundaries effectively and efficiently, and to improve the performance of the AFSC companies.

Keywords: Knowledge mobilization, knowledge boundaries, boundary-spanning mechanisms, agri-food supply chains, decision making

1. Introduction

An agri-food supply chain (AFSC) is a complex system responsible for the circulation of agri-food products in a "farm-to-fork" sequence from the initial stage of production to the final stage of consumption [1]. From process and value-adding perspective, an AFSC can be seen as a transformation system, which takes in inputs such as seeds, fertilizers, energy, and water, to transform them as desired agri-food products. Important activities such as raw material supply, postharvest, testing, packaging, storage, distribution and marketing, are all necessary for the fresh agri-food products' transformation. However, new challenges such as more strict food quality standards, globalization, agro-sustainability, rapid industrialization of agricultural-based products, and increasing customer and government concerns on food safety have resulted in the activities in AFSC becoming more complex [2]. Thus, exploring various knowledge management (KM) approaches, models and systems such as knowledge creation, knowledge sharing, knowledge retention and application in the upstream and downstream of AFSC appears to be the necessary response to the aforementioned new challenges.

KM is a well-developed area, which addresses the activities, processes and lifecycles of knowledge creation, holding, sharing and application [3]. It has been widely applied in different disciplines including human resource management, computer science, information systems, and management science [4]. In the contemporary world business environment associated with an increasing level of complexity, risk and uncertainty, KM has been extended to combine with decision support in order to have a better decision making. However, the application of KM decision support in the field of supply chain management seems to be neglected [5]. The aim of this study is to investigate the knowledge mobilization crossing boundaries for decision support in AFSCs. Thus, three research questions are formulated: (1) What is the knowledge boundaries and boundary-spanning mechanisms exist in literature? (2) How to use boundary-spanning mechanisms to tackle knowledge boundaries? (3) What are the benefits if knowledge boundaries are tackled? Based on the in-depth interviews with experienced AFSC practitioners from Chile and analysed the data with thematic analysis, this study provides insights into knowledge boundaries and boundary-spanning mechanisms, and makes the following contributions. First, this study empirically identifies where knowledge boundaries exist in a Chileans' AFSC. Second, four boundary-spanning mechanisms have been identified effectively in tackling knowledge boundaries. Finally, an integrative framework linking knowledge boundaries and boundary-spanning mechanisms has been built, by serving as a foundation for AFSC practitioners to acquire knowledge and advance collaboration efforts effectively.

This study builds on existing work on knowledge mobilization crossing boundaries, but extends existing work to the context of AFSC. The structure of this study is organized as follows. Section two reviews related work, followed by the research methodology in section three. Then, the empirical data collection is presented in section four. In section five, we provide the main empirical findings of the research. Further, the discussion is included in section six. Finally, conclusions are drawn in section seven.

2. Literature review

A knowledge boundary represents the limit, or border, of an agent's knowledge base in relation to a different domain of knowledge [3]. Knowledge boundary exists for many reasons, for example owing to the difference of their knowledge base, the way of people work, the difference in their cultural background, and the difference of their expertise [4]. A total of 14 sources of barriers that hinder knowledge mobilisation have been summarised by [5], some of them including personality differences, trust problem, openness to ideas, organization culture,

and afraid to loss competitive advantage. After conducting a research on ranking barriers of KM adoption in supply chain, [6] identified lack of management commitment is the most important barrier. There are three types of knowledge boundaries that have been widely cited by other scholars, which are syntactic boundaries (difference in language), semantic boundaries (difference in meaning), and pragmatic boundaries (difference in practice) [7, 8]. It is no doubt that knowledge boundaries can erect great barriers to knowledge mobilization, and further to hinder coordination and collaboration among individuals, groups, and organizations [9].

In order to overcome the barriers stemming from the knowledge boundaries, four specific boundary-spanning mechanisms covering human agents, presence of artefacts, practice and content of knowledge respectively have been deployed. Boundary spanners are human agents who use language and their cognitive power to translate knowledge across boundaries. Through promoting coordination and facilitating problem solving between parties, knowledge are translated and cognitive gaps are bridged [10]. Persuasion always used by the spanners to develop legitimacy especially when they outside a party's community. Boundary spanners are effective in translating explicit knowledge, particularly fluid knowledge. While boundary objects are focusing on a physical, abstract, or mental object that can be attached and transformed among organizations. The flexible nature of boundary objects provides sufficient opportunities for individuals from different communities to attach localized meaning to the object. Therefore, it is effective in facilitating coordination across knowledge communities. However, the object can only be effective in tackling knowledge boundaries after the shared meaning of the boundary object is carefully developed and strengthened. Boundary practice is normally used to tackle knowledge boundaries involving tacit knowledge that is not easily codified into explicit knowledge. It facilitates coordination by engaging experts from different domains in collective activities. Engaging in collective activities has two distinct advantages: (1) it helps to share tacit knowledge reside in people's mind that cannot be expressed or one party does not fully understand; (2) it facilitates involved parties to understand each other's integrative framework [10]. Thus, co-generating knowledge can be achieved. In comparison with boundary spanners and boundary objects heavily rely on existing knowledge to be recalled and transformed, boundary practice is more active in creating new knowledge. Finally, boundary discourse is focusing on what is communicated between knowledge communities. It is suggested to be used by experts who are engaged in cross-domain collaborations.

3. Research methodology

This section describes and justifies the data collection method, data analysis method, and sampling techniques used in this study. A qualitative approach was selected in this study, as it is highly appropriate for answering "how" and "why" research questions [11].

3.1 Data collection method

Main data collection methods include interviews, questionnaires, and observations [12]. The choice of interview rather than questionnaire and observation was employed because it offers sufficient flexibility in terms of adapting, adopting, and changing questions as the researcher proceeds with the interviews. Hence, the main data collection method of this study was through semi-structured interviews with experienced AFSC practitioners in terms of knowledge boundaries and boundary-spanning mechanisms. Semi-structured interviews rather than other interviewing formats (e.g. structured interview and unstructured interview) were selected as they are well-suited for the exploration of the perceptions and opinions of respondents regarding complex and sometimes sensitive issues and enable probing for more

information and clarification of answers. In order to achieve data triangulation, additional data from documents (e.g., organization brochures, publications and annual reports) and web sources (e.g., websites and organization newsletters) were collected.

3.2 Data analysis method

Thematic analysis is a foundational method for conducting qualitative analysis, which provides a rigorous and methodical manner to yield rich and meaningful data analysis results. Thematic analysis rather than other qualitative data analysis methods such as grounded theory, discourse analysis, and narrative analysis was selected in this study as it provides flexibility in analyzing data [13].

3.3 Sampling techniques and sample size

Purposive sampling provides suitable participants to answer the research questions and meet the research objectives [12]. Thus, participants are selected based on the research objectives and this ensures adequate representation of important themes. Suitable participants were selected using the following criteria: (1) The selected agri-food companies have been recognised by peers to have implemented boundary-spanning mechanisms in practice; (2) agri-food companies have knowledge extension departments are preferred as they are more expertise in tacking knowledge boundaries; and (3) The selected participants must have more than 10 years working experience in KM to ensure a high level of knowledge and experience. Based on the aforementioned criteria for recruiting participants, 9 participants were selected. These participants including farmers, wholesalers, retailers, exporters, and researchers from research institution. We continued adding appropriate firms to our sample by using aforementioned criteria that could help us to clarify the new concepts from our analyses. Initially, 9 interviews were conducted. After conducting further 3 interviews, new themes did not emerge and interviews did not help identify new or expand the emerging concepts, indicating we reached the data saturation point. Thus, the total sample size is 12 participants.

4. Empirical data collection

The empirical data collection process was conducted in the November 2019 from Chile through semi-structured interviews with experienced people who are directly involved in the AFSC KM process. Chile was selected as its agricultural industry is one of the backbones of Chile's economy. The agriculture industry is responsible for 28% of the total Chilean trade, as well as 11% of its total GDP. An interview guide with a predefined list of questions focusing on knowledge mobilization model was developed, but allow interviewees to express their ideas freely and expand on the initial questions. A pilot study was organized in the form of an open round-table discussion with two experienced AFSC practitioners and one professor in KM and business decision making. As a result, some question wordings were slightly changed and the logic of some questions was modified. Each interview lasted between 45 and 70 min. In order to get accurate information from transcripts and that direct quotations could be used, all interviews were audio-recorded with the permission from interviewees. During each interview, at least two research team members were presented and took notes to ensure all important information were emerged. Furthermore, additional documents used for checking the statements from the interviews, avoiding missing any important information, and triangulating our findings were collected during site visits. After each site visits, a meeting would be conducted to clarify what we had heard from the informants.

5. Data analysis and findings

The thematic analysis was used to analyze the data collected through semi-structured interviews. After following the eight steps of thematic analysis including familiarisation with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report, different types of knowledge boundaries were identified (see figure 1).

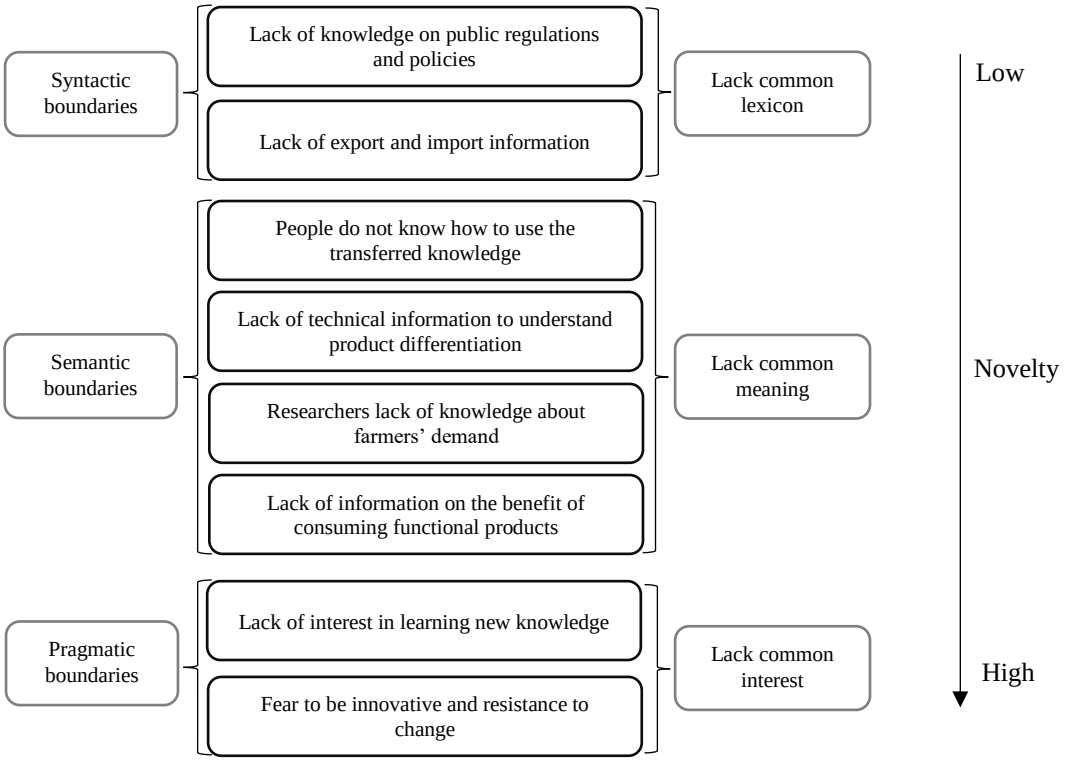

Figure 1 Different knowledge boundaries in AFSCs

Furthermore, various boundary-spanning mechanisms were identified in the empirical study to tackle knowledge boundaries (see table 1). Besides, various resources have been used to support boundary-spanning mechanisms, including knowledge networks, software tools and facilities, human resources, and financial resources. It is important to note the national vegetable network has been built in Chile in order to involve more research institutions in the knowledge network and increase the efficiency of knowledge mobilization. Furthermore, funds from private companies, government, and huge international projects have been indicated as the main financial sources.

Table 1 Empirical evidence for supporting boundary-spanning mechanisms

Direct quotes from transcript	Boundary-spanning mechanisms	Support from participants											
		1	2	3	4	5	6	7	8	9	10	11	12
"Mobile applications with specific agricultural information."	**Boundary objects**	√	√	√	√	√	√	√	√	√	√	√	√
"Documents related to the food safety and public regulations and policies are available for free download in the related website."													
"Action protocols for all AFSC stakeholders."													
"Generation of public platforms of companies that provide different supplies for the horticultural sector."													
"Coordinate with knowledge extension agents to transfer knowledge."	**Boundary spanners**	√	√	√	√	√	√	√	√	√	√	√	√

"Joint work with the Agricultural and Livestock Service of Chile (SAG) and exporters on agri-food products safety." "Establishments of collaboration agreements and internships among different institutions." "Research institutions' open days for other AFSC stakeholders."	**Boundary practices**	√	√	√	√	√	√	√	√	√	√	√	√
"Interview with AFSC practitioners regularly to acquire knowledge." "Informative speech on regulations, standards, new pests and diseases."	**Boundary discourses**	√	√	√	√	√	√	√	√	√	√	√	√

6. Discussion

This paper has investigated the effectiveness of boundary-spanning mechanisms in tackling knowledge boundaries with empirical evidence from Chile. Three knowledge boundaries (e.g. syntactic boundaries, semantic boundaries, and pragmatic boundaries) and four specific boundary-spanning mechanisms (e.g., boundary objects, boundary spanners, boundary practices, and boundary discourses) have been identified as critical. Boundary practices such as joint work with SAG (Agricultural and Livestock Service), establishment collaborations with different institutions, and research institutions' open days have been identified effective in tackling semantic boundaries and pragmatic boundaries. Boundary objects such as building public platforms, developing mobile applications, and establishing action protocols for all AFSC stakeholders have been identified effective in tackling syntactic boundaries. Figure 2 shows the evaluated boundary-spanning mechanisms in tackling knowledge boundaries and the potential benefits for tackling knowledge boundaries.

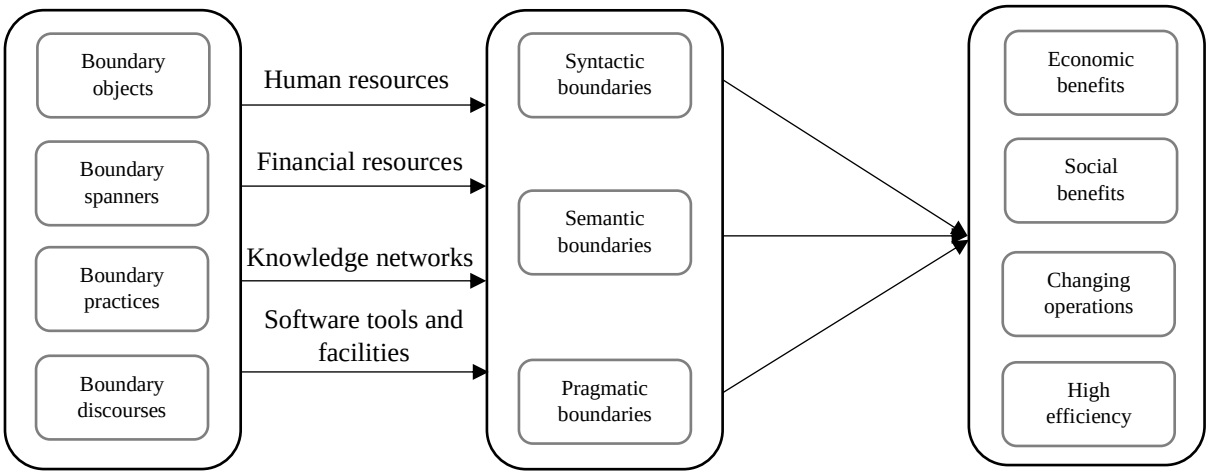

Figure 2 The evaluated knowledge mobilization model

7. Conclusions

Currently, the world business environment is characterized by increasing uncertainties and risks. There is no doubt that the business environment will place more pressure on AFSC managers to force them to respond and act quickly, which intensifies the need to develop strategies to overcome knowledge boundaries. Therefore, having a deep understanding of knowledge boundaries and boundary-spanning mechanisms plays a key role in AFSC companies' growth. This study conducted 12 semi-structured interviews with experienced AFSC experts in Chile. Then, thematic analysis was used to analyze the data. The research results indicate that boundary-spanning mechanisms are effective in tackling knowledge boundaries with appropriate inputs. Economic, social, efficiency and operation of a company will be improved if knowledge boundaries are properly solved. This paper contributes to managerial practices significantly. First, the positions of knowledge boundaries and specific

boundaries in the AFSC have been identified, which helps AFSC practitioners to target and deploy resources accordingly to maximum the benefits. Second, the integrative framework of knowledge boundaries and boundary-spanning mechanisms has been built. Thus, AFSC practitioners would benefit from the integrative framework through replicating specific measures in a similar context to enhance collaboration efforts.

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IV
DSS Methodologies
&
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To Click or Not to Click? Deciding to Trust or Distrust Phishing Emails

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ABSTRACT

While the email traffic is growing around the world, such questions often arise to recipients: to click or not to click? Should I trust or should I distrust? When interacting with computers or digital artefacts, individuals try to replicate interpersonal trust and distrust mechanisms in order to calibrate their trust. Such mechanisms rely on the ways individuals interpret and understand information.

Technical information systems security solutions may reduce external and technical threats; yet the academic literature as well as industrial professionals warn on the risks associated with insider threats, those coming from inside the organization and induced by legitimate users.

This article focuses on phishing emails as an unintentional insider threat. After a literature review on interpretation and knowledge management, insider threats and security, trust and distrust, we present a methodology and experimental protocol used to conduct a study with 250 participants and understand the ways they interpret, decide to trust or to distrust phishing emails. In this article, we discuss the preliminary results of this study and outline future works and directions.

Keywords: Insider Threats, Trust, Interpretation, Knowledge Management, Decision-making.

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Complexity Clustering of BPMN Models: Initial Experiments with the K-means Algorithm

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ABSTRACT

This paper introduces a method to assess the complexity of BPMN process models by utilizing a cluster analysis technique. The presented method paves the way for multi-criteria decision making based on specific performance indicators and managing process objectives in general. The presented approach leverages complexity metrics introduced in literature and combines three established and complementary metrics (i.e. NOAJS, CFC and CNC) to a single weighted measure, offering an integrated scheme for evaluating complexity. K-means clustering algorithm is implemented on a repository that contains 1000 BPMN models and classifies them to corollary clusters that correspond to complexity categories. By assigning weighted impact on specific complexity metrics -an action that leads to the production of threshold values- cluster centroids can fluctuate, thus produce customized model categorizations. The paper demonstrates the application of the proposed method on existing BP models from relevant literature. The assessment of their complexity is performed by comparing the weighted sum of each model to the defined thresholds and proves to be a straightforward and efficient procedure

Keywords: Business Intelligence, BP Complexity, Data Mining, Cluster Analysis, Multi-Criteria Decision Making, BPMN, K-means.

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Decision-making in the field of Resilience: literature review

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ABSTRACT

In recent years, the concept of "Decision-making" in the field of resilience has become particularly important, which explains the frequency of publications in this context. Based on literature published in various journals, this article proposes a classification of 66 articles in the four dimensions of resilience (technical, organizational, economic and social), to help researchers, and decision-makers avoid confusion and optimize their search method.

Keywords: Resilience, Disasters, Decision-making, Classification

INTRODUCTION

Currently, natural hazards (earthquakes, hurricanes, floods, climate change, etc.) and human-induced risks (wars, terrorist events, information warfare, financial crisis, etc.) are more frequent and violent, which engender enormous impacts on societies and economic stability. For this reason, several studies and research are focusing on the term "Resilience". In fact, this term has emerged in many fields such as psychology, psychiatry, material sciences, economics, engineering, social science and so on, which has opened the door to numerous definitions. Holling (1973) [1], was the first scientist who defined the concept of resilience while describing the evolution of ecological systems. He proposed two definitions: one focuses on the existence of system functions; "ecological resilience" and the other focuses on the efficiency of these functions; "the engineering resilience". Examining adaptation concepts in the context of climate change, Levina and Tirpak (2006) [2], identified the resilience first as the ability of a system to continue functioning despite a disaster and second as the ability of a system to recover after being affected by the disaster. By focusing on the resilience of communities with critical infrastructure, O'Rourke (2007) [3], identified resilience as the preparation of a community to react and then rapidly recover from disruptive damage. Maguire and Catwright (2008) [4], defines the resilience on three stages; stability, recovery and then transformation. Moreover, several organizations and scholars have identified disaster resilience in different ways. For

example, The Intergovernmental Panel on Climate Change (2001) [5], defines the resilience of a system affected by climate change as "amount of change a system can undergo without changing state", which is not entirely true because climate change often has negative effects on the state of systems. Similarly, the US National Infrastructure Advisory Council (USNIAC 2008) [6] defines disaster resilience as, which focuses on the importance of taking into account the resilience of critical infrastructures when developing risk assessment strategies, the resilience of infrastructure can be characterized by four features: robustness, resourcefulness, rapid recovery and learning. The first refers to the inherent resistance or ability of a system to withstand a potential level of stress without any degradation or lack of functionality. The Second feature "resourcefulness" was viewed as the capacity of a system to provide services and resources in order to flexibly respond to and cope with disruptions or crises. Rapidly recovery was viewed as the excess capacity to rapidly transform negative impacts to positive and prevent critical states. The last characteristic "Learning" refers to the ability of a system to learn new lessons from the disruptive event.

Currently, there is much literature defined resilience, which makes it difficult to extract a common definition. Thanks to these various definitions, we can have an overall vision of this concept. Analyzing 113 articles, Clément et al. (2018) [7] established three main types of the resilience definitions. Two common aspects characterize each type: Absorption and Response. According to this study, some authors defined resilience as the capacity of a system to return to the original level of performance after being affected by a disturbance. Authors illustrated the objective as an acceptable level of performance should be achieved, and not necessarily reach the original level. More than just absorbing and responding, for other authors, resilience is the adaptation of the system to its new level of performance and the ability to operate stably. In this article, in order not to limit the collection process, we have taken into account all articles dealing with our subject of analysis, whatever the definition of resilience used.

Nevertheless, often literature dealing with resilience has emphasized another important term, which is "decision". Also, in recent years, approaches, theories, studies of decision-making have been enormously developed and agreed that the process of decision-making is complex and time-constrained. However, the large number of publications dealing with resilience in several fields (engineering, social sciences, business, etc.) blurs the vision and makes the decision-making process more complex. For example, if decision-makers decide to focus on the resilience of infrastructure, they will find difficulties, first, to understand the appropriate concept of resilience and second, to recognize the decision-making approaches can be used in this area.

This paper is primarily addressed to decision-makers and researchers who look for improving resilience, through applying appropriate decision-making approaches, to help them reach the suitable publications based on dimensions of resilience used in their research.

Wied et al. (2019) [8] have analyzed 251 definitions of resilience, to clarify this concept and understand its involvement in engineering systems. Clément et al. (2018) [7] have analyzed the concepts "resilience" and "robustness" based on 113 articles discussing these terms, to extract three main definitions for each one. However, almost no article analyzes the literature, dealing with the two terms "Resilience" and "Decision-making".

This paper focuses on risks/uncertainties of natural and human and proposed a classification of 66 articles discussed the two terms: "Resilience" and "Decision-making", into four clusters, according to four dimensions of resilience.

COLLECTION AND SELECTION METHOD

Regarding system resilience assessments, several authors, organizations, and scholars argue that there are several dimensions to consider (Kamissoko et al., 2019 [9]). United States Department of Homeland Security (USDHS 2009) [10] have classified the several dimensions of resilient systems into two, "Hard systems" related to technical/physical resilience (e.g., organizations, infrastructure, assets), while "soft systems" are pertaining to psychology, human needs, behavior within organizations and communities. Also, in the context of transport infrastructure, five levels were considered dimensions of resilience according to Victoria Transport Policy Institute (VRPI 2019) [11], which are individual, community, design, economic and strategic planning. However, Bruneau et al. (2003) [12] summarized the multidimensionality of resilience in four levels (TOSE):

- technical: the capacity of physical systems to successfully achieve an acceptable level when a hazard event occurs
- organizational: the capability of an organization to reach an acceptable level of resilience by making decisions to better cope with an incident and to save the organization from the critical state.
- social: the ability of communities to suffer less from the negative consequences of a dangerous event
- economic: the capacity to reduce direct/indirect economic losses after a disruptive event

In this work, we used Bruneau's model in our classification process, because first, TOSE serves as relevant constructs for understanding the high-level dimensions of resilience (Hughes et al., 2014 [13]), and second, it can be applied for various types of systems (Bruneau et al., 2003 [12]).

To identify articles dealing with the two target terms, we conducted a structured search. We have chosen one of the most trusted databases of scientific articles: Web of Science (WoS). Only English papers from 1975 to 2020 were considered. The principle of the search process focused on the title of articles, using the keyword "Resilien* AND Decision-mak*". As a result, we found 66 articles to classify.

In this step, we focused on reading and analyzing the title, the abstract, the introduction and the conclusion of each 66 articles, and the classification process has depended on this analysis. Considering our analysis, 21 of the 66 articles were considered irrelevant because they didn't address the target topic (disaster resilience and decision-making). Thus, as results, 24 articles have treated the term "Decision-Making" in the context of technical resilience, 17 discussed this term with relation to the organizational dimension of resilience, moreover, two articles dealt with both "Decision-Making" and "Social Resilience", and two focused on the economic dimension of resilience and the importance of decision-making in this field. The results of the classification are as follows:

- ***articles using the decision-making concepts in the <u>Technical</u> dimension of resilience:*** Decision making under uncertainty for design of resilient engineered systems [MacKenzie et Hu - 2019], Multi-criteria decision-making for seismic resilience and sustainability assessment of diagrid buildings [Asadi et al. - 2019], Decision-Making Analytics Using Plural Resilience Parameters for Adaptive Management of Complex Systems [Thekdi et Santos - 2019], Bayesian networks as a resilience tool for decision-making processes in uncertainty conditions [Novi - 2018], Working with decision-makers for resilient forests: A case study from the UK [Young et al. - 2018], Resilient Decision Making in Steam Network Investments [Bungener S.L. et al. - 2015], Resilient critical infrastructure management with a

service oriented architecture: a test case using airport collaborative decision making [Hall-May et al. - 2011], Ecosystem Services to Enhance Coastal Resilience in Mexico: The Gap between the Perceptions of Decision-Makers and Academics [Lithgow et al. - 2017], Implementing fuzzy decision making technique in analyzing the Nile Delta resilience to climate change [Batisha - 2015], Realizing resilience for decision-making [Grafton et al. - 2019], Resilience, Decision-making, and Environmental Water Releases [Chu et al. - 2018], Utility and regulatory decision-making under conditions of uncertainty: Balancing resilience and affordability [Decker - 2018], Missing data resilient decision-making for healthcare IoT through personalization: A case study on maternal health [Azimi et al. - 2019], Designing resilient infrastructure systems: a case study of decision-making challenges in railway tunnel projects [Cedergren - 2013], Characterizing a Naturalistic Decision-Making Phenomenon: Loss of System Resilience Associated With Implementation of New Technology [Patterson et al. - 2016], Groundwater recharge indicator as tool for decision makers to increase socio-hydrological resilience to seasonal drought [Hund et al. - 2018], Resilient Decision Making in Open Pit Short-term Production Planning in Presence of Geologic Uncertainty [Rahmanpour et Osanloo], A catchment scale Integrated Flood Resilience Index to support decision making in urban flood control design [Miguez et Veról - 2017], Adding value to the decision-making process of mega projects: Fostering strategic ambiguity, redundancy, and resilience [Giezen et al. - 2015], Risk-Based Decision Making for Sustainable and Resilient Infrastructure Systems [Lounis et McAllister - 2016], Practical Resilience Metrics for Planning, Design, and Decision Making [Ayyub - 2015], Articulating the differences between safety and resilience: The decision-making process of professional sea-fishing skippers [Morel et al. - 2008], A decision-making model for Lean, Agile, Resilient and Green supply chain management [Cabral et al. - 2012], Systems Resilience for Multihazard Environments: Definition, Metrics, and Valuation for Decision Making [Ayyub - 2014]

- ***articles using the decision-making concepts in the <u>Organizational</u> dimension of resilience:*** Empowering strategic decision-making for wildfire management: avoiding the fear trap and creating a resilient landscape [Castellnou et al. - 2019], A multi-criteria decision making method for urban flood resilience evaluation with hybrid uncertainties [Li et al. - 2019], A Reinforcement Learning-Based Stakeholder Value Aggregation Model for Collaborative Decision Making on Disaster Resilience [Zhang et al. - 2019], A decision making support tool: The resilience management fuzzy controller [Cardenas et al. - 2016], Analysis of dynamic decision making underpinning supply chain resilience: A serious game approach [Nonaka et al. - 2016], How CEOs of small firms make decisions to ensure information systems resilience? [Sarkar et Wingreen - 2015], Resilient Supplier Selection Through Introducing a New Interval-Valued Intuitionistic Fuzzy Evaluation and Decision-Making Framework [Davoudabadi et al. - 2019], Interactive Fuzzy Multi Criteria Decision Making Approach for Supplier Selection and Order Allocation in a Resilient Supply Chain [Mari et al. - 2019], Decision making framework for emergency response preparedness: A supply chain resilience approach [Timperio et al. - 2016], Decision-Making and Building Resilience to Nexus Shocks Locally: Exploring Flooding and Heatwaves in the UK [Howarth et Brooks - 2017], Understanding decision making during emergencies: a key contributor to resilience [Mishra et al. - 2015], Resilience metrics for improved process-risk decision making: Survey, analysis and application [Jain et al. - 2018], Resilience and brittleness in the

ALERTA RIO system: a field study about the decision-making of forecasters [Dolif et al. - 2013], Adaptation Planning Support Toolbox: Measurable performance information based tools for co-creation of resilient, ecosystem-based urban plans with urban designers, decision-makers and stakeholders [van de Ven et al. - 2016], Coping with uncertainty: police strategies for resilient decision-making and action implementation [van den Heuvel et al. - 2014], Towards a resilience indicator framework for making climate-change adaptation decisions [Engle et al. - 2014], Towards Integrated Security and Resilience Framework: A Tool for Decision-makers [Chmutina et al. - 2014]

- ***articles using the decision-making concepts in the Social dimension of resilience:*** Rebuild or Relocate? Resilience and Postdisaster Decision-Making After Hurricane Sandy [Binder et al. - 2015], Community resilience, globalization, and transitional pathways of decision-making [Wilson - 2012]
- ***articles using the decision-making concepts in the Economic dimension of resilience:*** Using Financial Reporting for Decision Making as a Measure Towards Resilient Government Finances: The Case of Switzerland [Fuchs et al. - 2017], A Model to "Make Decisions and Take Actions": Leif Johansen's Multisector Growth Model, Computerized Macroeconomic Planning, and Resilient Infrastructures for Policymaking [Halsmayer - 2017]

This classification shows that studies focus more on the concepts of decision-making in the technical and organizational dimensions of resilience and ignore the social and economic dimensions, which already considered non-resilience from the side of scientists and researchers.
From 2000 to 2019, the 45 articles (24+17+2+2) have been cited within the Web of Science databases only 35 times on average per year, which reflects the non-interest of researchers in this context. However, looking closely, for the 10 most cited articles (from the 45), the graph of the sum of times cited per year shows a strong trend (see Figure 1).

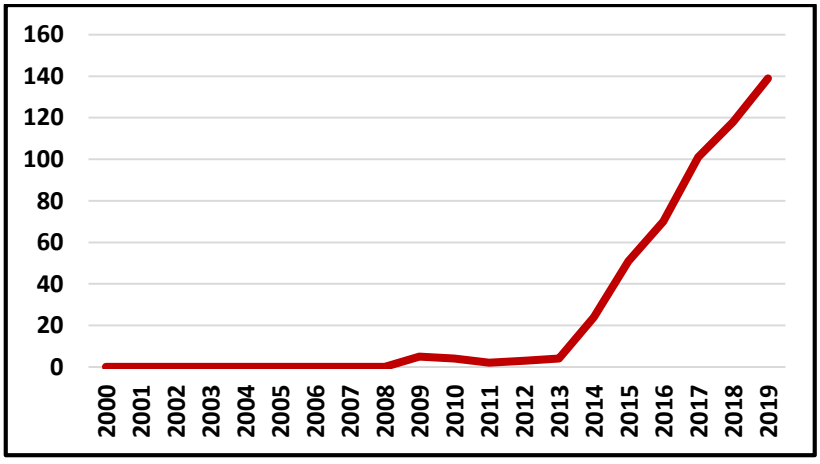

Figure 2: Sum of Times Cited by Year

The trend started in 2013, which means that this context is new in the scientific field. This trend also shows how recently decision-makers and researchers are increasingly focusing on

the use of decision-making concepts in the four dimensions of disaster resilience, which proves the importance of literature review in this context to help future research.

CONCLUSIONS

Studies, theories, and approaches of decision-making in relation to disaster resilience are constantly increasing, which blurs the vision of researchers and decision-makers and makes it difficult to find suitable publications. The main objective of this paper is to clarify the vision and to help researchers and decision-makers to find articles relevant to their research. A structured analysis was carried out regarding the subject of decision-making in the resilience field, on the basis of 66 articles published from 1975 to 2020. This paper classified these articles into four clusters, depending on the resilience dimensions, which allows researchers or decision-makers to search directly in the dimension that corresponds to their research. This paper also discussed the trend of using decision-making concepts in these four dimensions.

To conclude, this article offers an overall visualization of the intersection between the two concepts "Resilience" and "Decision-making", which can help for future studies in this context.

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In Light of Industry 4.0: The Trends of the 4th Industrial Revolution's Key Technologies in Human Well-being Studies

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ABSTRACT

There are many studies done by different research teams around the globe in which their main concern is the influence or impact of the emerging technologies on the well-being of humankind. In this study, by using text mining algorithms and decision science theories in a framework of content analysis, the weights of the emerging technologies in different science databases were extracted. Also, by considering technology-related archives and databases, the relationship between emerging technologies and wellbeing was mapped. This will help a better understanding of the main trends and growth patterns in the well-being's technologies, which potentially would be translated into the business in the future. It also helps to analyze the gap and the vulnerability of research portfolios applied to employ emerging technologies in well-being and could lead to better research plans in this area.

Keywords: well-being, 4th Industrial Revolution, Text Mining, Industry 4.0, Content Analysis.

INTRODUCTION

Emerging Technologies are the initiators of the 4th industrial revolution also known as Industry 4.0 (i4.0) [1] and they are changing every aspect of human life including human well-being. They are the engine of this paradigm changes and the trigger of startups movement in different industries [2] where the health industry and particularly life improvement and human well-being are not exceptions [3].

For the decision-makers in almost every field, having related information is critical and part of that information could be the trends of the evolvement of emerging technologies in that field's studies. Strategic decision-makers could use this information to know the trends, estimate future attention, investigate the causes, plan potential areas of work and do fruitful investment by technology types. The challenge is that extracting the knowledge by investigating the data and recent studies in any area of science is time-consuming. It needs a lot of effort to find the resources, reducing them to the most related ones and then investigating the results to find out useful information. So, it is not surprising that although there is increasing attention to the impact of 4IR's key technologies to raise the human well-being, no scientific study about the trends and patterns of this area found in recent years' studies.

These facts were the motivations to conduct this research and employing content analysis techniques to enhance this investigation. Content analysis techniques help to find out the

number of studies was done about well-being considering 4IR's emerging technologies, the trends of those studies and, the weight of each technology in well-being and 4IR's studies. This work is based on a hybrid approach using text mining and Shannon's Entropy. Shannon's Entropy is a method for content analysis and calculating the weights of the formal concepts in documents based on their information gains which are more reliable than only word counting [4].

In this study, nine selected emerging technologies of 4IR were used to measure their frequency and weight in 7291 papers from a variety of databases. The hybrid algorithm used in this paper, not only helps the researchers to identify the trends and weights among a large number of documents in a short time but also as mentioned before, the result could help both at the micro & macro level, decision-makers, and policymakers either in research or industry.

CONCEPTS & BACKGROUNDS

In this section, the 4th industrial revolution and the content analysis concepts are briefly reviewed.

The fourth industrial revolution (4IR)

Before the "4th Industrial Revolution" became the title of Charles Schwab's book in 2016 [5], it was "Industrie 4.0" the German term that coined at the Hannover Fair in 2011 and becomes popular in every field of science and industry [6]. Although the concept born in 2011, it can be argued that 4IR has been flourished from 2015, and practically found its place after being discussed at the World Economic Forum (Davos summit) to be widely used by researchers [7]. Besides this historical fact about 4IR and i4.0, today both of them are used to name the same concept and refer to this new paradigm.

The fourth industrial revolution believed is happening by aggregation of emerging technologies and will reshape industry, economy, business, society and moving toward every dimension of human life [8].

Different groups of researchers mentioned different groups of technologies in their articles and named them as the initiators of the 4IR [1, 9, 10]; for instance, four key components of 4IR which believed that this revolution is based on them are Internet of Things (IoT), Cyber-Physical Systems (CPS), Internet of Services (IoS) and, Smart Factories (SF) [11]. "There are nine identified technological trends that are said to be primarily instrumental in shaping industrial production", Gilchrist wrote in his book "Industry 4.0" page 204 [12]. Some of the recent studies introduced these nine key technologies of the 4IR as "the 9 pillars" or "the building blocks" of the 4IR [1, 13]. These nine technologies are: Industrial internet of things, Cloud Computing, Big Data, Simulation, Augmented Reality/Virtual Reality, Additive Manufacturing, Horizontal vertical system integration, Autonomous Robots and, Cybersecurity.

Content analysis

In case of facing a huge amount of data in documents (as texts), the techniques for analyzing the data and getting meaningful and useful information from them is content analysis [14]. Steve Stemler in his research [15] defined it as a technique to identify the specific characters of a text.

This is a broad definition of content analysis that not limit it to textual content and suggests it applies to different contents like arts, films and, TV shows [16, 17].

A combination of two techniques for the content analysis of the extracted articles in this study was used: Text-Mining and Shannon's Entropy.

Text mining

Text mining is a method to analyze the databases and extract information from them, which is also called knowledge discovery in a database [17]. Among different definitions of Text Mining, the one proposed by Klaus Krippendorff in his book [18] is what is done in this research which is searching the large textual scientific databases to find out the most appropriate online results to answer the questions of the research.

Concerning content analysis, in this research text mining is used as a tool for processing the papers and extracting information from them. The extracted articles from scientific databases are in the text format, so for content analysis, they should be transformed into structured data to make the process of keyword extraction possible. It could help to identify the word count of the emerging technologies in the structured data and calculating their weights in scientific studies.

Shannon's entropy

For dealing with real-world problems, it is usual to use experts' opinions and judgments in a variety of decision-making techniques. One of the applications of the experts' opinions can be subjective weighting the alternatives' attributes and in those cases, sometimes applying the objective weights is helpful [19]. Among the objective weighting measures, Shannon's Entropy is used for calculating the semantic aspect of communication [20].In the content analysis context, Shannon's Entropy is a method for calculating the weights of the formal concepts in documents [4].

The application of this method in the content analysis framework is evaluated by researchers and used as a reliable measure for calculating the weights of attributes in Multi-Attribute Decision Making (MADM) [19, 21].

RESEARCH METHODOLOGY

This research combined text mining techniques with Shannon's entropy to analyze the content of the scientific papers in the area of well-being. As it is shown in Fig 1, almost all of the well-known scientific databases were considered in the paper extraction process. These databases were chosen by the suggestion of experts. In the search process, a combination of keywords related to both "well-being" and "technology" was selected to cover two main concepts simultaneously.

The search keywords are "well-being", "wellbeing", "digital", "technology", "industry 4.0", "4th industrial revolution", "fourth industrial revolution", "technologies" and combined by using Boolean operators such as "AND", "OR", "NOR" and "NOT". The search criteria have limited to only English articles from 2015 to 2019 which contained the search phrase in their title, keywords or abstract.

After performing the search process in each database, the reference data of the resulting papers were downloaded in batch files. The data cleaning process is done by removing duplicate results.

Text Mining processes are done by a data mining toolbox in Python that contains: Transformation (lowercasing every word, removing accents, parsing HTML and removing URL from the text [21]), Tokenization (breaking down the text to its tokens or meaningful

elements like words, characters, phrases and symbols [22]), Normalization (using a method for language modeling techniques, called Lemmatization technique that returns the dictionary form of a word and removes inflectional endings [23]), Filtering (Removing the stop-words like “an, it, did”, from the texts of articles by using Natural Language Processing Tool Kit (NLTK) [24]) and finally N-Grams detection (to find meaningful phrases and add them to the final result [25, 26]). The output of the text mining process can be a matrix of word count which can be used to calculate Shannon’s entropy.

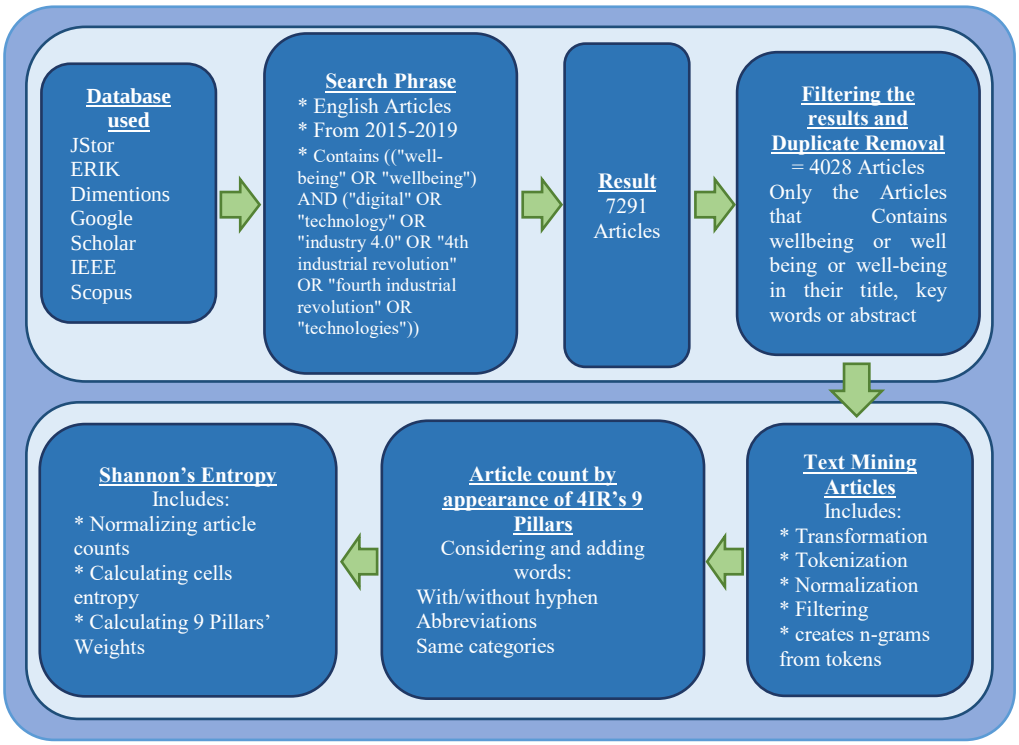


Figure 1: Research methodology in this study.

Shannon’s Entropy is an effective method in content analysis and can be used to compute the weights of the attributes in Multi-Attribute Decision Making (MADM) problems [4, 19, 27]. The following steps are showing the procedure of calculating the Shannon’s Entropy and weights of the attributes in this research:

- Normalizing the word count matrix by using formula (1) to smooth differentiation in the scales and eliminating the anomalies. By performing this process, the numbers transform to a range between 0 and 1.

$$P_{ij} = \frac{X_{ij}}{\sum_{j=1}^{m} X_{ij}}, \; j = 1, \dots, m, \qquad i = 1, \dots, n \qquad (1)$$

  In this formula, (i) is the index for columns, (j) is the index for rows, (P_{ij}) is the transformed number and (X_{ij}) is an array in word count matrix

- To compute the entropy of each array in the count word matrix, formula (2) is used.

$$H_i = -K \sum_{j=0}^{m} P_{ij}.\ln P_{ij}, \quad i = 1, \dots, n \qquad (2)$$

  Where Claude Shannon said K is positive constant to satisfy $0 < H_i < 1$ and can be calculated by the formula (3) [20, 27].

$$K = (\ln m)^{-1} \qquad (3)$$

  Where the $K = 0$ when $P_{ij} = 0$.

- The following formula (4) is used to calculate the degree of importance of the attributes.

$$W_i = \frac{H_i}{\sum_{i=1}^{n} H_{ij}}, \qquad i = 1, \dots, n \qquad (4)$$

Where the W_i is a measure that defines the degree of importance of each attribute in this research also it is possible to rank the attributes by their weights [27].

FINDINGS

In this research, the papers from well-known science and technology databases related to well-being are gathered by using the search phase already introduced in the methodology section. As it is shown in table 1, among the results, 7291 articles from 2015 to 2019 proceeded to the next step where only 4028 articles out of them contained the term "well-being" in their title, keywords or abstracts.

Table 1: Status of Databases used in this research

Database Name	No. of Extracted Articles	Status	Text Mined Articles
Web of Science	1131	Used	958
Scopus	872	Used	869
Google Scholar	914	Used	642
IEEE	769	Used	655
JStor	1751	Used	505
ERIK	167	Used	150
Dimentions	1687	Used	249
Oxford Academic	76672	Time out problem in the advanced search Eliminated from the research process	-
Taylor and Francis	2889	Do not support batch reference download Eliminated from the research process	-
Emerald	461	Same as above	-

As you can see, table 2 consists of the name of the 4IR's emerging technologies in the columns and the name of the scientific databases in the rows. The arrays of this table are the results of text mining which are the numbers of the final papers that have the term "well-being" and one of those 4IR's pillars in each of the databases.

The contents of table 2 were normalized by using the formula (1), then Shannon's entropy and the final weights of the emerging technologies calculated with the formulas (2-4) and final results are shown in Table 3.

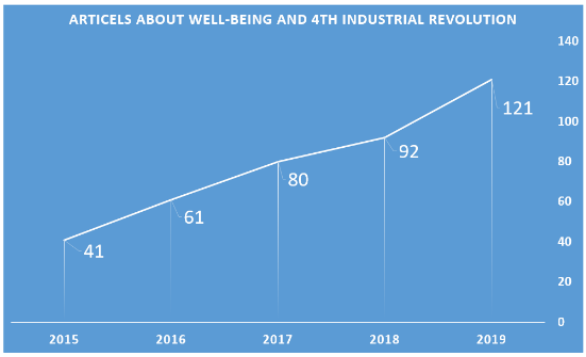
Table 2 (left): Numbers of papers that contain the key technologies

Table 3 (right): Shannon's Entropies and degree of importance (weight) of the key technologies

	IIoT	cloud comp.	big data	simulation	AR/VR	Add. Man.	Hor. Ver. Sys. Integration	Robotics	Cybersecurity
Web of Science	0	3	5	9	12	0	2	5	6
Scopus	1	12	13	11	14	4	14	15	2
Google Scholar	0	2	9	0	3	4	4	11	2
IEEE	1	45	30	29	31	1	40	27	9
ERIK	0	0	2	3	3	0	7	2	0
Dimentions	0	0	0	0	3	0	0	1	0
JStor	0	0	1	0	0	0	0	0	1
Total Word Count	2	62	60	52	66	9	67	61	20

	IIoT	cloud comp.	big data	simulation	AR/VR	Add. Man.	Hor. Ver. Sys. Integration	Robotics	Cybersecurity
Entropy H (i)	0.356	0.415	0.694	0.577	0.727	0.496	0.588	0.719	0.684
Weight W (i)	0.068	0.079	0.132	0.110	0.138	0.094	0.112	0.137	0.130

The result shows that among the published studies between 2015-2019 in scientific databases about well-being, there is an increasing trend toward emerging technologies of the 4IR, which are shown in figures 2 and 3.



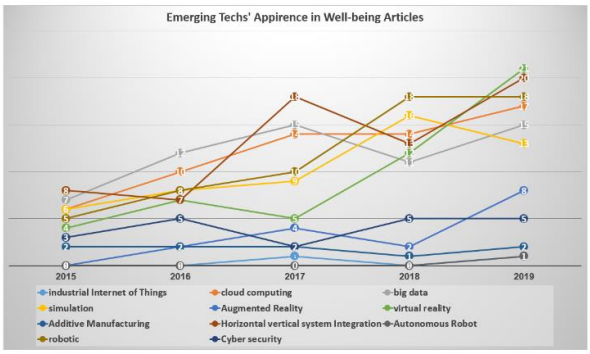


Figure 2 (left): Distribution of the studies in the years between 2015 to 2019

Figure 3 (right): The overall increase in the number of studies

In table 4, all of the 4IR's Emerging technologies were sorted by their degree of importance and the importance of each of those technologies in the recent studies related to well-being It can be seen in table 5 that the order of the technologies by their weights is different compare to their order by word frequency.

Table 4: The 4IR's key technologies in order of their weights in the well-being studies

Ordered by the degree of importance (Wight)	Weights	Ordered by the word counts	Word count
Augmented Reality/Virtual Reality	0.138	Horizontal and Vertical Sys. Integration	67
Robotics	0.137	Augmented Reality/Virtual Reality	66
Big Data	0.132	Cloud Computing	62
Cybersecurity	0.130	Robotics	61
Horizontal and Vertical System Integration	0.112	Big Data	60
Simulation	0.110	Simulation	52
Additive Manufacturing	0.094	Cybersecurity	20
Cloud Computing	0.079	Additive Manufacturing	9
Industrial Internet of Things	0.068	Industrial Internet of Things	2

CONCLUSION

This research shows the trend of emerging technologies that are getting higher attention in the field of well-being every year while there is increasing growth in related literature. This means the fourth industrial revolution has an impact in this field research & the new paradigm shift is evolving in different aspects of human life and well-being to improve the quality of our lives. Using Shannon's entropy shows the degree of importance of these technologies based on the extracted papers from leading scientific databases. In short, it could be seen that some technologies are more familiar for this group of researchers such as Augmented Reality/Virtual Reality, Robotics, Big Data & Cybersecurity which could be recognized as future business opportunities in this area. The investors in this field could follow the trends to have a better picture of the related industry in the future. At the same time, lack of interest in some technologies such as IIoT & Cloud Computing passes this message that these are the gaps where research policymakers and foundations could focus and by using incentive models support to bring them back to the consideration. This paper

is just the initial result of comprehensive work and to have a better and more accurate result, we have to do more deep analysis to find out hidden patterns between attributes and alternatives. Also, it is crucial to merge the extracted information with field research data such as hearing from main players in the field, to have a better, and more clear picture.

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Collaborative Story Generation using JSON in Godot Engine as Decision Making Support Tool

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ABSTRACT

In our paper we propose JSON (JavaScript Object Notation) as a plot description format. The JSON notation allows for multiple writers to collaborate in creating game world. We are using hierarchical graph and rules of graph embedding to allow designer and story writers to create game world. Proposed notation for world elements allowed us to create decision-making supported tool developed in Godot Game Engine. The tool helps the story writers to control the impact of the created story elements on the game world. Using the tool, it is possible to explore the game world and every aspect of the stories and adventures created by the writers. This can be used as "debugging" method and can help writers to avoid inconsistencies, dead ends and loopholes. Using JSON notation, it is possible to define how the designed world operates, what are the methods of interaction with the world, what are the key locations, characters, etc. As well as create detailed short stories and interactions. Furthermore, early experiments shown that using proposed approach it is possible to create living worlds where characters interact with each other without the external influence. By simulating the player, we can generate multiple gameplay experiences and analyze them. It is also possible to create specific well-crafted stories with highly restrictive world interactions, this is common in adventure games, or point and click games.

Keywords: Decision Support, Collaborative Design, Graph Transformations, Procedural Storytelling,

INTRODUCTION

In this paper we present decision-making support tool for collaborative story generation made with Godot Engine an open source game making software. The tool is using JSON notation to describe game worlds, story arcs, and base actions that can be taken within the world. Using the notation allows for collaboration between multiple world designers and story writers. The collaboration is divided in series of steps that are dependent on each other:

- definition of the world by featuring key locations and characters,
- definition of basic action a player character can take in the world,
- designing of adventures, quests, story arcs, plot points,
- interweaving the individual stories into overarching plot.

To define the game world, we are using layered graph representation. The graph representation is stored in JSON format.

JSON AS PLOT POINT REPRESENTATION

In presented research we use JSON notation for multiple components of developed decision-making support tool. Those components can be divided into:

- in game action definition,
- story arc design,
- game world representation.

Though the components have similar graph structure, the purpose is different in each case. In order to easily communicate between the components a JSON notation is used as it is specifically designed for object description [1].

Graph representation

In presented tool the underlying logic is based on graph operations and graph pathfinding, and for that reason it was necessary to define a notation that is easily readable to story writers and at the same time can be converted into data structure.
At first we used notations that closely follows graph representation, where list of vertices is defined, followed by list of edges defining connection between vertices. The notation is presented in Table 1 where simple action is presented as left and right side of production.

Table 1: Text notation for graph of an action.

```
"L_Side": {
        "Vertex": {
            "Locations": {"Wizard's Hut":""},
            "Characters": {"Hero":"Aggression", "Wizard":""},
            "Items": {"Sword": ""}
        },
        "Edges": {"Hero":"Wizard's Hut", "Wizard":"Wizard's Hut", "Sword":"Hero"}
},
"R_Side": {
        "Vertex": {
            "Locations": {"Wizard's Hut":""},
            "Characters": {"Hero":"", "Wizard":"Dead"},
            "Items": {"Sword": ""}
        },
        "Edges": {"Hero":"Wizard's Hut", "Wizard":"Wizard's Hut", "Sword":"Hero"}
}
```

The notation presented in Table 1 is clean and works well for theoretical graph representation, unfortunately it in practice it is missing some features. E.g. Having multiple objects of the same name is forcing the use of unique vertex identification, hence object name needs to be added in other way. This made implementation of the ownership of the objects problematic, and impractical, as the solution would make the notation difficult to maintain for story writers. The problems with theoretical graph representation directed us to more natural JSON notation as it is well suited for object description [2]. Table 2 shows actual notation used in decision-making support tool that represent the same situation as the example shown in Table 1.

Table 2: JSON notation of simple combat action.

```
"Title": "Fight with Wizard - Wizard defeated",
"Title_Generic": "Combat - death of defender",
"Id": "00-015",
"Description": "Hero meets a Wizard and attacks.",
"L_Side": { "Locations": {
        "Wizard's Hut": {
            "Characters": {
                "Wizard": { },
                "Hero": {
                    "Items": { "Sword": { } },
                    "Attributes": { "Aggression": "" }
                } } } }
},
"R_Side": {
    "Locations": {
        "Wizard's Hut": {
            "Characters": {
                "Wizard": { "Attributes": { "Dead": "" } },
                "Hero": {
                    "Items": { "Sword": { } },
                } } } }
}
```

The used notation is completely hierarchical and can support many of the situations that could not be supported in in previous approach. E.g. it is possible to have multiple objects of the same name; it is easy to add multiple attributes to any object in the graph; items can contain other items (a bag in a bag). Figure 1 is a visual representation of the JSON action notation as it can be seen in the decision-making support tool.

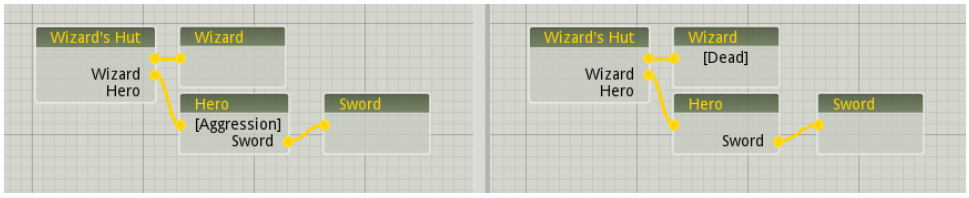

Figure 1: Action graph representing simple combat action.

Looking at the notation form Table 2 it can be observed that there are nodes: “Locations”, “Characters”, “Attributes”, “Items”. There are two more nodes that are used: “Narration” and “Connections”. Those specific nodes are common building blocks in all components of the decision-making support tool and allows us to build complete and detailed game worlds.

Decision making tool implementation in Godot Engine

To implement the tool, we have decided to us Godot Engine [3], a free and open-source game engine that comes equipped with components for easy graph building, furthermore Godot supports storing any engine structure as JSON format. Figure 2 illustrate game graph created form JSON file containing definition of simple game world.

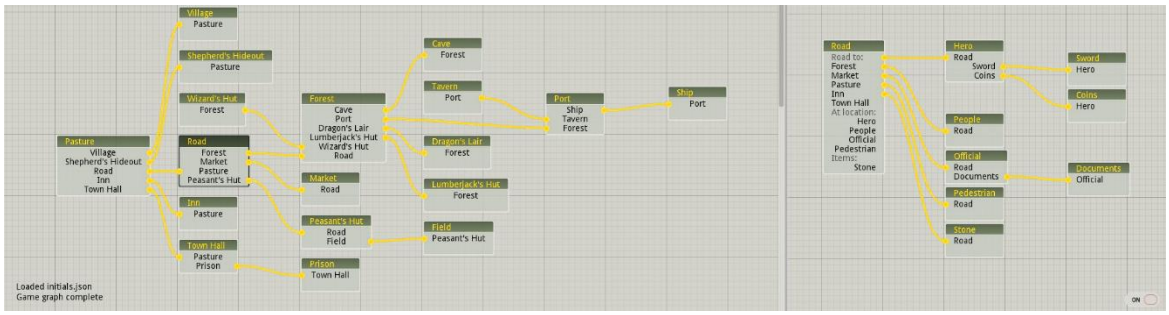

Figure 2: On the left is a game graph representing initial world state. On the right specific location in the world is inspected.

Godot Engine features scene system [4] where every object is represented by a node in hierarchical order. The hierarchy of objects can be saved as JSON file and later restored if needed. This implementation allows us to observe how a player can interact with the game world, simulate a player character by using actions that are defined by the story writers to verify if the game world is playable and the game can be completed.

DECISION MAKING USING JSON REPRESENTATION

Decisions taken by the player are represented as graph rules called productions. These are rules that modify current Game State Graph. Every rule (production) consists of two subgraphs. One subgraph is a template that need to match fragment of Game State Graph, second subgraph will replace fragment of Game State Graph when the template is found. This replacement is done according to embedding instructions. The structure and formal definition of the graph and graph productions is presented in [5,6]. A playthrough is represented as a sequence of productions used by the player.

Game action definition

At the stage of game plot design, the first step is to propose the generic actions corresponding to the game mechanics. In our system they are called “generic production” and represent all possible interactions with the game word e.g. location change, combat, item interaction, acquisition of information, etc.

The next step is to prepare specific world interaction based on generic productions. Those interactions are also represented by graph productions but are more specific and introduce world restrictions and add narrative meaning to the actions. E.g. Generic item interaction is divided into more specific: picking up an item, stealing an item, etc. Those productions are called “specific productions”, they contain requirements for node attributes, e.g. buy a sword if a hero has coins (at least 10). The difference between productions is shown in Figure 3.

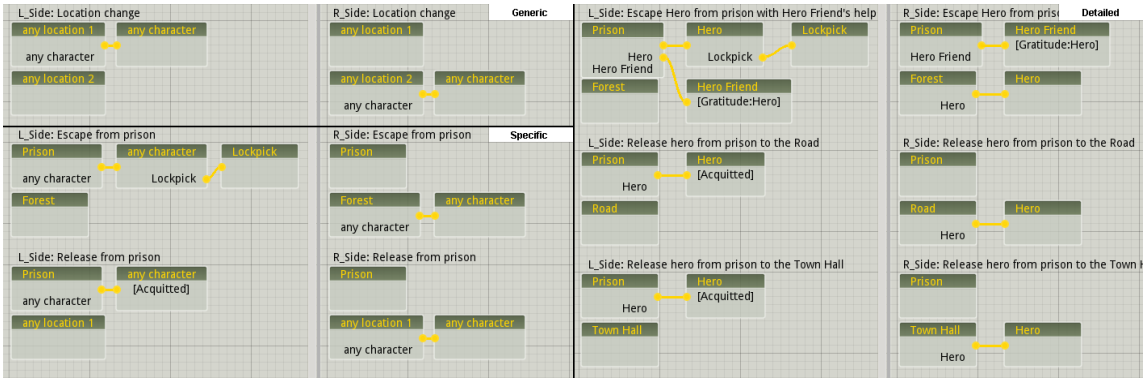

Figure 3. Differences between productions. Generic: “Location change”. Specific: “Escape from prison”, “Release from prison”. Detailed production use exact nodes and are part of story arc.

Player can influence (change state) the objects in the game word by using productions. If multiple productions match the same action the most detailed is used. E.g. player can attack any character as a generic action, though the result of an attack can be defined by any applicable detailed productions, as a result player can attack the innkeeper, but as a result he may attract aggression of other patrons.

From close to open game world – story designers’ decisions

As mentioned above, during the gameplay player makes decisions based on available productions. Generic productions define the model of interactions in the game world and because of that, they are part of game mechanic, not part of the plot.

The plot design take place during the creation of specific productions, which can represent plot twist. E.g. getting item can mean buying it or stealing. Both of those actions have different consequences on the plot. The intermediate level of designing process is crucial especially for collective and collaborative design process where a group of world designers, story designers, and graphic designers rely on each other to give the world detail. Hierarchy of specific productions enforces the consistency of the game word interactions and help to organize the design process. This situation leads to the game with few plot paths, all precisely designed.

Another approach is to make game world widely open to unrestricted player actions. This approach also can be supported by proposed system. Specific productions can be available for player and expand into detailed productions on the fly during the gameplay.

The problem is, as always with the open game world, that design decisions can result in unexpected gameplay shortcuts or possible actions contrary to the plot or common sense. E.g.: generic location change production allows the player for world exploration but can allow the player to bypass important plot points.

To avoid such problems, we propose the system of hierarchical production application. If it is possible to apply two generic productions, but one of them gives additional restrictions – the more detailed one should be applied. For example: generic productions of location changing with no restrictions will not be applied to the location “prison” if there are production that allow the player to leave the prison only with the attribute “acquittal”.

CONCLUSIONS

Using JSON notation to describe world components allowed us to create a useful tool for generating stories, and game worlds while being easily extensible. The hierarchy of rules aids in assuring the consistency of plot and allows for flexible plot creation. Giving story writers option to create story element in JSON format allows for complete freedom in story creation, although a Graphic User Interface might be needed to bypass the need to understand JSON structure for the writers. The graph base structure is adjustable to subsequent design's decisions and allows us to verify the results of going through story arcs. Early experiment shows that allowing non-player characters to use productions can result in living world where characters interact with the world, though in our first experiments characters could use generic actions, and that resulted in excessive use of attack action, creating an unexpected emergent story. The proposed decision-making tool helps with game story generation by introducing formalization to the world structure. The collaboration process is enhanced as it is possible to rapidly test or even visualize the story, and by doing so it is possible to identify sections of the game world that would benefit from enrichment and added detail.

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Zaragoza, Spain, 27-29 May 2020

ICDSST 2020 on Cognitive Decision Support Systems & Technologies

Using Multi-level DEA to go beyond the three dimensions of sustainability

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ABSTRACT

Sustainable development and sustainability are two notions that despite their importance for policy-making, have neither unified definitions nor a common methodological framework to measure them. The purpose of this paper is to propose a measure of sustainability that goes beyond the traditional, three-dimensional structure and accounts also for different definitions and perceptions. To do so, a new, multi-level DEA variation is used, and the method is tested to measure the sustainability of EU countries under three combinations of inputs and outputs (representing perceptions of what sustainability is). The results illustrate that there are countries with variations in the results for the different combinations of inputs and outputs. Thus, no safe conclusions can be drawn for these countries, since the different perceptions alter the measurement level of sustainability.

Keywords: Sustainability, Data Envelopment Analysis, multi-dimensional structure, composite indicator.

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Improving the non-Compensatory Trace Clustering Decision Process with Robustness Concerns

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ABSTRACT

In flexible environments (like healthcare or customer service), the observed behavior is expected to considerably vary, namely there is no dominant flow path. Such a high variability obstructs the process discovery task since it regularly leads to 'spaghetti' process models. Trace clustering is about grouping behaviors, and discovering a distinct model per group, thus delivering more comprehensible results. In previous works, we have proposed a multiple criteria non-compensatory approach to create a similarity metric and finally perform trace clustering. The main problem that we tried to respond to is how to summarize a Process Event Log, when a lot of variability exists, thus to facilitate knowledge discovery. The underpinnings of the non-compensatory approach are first the fact that a sufficient number of criteria must be concordant with the similarity (concordance setting) and second that there should not exist any criterion raising a veto logic, i.e., among the criteria that are not concordant, none of them must be conflicting with the similarity (discordance setting). This work challenges improved support for the decision maker and it extends the previous approach by:

i) proposing an improved clustering technique based on Spectral Clustering

ii) guiding the clustering process by allowing *reinforced* or *counter-veto* effects and pairwise constraints

iii) handling outliers through a trimming approach as a quadratic program.

All improvements aiming at making elements of the trace clustering process more accessible to the decision makers and enhancing the understandability of the analysis.

Keywords: Process Mining, Trace Clustering, Outranking methods, Robustness

INTRODUCTION

In flexible environments (like healthcare or customer service), the observed behavior is expected to considerably vary, namely there is no dominant flow path. Such a high variability obstructs the process discovery task since it regularly leads to 'spaghetti' process models. Trace clustering is about grouping behaviors, and discovering a distinct model per group, thus delivering more comprehensible results. In previous works, we have proposed a multiple criteria non-compensatory approach to create a similarity metric and finally perform trace clustering. The main problem that we tried to respond to is how to summarize a Process Event Log, when a lot of variability exists, thus to facilitate knowledge discovery and relevant management decisions.

In such management decisions, the relevant decision support processes inherently follow a constructivist's approach, i.e., the decision analyst's goal is to *provide the decision maker with a set of results derived from the reasoning modes and working hypotheses* [1]. On the other hand, there is an abundance of clustering algorithms, that are capable to automatically detect clusters of items in large datasets. Nevertheless, the (frequently complex) algorithmic operations of the clustering techniques, combined with the inevitable lossy description of original objects (particularly in case of high-dimensional feature spaces) render the clustering process into a black box for decision makers [2]. This situation highlights an antiphasis: The results of the clustering algorithm suggest the existence of a unique context reality, of a definite optimum, which violates the constructivist thesis of the decision support process. The aim of this work is to decommission that antiphasis by making elements of the trace clustering process more accessible to the decision makers and enhancing the understandability of the analysis. The focus is on showing how the results can be veracious by examining a set of robustness concerns.

In previous work [3], we have showed that a non-compensatory approach can yield compelling results considering the classical trace-clustering problem. The underpinnings of the non-compensatory approach are first the fact that a sufficient number of criteria must be concordant with the similarity (concordance setting) and second that there should not exist any criterion raising a veto logic, i.e., among the criteria that are not concordant, none of them must be conflicting with the similarity (discordance setting). This work challenges improved support for the decision maker and it extends the previous approach by: *i*) proposing an improved clustering technique based on Spectral Clustering; *ii*) guiding the clustering process by allowing *reinforced* or *counter-veto* effects and pairwise constraints; *iii*) handling outliers through a trimming approach as a quadratic program.

The nature of this manuscript (short paper) does not favor a more elaborated presentation of the results or of the related literature, therefore, in the next sections, although the focus in on the methodological approach, we try to discuss the related works, as well as the outputs of the proposed approach.

PRINCIPLES OF THE CLASSICAL NON-COMPENSATORY TRACE CLUSTERING

Let us first present the principles of the non-compensatory trace clustering, as it was introduced in [3]: For every two objects (traces), we define a set of pairwise relations to represent the similarities between two objects (x, y): $x\mathcal{S}y \Leftrightarrow x$ and y are strongly similar; $xQy \Leftrightarrow x$ and y are weakly similar; $x\mathcal{I}y \Leftrightarrow x$ and y are indifferent with respect to their similarity; and $x\mathcal{R}y \Leftrightarrow x$ and y are disparate.

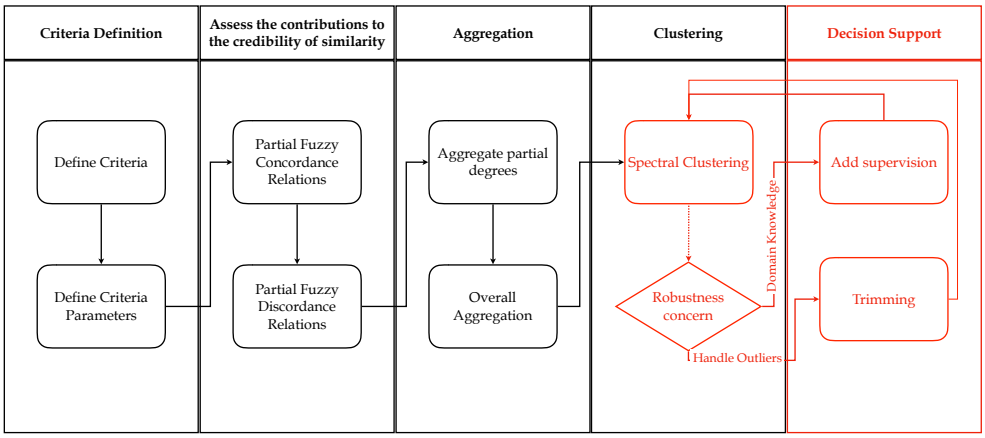

Figure 1: The improved process of non-compensatory trace clustering. The red parts are the specific contributions of this work.

Next, a criterion is defined as a function $g: A \to \Re \,/ \alpha \;\; \to g(\alpha)$ where g(a) is the evaluation of the alternative $\alpha \in A$ over the criterion g (in our case an alternative is a pair of traces and A $\equiv$ U $\times$ U). This function must fulfill the monotonicity property, namely for two alternatives $\alpha, \beta \in A, g(\alpha) > g(\beta)$ implies that α outranks β. The overall similarity evaluation system must define a set of n criteria in a way that they form a consistent family of criteria G. Then, we attach to every criterion g_j three thresholds: the *veto* threshold v_j, the *indifference* threshold q_j, and the *similarity* threshold s_j, defined in such a way that the following relations hold:

$$s_j \leq g_j(x,y) \Leftrightarrow x \mathcal{S}_j y$$
$$q_j \leq g_j(x,y) < s_j \Leftrightarrow x \mathcal{Q}_j y$$
$$v_j < g_j(x,y) < q_j \Leftrightarrow x \mathcal{I}_j y$$
$$g_j(x,y) \leq v_j \Leftrightarrow x \mathcal{R}_j y$$

where the superscript index j on the pairwise relations indicates a partial (with respect to the current criterion) relation, and the criterion's monotonicity is assumed to be ascending. In case of a decreasing monotonicity, we just have to reverse the inequality operators. These steps correspond to the leftmost box ("Criteria Definition") of Figure 1. The next step is to assess the contributions of criteria to the credibility of similarity. To this end, For any pair of traces x, y we define the *partial fuzzy concordance* $c_j(x,y)$ and *discordance* $d_j(x,y)$ relations with respect to each criterion g_j like the following:

$$c_j(x,y) = \begin{cases} 1, & \text{if } j \in J^{\mathcal{S}} \\ \dfrac{g_j(x,y) - q_j}{s_j - q_j}, & \text{if } j \in J^{\mathcal{Q}} \\ 0, & \text{else} \end{cases}$$

and

$$d_j(x,y) = \begin{cases} 1, & \text{if } j \in J^{\mathcal{R}} \\ \dfrac{q_j - g_j(x,y)}{q_j - v_j}, & \text{if } j \in J^{\mathcal{I}} \\ 0, & \text{else} \end{cases}$$

where $\boldsymbol{J^{\mathcal{S}}}$ is the set of criteria that support the strict similarity; $\boldsymbol{J^{\mathcal{Q}}}$ the set of criteria that support only the weak similarity; $\boldsymbol{J^{\mathcal{I}}}$ the set of criteria that are indifferent; and $\boldsymbol{J^{\mathcal{R}}}$ the set of criteria that pose a veto to the assertion of the similarity. Finally, during the "Aggregation" step, to get the

overall concordance index, we can aggregate the partial degrees using a weighted sum, and to get the overall discordance index, we use an disjunctive operator, like the following:

$$C(x,y) = \sum_{j=1}^{n} w_j c_j(x,y) \quad , \qquad D(x,y) = 1 - \prod_{j \in J / d_j > c_j} \frac{1 - d_j(x,y)}{1 - c_j(x,y)}$$

To measure the overall similarity between two traces $\boldsymbol{x}$ and $\boldsymbol{y}$ the following formula is used:

$$s(x,y) = min\{C(x,y), 1 - D(x,y)\}$$

THE IMPROVED TRACE CLUSTERING DECISION PROCESS

Spectral Clustering

The similarity metric that is the output of the non-compensatory approach that we described so far (3 first stages of the methodology illustrated in Figure 1), can be used by several clustering techniques. In [3] the agglomerative hierarchical clustering is applied. In this work, we suggest the use of a spectral clustering approach [4] because it performs better on a variety of metrics, it allows to add pairwise supervision, and it fits the trimming approach for handling outliers, which suggests a non-hierarchical technique [5], [6].

To perform Spectral Clustering, the similarity matrix S (or adjacency matrix) is created. Letting D be the degree matrix pertinent to S, then the *Laplacian matrix* is defined as $L = D - S$. Then, following the symmetric version of the Normalized Spectral Clustering algorithm [7], we compute the symmetric normalized graph Laplacian $\tilde{L} = D^{\frac{1}{2}} L D^{-\frac{1}{2}}$. Targeting for k clusters, we construct a matrix $E \in \Re$ from the top-k eigenvectors of $\tilde{L}$. Then, after normalizing the rows of E to 1, we treat the rows of E as a k-feature vector, to be clustered via k-means into k clusters. The output is a (hard) membership of every row (trace) to one of the k clusters.

Incorporate Domain Knowledge

The first robustness concern about the trace clustering problem is about taking greater account of the reasoning modes of the decision maker. There are two levels where these can be reflected: the criterion, and the overall similarity level.

At the criterion level, Roy and Słowiński [8] describe two situations that could affect the credibility of the outranking relation, but that the classical model does supply:

- When two objects (traces) are similar with respect to a criterion beyond the level of similarity that is implied by the similarity threshold, i.e., there is evidence of "distinguished" similarity just by examining that criterion, then the overall similarity should be reinforced.
- When the performance of a pair of objects on some criteria is such that it is meaningful to alleviate the veto effect that is raised by a different criterion.

At the overall similarity level, Cohn et al. [9] describe four types of feedback on the pairwise relations of objects:

- Indicate if two objects must be in the same cluster.
- Indicate if two objects must not be in the same cluster.
- Indicate if an object should belong to a specific cluster.
- Indicate if an object should not belong to a specific cluster.

However, since the cluster membership is known to the decision maker before providing this feedback, the four types boil down to the first two.

In a graph-based clustering approach (which follows the similarity matrix input), it is possible to formulate an optimization problem to cluster the objects, subject to the above constraints. However, this has proved to be an NP-hard problem [10]. Therefore, the rather popular approach is to add the constraints to the graph edges' weights [11].
The above concerns can be integrated into the classical non-compensatory trace clustering method as follows: Let us denote with rp_j and cv_j the reinforced preference threshold and the counter-veto threshold for a criterion j respectively. We should note that no order relation is imposed for these thresholds. For example, one could wish to ignore one of them by assigning a very high value, or variously, one could expect a single value to provoke both effects. Therefore, we can assume the following equations independently to each other as well as to the threshold equations of the classical model:

$$g_j(x,y) > rp_j \Leftrightarrow x\mathcal{RP}_j y \Leftrightarrow j \in J^{\mathcal{RP}}$$
$$g_j(x,y) > cv_j \Leftrightarrow x\mathcal{CV}_j y \Leftrightarrow j \in J^{\mathcal{CV}}$$

where $x\mathcal{RP}_j y$ and $x\mathcal{CV}_j y$ are the corresponding outranking relations for reinforced preference and counter-veto between x and y respectively.
Let us also denote with $\mathcal{CT}$ the set of *clustered-together* (must-link) recommendations, i.e., iff $(x,y) \in \mathcal{CT}$, then we should boost the algorithm to cluster together the traces x and y, and with $\mathcal{CS}$ the set of *clustered-separately* (cannot-link) recommendations, i.e., iff $(x,y) \in \mathcal{CS}$, then we should boost the algorithm to cluster the traces x and y in separate clusters.
There is no need to modify the partial fuzzy indices, but we need to modify the indices of the Aggregation step. The new indices will be:

$$C'(x,y) = \begin{cases} \dfrac{\sum_{j \notin J^{\mathcal{RP}}} w_j c_j(x,y) + \sum_{j \in J^{\mathcal{RP}}} b_i w_j c_j(x,y)}{\sum_{j \notin J^{\mathcal{RP}}} w_j + \sum_{j \in J^{\mathcal{RP}}} b_i w_j}, & \text{if } (x,y) \notin \mathcal{CT} \\ max\{C\}, & \text{if } (x,y) \in \mathcal{CT} \end{cases}$$

and

$$D'(x,y) = \begin{cases} 1 - \left[\prod_{j \in \frac{J}{d_j} > c_j} \dfrac{1 - d_j(x,y)}{1 - c_j(x,y)} \right]^{(1 - cv/n)}, & \text{if } (x,y) \notin \mathcal{CS} \\ 0, & \text{if } (x,y) \in \mathcal{CS} \end{cases}$$

where $b_j > 1$ the boosting factor for reinforced preference for criterion j and $cv = \left|J^{\mathcal{CV}}\right|$, the number of criteria (out the n criteria in total) for which the counter-veto threshold is crossed.

Handle Outliers

As in any clustering problem, the homogeneity of clusters is heavily influenced by the existence of outliers. One prevalent approach to deal with them is trimming, i.e., removing them and cluster the remaining objects [12]. There is not a single definition for outliers, but as Grubbs [13] early noted, "an outlier is an observation that appears to deviate markedly from other members of the sample in which it occurs". The dominant way to check this deviation is by examining the "*closeness*" of the outlier to a set of other points with a suitable distance metric [14]. In our approach, and given the similarity matrix, such a metric could be the sum of similarities of a trace to all the other ones. The less the similarity, the more distant that object would be among the sample.
Assuming this approach, detecting the most outlying observation is rather trivial. However, if we wish to trim more than one observation, the following problem emerges: Assume we want

to trim 2 observations. To this end, we calculate all the row-wise sums. To remove the first one, we select the minimum sum, and remove the corresponding row. However, since the similarity matrix is a square symmetric matrix, the matching column should be removed as well. The column removal renders the previous row-wise sums calculation useless, so we have to re-calculate them. Apparently, this is a very computationally expensive task. Therefore, in this work, we propose to treat the outliers trimming problem as an equivalent binary quadratic program.

Let $x \in \{0,1\}^n$ be the decision vector that indicates which traces (out of the total n) should be trimmed (outliers). If $x_i = 1$ then the i[th] row of the similarity matrix S is removed, and since the similarity matrix is a symmetric matrix, the corresponding i[th] column is removed as well. Therefore, the entries of S that will be removed are indicated by the matrix xx^T. We want to remove the k traces that have overall the minimum similarity with all the other points.

The sum of these entries can be calculated as the inner product of the similarity matrix and the indicator matrix $\langle S, xx^T \rangle$.

By definition, $\langle A, B \rangle = tr(AB^T) = tr(A^T B)$, so $\langle S, xx^T \rangle = tr(S^T xx^T)$.

Due to the *cyclic property* of the trace $tr(S^T xx^T) = tr(x^T S^T x)$, and because a matrix and its transpose have the same trace, we can write that $tr(x^T S^T x) = tr(x^T Sx)$. Moreover, because $x^T Sx$ is a scalar, its trace is equal to itself, i.e., $tr(x^T Sx) = x^T Sx$.

Because we want to remove k traces, the decision vector x must contain exactly k ones. In matrix format, we can write this constraint as $\boldsymbol{J}_{n\times 1}^T x = k$, where $\boldsymbol{J}_{n\times 1}$ is a vector of ones with dimensions $n \times 1$.

Therefore, we have the following minimization program:

$$\min x^T Sx$$
$$subject\ to\ \boldsymbol{J}_{n\times 1}^T x = k$$
$$x \in \{0,1\}^n$$

which can be rewritten as the following quadratic program by a trivial modification:

$$\min \frac{1}{2} x^T 2Sx$$
$$subject\ to\ \boldsymbol{J}_{n\times 1}^T x = k$$
$$x \in \{0,1\}^n$$

The above quadratic program can be solved by any of the available software tools, e.g., the IBM CPLEX Optimizer, the General Algebraic Modeling System (GAMS), etc. In this work we used the package "quadprog"[15] of the famous computational framework R.

■

CONCLUSIONS

Building on top of previous work, in this short paper we propose a set of actions to further involve the decision maker into the trace clustering process, and thus, to improve the process by addressing the robustness of the outputs. Besides providing a clustering techniques with more compelling performance (Spectral Clustering), we described how the decision maker can guide the results either by reinforcing the effect of his/her preferences, or by allowing a counter-veto behavior to the non-compensatory logic of the algorithm, or by declaring pairwise constraints such as which traces should be or should not be clustered together. In addition, we provided a proof of why the outlier detection problem can be treated as a quadratic program, a proof that is useful beyond the context of the non-compensatory trace clustering. The nature of this work (short paper) leaves much to be desired, so in future, more complete works, sound evaluation sections shall be attached.

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V
DSS Applications in Public and Private Contexts

ICDSST 2020 PROCEEDINGS – ONLINE VERSION
THE EWG-DSS 2020 INTERNATIONAL CONFERENCE ON DECISION SUPPORT SYSTEM TECHNOLOGY
I. Linden, A. Turón, F. Dargam, U. Jayawickrama (editors)
Zaragoza, Spain, 27-29 May 2020

ICDSST 2020 on Cognitive Decision Support Systems & Technologies

Analysis of Graphical Visualizations for Multi-Criteria Decision Making in FITradeoff Method using a Decision Neuroscience Experiment

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ABSTRACT

The use of bar graphics and tables to represent a Multi-Criteria Decision Making/Aiding (MCDM/A) problems are investigated in this study since these visualizations present a holist vision for MCDM/A situations. In this context, these visualizations bring flexibility to the decision-making process conducted in the Decision Support System (DSS) developed for the FITradeoff method, being an important advantage in this method. In order to support this study, the Neuroscience approach is aggregated to MCDM/A and a neuroscience experiment is constructed to investigate how decision-makers (DMs) evaluate bar graphs and tables in order to identify some patterns of behavior. The main task required in this experiment was to evaluate MCDM/A situations and select the alternative which performed best. Based on descriptive and statistical analyses of the results, some suggestions could be made about DMs behavior´s when the visualizations were evaluated. Therefore, for this study, two main purposes were raised: provide insights for the analyst about the use of graphical and tabular visualization in MCDM/A situations and to improve the FITradeoff Decision Support System. Regarding to the first purpose, an advising rule has been built to support the analyst in the advising process performed with the DMs. Regarding to the second purpose was suggested that tables should be included in the FITradeoff DSS. In total, 51 Management Engineering students took part in the experiment.

Keywords: Multi-Criteria Decision Making/Aiding (MCDM/A), Graphical Visualization, FITradeoff Method; Decision Support System.

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Direct Email Marketing optimisation with a Random Forest based approach

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ABSTRACT

Optimisation in digital advertising is a complex task deemed to increase customers engagement and satisfaction. In more detail, optimisation involves not only identifying the right images, template and timing to engage a given customer, but also understanding the context and judge whether the message is actually relevant to the recipient. To be successful advertising optimisation requires taking into account lots of data coming from multiple digital sources such as Customer Relationship Management (CRM), web analytics, and advertising interactions. Although this process could be performed manually by marketing specialists, more recently data-driven methodologies have shown promising results. In this direction, our study proposes an automated system addressing advertising optimisation via a supervised learning approach where decision-making is performed accounting for the latest customers interactions in a near-real-time fashion. Specifically, this work presents a solution for direct email marketing (DEM) composed of three modules: monitoring, decision-making and automation. Monitoring is provided through a web dashboard showing historical performance of relevant Key Performance Indicators (KPI). The decision-making module computes a relevance score predicting how a given email message or sequence of messages are suitable for a specific customer or cluster of customers. Subsequently, this score is used to support the decision process within the automation module in order to deliver fully personalised messages. Experimental results confirm that the proposed DEM management system promotes customer satisfaction minimising perceived spamming. Moreover, DEM activities contribute to boost the revenue without sacrificing the customer's experience.

Keywords: Email marketing, Machine learning, Prediction, Email personalisation, Direct email marketing automation.

INTRODUCTION

Nowadays, digital advertising strategies aim to engage customers over multiple touchpoints where highly personalised content and messages are delivered. Within this

context, direct email marketing (DEM) represents a crucial moment along the customer journey where a sequence of optimised messages could influence customer decisions [1]. Not only this optimisation process may lead to revenue growth but it also promotes a fruitful customer engagement and satisfaction over a long time period. To this end, one of the main challenges in DEM optimisation involves understanding customer needs and preferences in a timely fashion by observing his interactions with all digital sources. DEM optimization takes into account a variety of features including message copy, interactivity, promotions & rewards, illustration and timing. Different permutations of those features may be appealing to different customers: for instance, students tend to be more sensitive to price while business managers could be more interested in comfort [2]. However, when business managers book for their family they may be sensitive to price as well. Consequently, understanding the context also plays a significant role. Historically, this analysis has been performed manually by marketing specialists, while more recently, data-driven methodologies have been extensively tested and have shown promising results [3].

In this paper, we propose a machine learning based approach for DEM optimisation where a variety of data, generated by multiple digital sources such as Customer Relationship Management (CRM), web analytics and advertising tracking are analysed in near-real-time to account for behavioural changes in customer's preferences. This objective is achieved with a classification model that provides a relevance score for a given email message. This classification model is the core of the DEM managing system used in this experiment. The proposed DEM managing system is composed of three modules: monitoring, decision making and automation. Monitoring is provided through a web dashboard showing historical performance of relevant Key Performance Indicators (KPI) such as click-through rate (CTR), conversion rate (CR), and customer engagement. The decision-making module computes a relevance score predicting how a given email message or sequence of messages are suitable for a specific customer or cluster of customers. This score is then used to support the decisions process within the automation module in order to deliver fully personalised messages.

The paper is organised as follows. The next section describes the related work in the field of marketing automation. The third section presents the proposed DEM managing system with a focus on the classification model. Finally, the fourth section shows experimental results and the final section summarises the conclusions and achievements.

RELATED WORK

In the field of machine learning several papers tackle direct email marketing optimisation [3,4,5]. These studies show the possibility of identifying patterns in human behaviours and use them to predict customers interactions or optimise email marketing campaigns. Interesting results are reported by Flici et al. [6] when predicting customers interactions using a machine learning framework. Cui et al. [7] propose a comparison among different classifiers by testing a U.S. based catalogue of direct marketing emails; from this study emerges that a Bayesian Networks (BN) learned by evolutionary programming models reports the best performances. Ma et al. [8] presents a nonhomogeneous hidden Markov model of dynamics response and mailing optimization in the context of direct marketing. In [9] Ładyżyński et al. apply classification trees (CART), random forests (RF) and deep belief networks (DBN) to predict if a specific campaign and contact time will be effective over a customer. Zhu et al. [10] focus more on e-commerce applications where the challenge of purchase prediction is addressed applying a Logistic Regression model in a semi-supervised

learning and multi-view learning. Besides the different goal, this paper contains interesting insights on data modelling procedures for the travel industry. A similar challenge is studied by Lang et al. [11] where a Recurrent Neural Network (RNN) was applied over a set of website sessions recording aiming to predict a purchase event. Despite positive results they remark how poor sessions tracking can compromise the quality of the model.

All the above-mentioned works show strong potential in the application of machine learning models for direct marketing optimisation.

OPTIMISED DEM MANAGING SYSTEM WITH A MACHINE LEARNING APPROACH

The proposed DEM managing system, composed of monitoring, decision making and automation modules, have been applied to two real world scenarios in the travelling sector which provided comparable datasets for processing.

Data

The used dataset [13] integrates multiple sources including: CRM, web tracking, advertising engagement and email marketing interactions. This information is then aggregated creating a rich customer profile describing the propension toward certain products, web navigation habits, and the level of advertising engagement. For instance, from the CRM are extracted features such as number of trips bought, average number of passengers per trip, percentage of trips during working days/holidays, favourite environment (first or second class) or usage of discounts. Complementary features come from web analytics including: website search behaviour, preferred web navigation time (morning, afternoon, evening, night), customer interests toward a product measured by time spent on a certain webpage. Regarding customer interaction with previous email marketing campaigns, features such as the number of emails received, number of emails opened, number of clicks and conversions are computed.

Monitoring dashboard

A web dashboard has been designed for continuous monitoring purposes and historical KPIs evaluation. Given a selected time period, the dashboard shows a variety of aggregated information including emails sent, A\B testing results, along with other KPIs (open rate, CTR, CR). Furthermore, it is possible to perform deep-dives for each single campaign. This dashboard is extensively used by analysts during planning activities and business intelligence explorations; Figure 1 proposes one of the available charts.

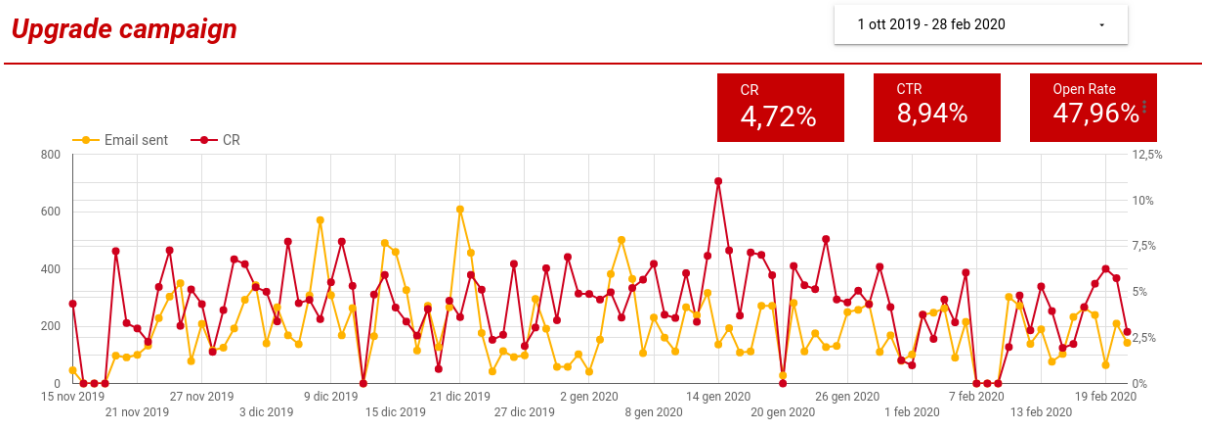

Figure 1: Example of one of the charts available in the monitoring dashboard

Classification model for decision-making

An ensemble learning classification model has been developed to support decision-making in the proposed DEM managing system. The model, a Random Forest classifier, provides a relevance score describing how a given email message could be of interest for the given customer (or cluster of customers). The main motivation behind Random Forest is to tackle an unbalanced and sparse dataset while avoiding overfitting. As validation step, Random Forest is compared against logistic regression, chosen as a baseline for its simplicity and robustness.

Aiming to improve the model accuracy without overfitting, a recursive backward feature elimination step is employed. Given the unbalanced dataset, different oversampling and undersampling techniques were applied, leading to the choice of SMOTE + Tomek Links since delivering better performances against the testing set. SMOTE is an oversampling method that synthesizes new plausible examples in the majority class; Tomek Links performs undersampling making the decision boundary less ambiguous. Throughout a k-fold cross-validation process the classifier hyperparameters, number of estimators and max depth, are selected and used to train the model. Similarly, to identify the optimal relevance score threshold used within the automation module, a selection process is performed. Importantly, the above-mentioned training routines are repeated weekly, in order to maintain the model up to date with respect to new user behaviours.

Within the Automation module the computed relevance score and the optimal threshold, in combination with the customer profile, are then iteratively consumed to: a) optimise the email parameters such as images, template, and sending time. b) Decide whether to fire or not the optimised email to a given customer.

Automation module

As part of a continuous integration pipeline, the automation module is deployed on a Cloud environment. As the first task, this module attempts to optimise an email message based on the customer profile (or cluster of customers) and verify whether the computed relevance score is above the acceptance threshold. If this check is positive the module schedules the email sending at an optimal time. Moreover, the automation module implements an anti-spam filter which controls the maximum number of marketing emails a user can receive during a time period and the time window between two emails in order not to overload user's mailbox. Finally, it offers an A/B testing solution to evaluate performances

against a control group. As it can be seen, this automation module delivers a fast and dynamic decision-making approach towards DEM optimisation.

EXPERIMENTS

The proposed DEM management system has been validated and deployed on two real-world travel companies. The reported performances are evaluated over a 6 months period and importantly, in accordance with European GDPR [12] law, email personalisation is offered exclusively to customers having explicit marketing and profiling consent. Table 1 provides a summary of the experiment size.

Table 1: Summary of the monthly average number of users processed

	Monthly website users	**Users with marketing & profiling consent**
Company 1 Dataset	2,970,00	830,000
Company 2 Dataset	430,000	172,000

This paper evaluates two distinct email marketing campaigns applied in both travel companies: the first campaign consists of a reminder for an abandoned cart, the second is a discount for class upgrade. In detail, the abandoned cart reminder is sent to all customers who attempt to buy a ticket on the website (i.e. the ticket was in the cart) but didn't complete the purchase. The email is fired after around 15 minutes from the abandon and doesn't offer any discount. Differently, the class upgrade campaign offers a discount that expires within 3 days; is available only to a business cluster and the emails are fired at an optimal time based on customer habits. In both campaigns the goal consists of minimising the number of emails sent without sacrificing the revenue. In other words, the challenge involves finding the right balance between customer satisfaction (avoiding spamming) and revenue.

As presented in the previous section, the collected dataset appears unbalanced hence we use f1 score as metric for comparing different approaches. Table 2 presents the performances observed using a logistic regression classifier and a random forest.

Table 2. Comparison of classification performances on historical data valuated in terms of Accuracy (Acc), Precision (P), Recall (R), and F1 score (F1)

		Company 1				**Company 2**			
		Acc	**P**	**R**	**F1**	**Acc**	**P**	**R**	**F1**
Abandoned cart reminder	Logistic Regression	0.93	0.05	0.03	0.04	0.89	0.08	0.15	0.11
	Random Forest	0.94	0.17	0.09	0.12	0.91	0.18	0.24	0.2
Class upgrade	Logistic Regression	0.94	0.28	0.09	0.13	0.94	0.29	0.07	0.11
	Random Forest	0.94	0.29	0.09	0.14	0.95	0.31	0.08	0.12

Experimental results on historical data confirm that Random Forest based classification delivers a better performance compared to the benchmark and this solution is therefore adopted in the decision-making module.

For clarity, Figure 2 reports an example of feature importance for Company 1 dataset used in class upgrade. Interestingly, the three features with highest contribution are: number of trips, travelled in first or second class and number of opened emails with a discount offer. Those are coming from both CRM and email marketing interactions.

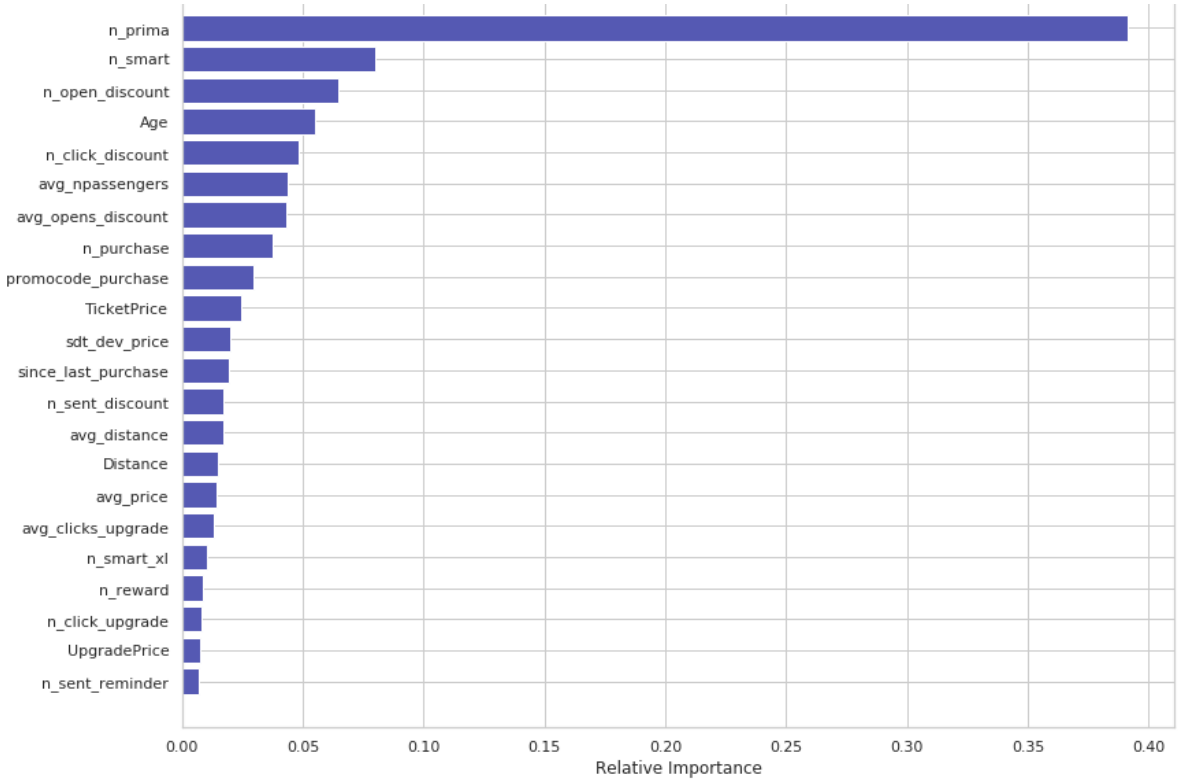

Figure 2: List of a subset of Company 1 dataset's features ordered by importance. Those features are used for class upgrade.

In order to verify the effectiveness of the proposed DEM managing system on live data, an A\B testing validation is performed by the automation module, setting as conversion goal the ticket purchase Specifically, marketing emails are also sent to a randomly selected control group representing 5% of the experiment population. Interestingly, as depicted in Table 3, the observed open and conversion rates appear notably higher when emails are delivered to customers selected by the proposed solution, which consists of 10% of the entire population for the reminder email and 12% for the class upgrade. This result confirms the effectiveness of the methodology highlighting that: 1) in both campaigns emails are delivered to actually interested customers. 2) A high open and conversion rates are associated with customer satisfaction and minimization of perceived spamming. 3) Revenue boost from DEM is achieved without sacrificing customer's experience.

Table 3. A\B Testing results on live data. Open Rate refers to opened email, Conversion Rate to purchased tickets

	Abandoned cart reminder		**Class upgrade**	
	Open Rate	**Conversion Rate**	**Open Rate**	**Conversion Rate**
(A) Selected customers	78.8%	12.4%	83.4%	18.7%
(B) Control group	44.2%	3.4%	48.3%	4.7%

CONCLUSIONS

This paper proposes an innovative DEM management system capable of personalising messages by selecting the most appropriate images, template, and sending time for a given

customer. Additionally, a decision-making approach based on machine learning is introduced in order to judge whether an email message is actually relevant for a given customer within a specific context. This innovative DEM managing system is composed of three modules named monitoring, decision-making and automation. Experimental results on two real-world travel companies confirm the effectiveness of the system underlining that emails are delivered to customers actually interested in the advertisement. The observed open and conversion rates are expressions of customer satisfaction and minimization of perceived spamming. Finally, both direct marketing campaigns deliver an increase in revenue without sacrificing customers experience. Although the obtained results are promising, future improvements could be achieved by exploring different areas such as email wording optimisation, accounting for social network interactions and by testing more sophisticated classification algorithms as deep learning.

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Analysis of a system with non identical unreliable suppliers, multiple non identical retailers and an intermediate distribution center

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ABSTRACT

This paper examines a push-pull system with K ($K \geq 1$) non identical suppliers with disruptions, M ($M \geq 1$) non identical retailers and an intermediate distribution center. It is assumed that K non identical suppliers feed a distribution center which in turn provides products to M non identical retailers. Each retailer satisfies a Poisson distributed external demand of one product unit. The flow of material at the upstream stages (suppliers) is push type. The flow of material at the downstream stages (retailers) is driven by a continuous review inventory control policy (s, S). The replenishment rate of suppliers and retailers is exponentially distributed. More over it is assumed that the suppliers may be not always operational. This is modelled using exponentially distributed failure and repair rates of the suppliers. The considered system is modelled as a continuous time Markov process with discrete states for which the transition probabilities among the various states of the system are derived. The stationary probabilities of the system's states can be computed and used to compute various performance measures of the considered system such as the Fill Rate and WIP.

Keywords: Push-pull systems, supply chain management, merge systems, performance evaluation, Markov processes.

INTRODUCTION

Inventory control has a major impact on the analysis of supply chains. If the inventory is properly controlled, then customers demand can be satisfied on time increasing the service level of the supply chain. One important factor of inventory control is the reordering process. The keys of this process are the review interval, the determination of the order size and the order costs. There are two classes of review systems in the literature. In the first class, inventory is continuously monitored (continuous review), while in the second class inventory is reviewed at regular periods (periodic review).

Important factors that influence the inventory control are the demand distribution, the lead time and the maximum number of outstanding orders. The demand that cannot be satisfied by the inventory on hand can be back-ordered to be satisfied in the future, or can be assumed lost (lost sales assumption).

Noblesse et al. [1], developed an approach to identify the order process of continuous review (s,S) and (r,nQ) inventory policies, and studied the impact of parameter (Q or S-s) on the variability in the order process. They showed that the time interval, during which the number of units ordered is observed, also impacts the level of variance amplification.

Two echelon discrete material supply chains with exponential processing rates at all nodes were examined by Vidalis et al. [2, 3]. They used continuous time-discrete state Markov processes for the performance evaluation of the considered systems. They proposed the appropriate algorithms to generate the transition matrix for any values of the system's parameters in order to estimate the performance measures of the examined systems.

Chen and Li [4], applied the guaranteed service approach to optimize the (*R*, *Q*) policy for a continuous review serial inventory system with Poisson demand and fixed order costs at each stocking location. They also considered fixed order costs and operating flexibility costs in the system.

Diamantidis et al. [5], examined a push-pull merge system with multiple reliable non identical suppliers that sent products to a storage area which was located immediately upstream a distribution center (DC) with parallel identical reliable distribution channels. The finished products were stored in a finished products buffer, located immediately downstream the DC. Customers arrivals were assume to follow a Poisson process. The considered system was modelled as a continuous time Markov process with discrete states and various performance measures were evaluated.

Diamantidis et al. [6], studied a system with two reliable merging suppliers, an intermediate buffer and two retailers following a continuous review, reorder point/order quantity inventory control policy (*s*, *S*). They modelled the system using a continuous time, discrete state Markov process and they calculated various performance measures of the considered system.

Perera et al. [7], examined a single stage, continuous time inventory model where unit-sized demands arrived according to a renewal process. They proved that an (*s*, *S*) policy is optimal under minimal assumptions on the ordering/procurement and holding/backorder cost functions.

Federgruen et al. [8], studied a two-echelon distribution system with a depot and multiple retailers, under random demands. They proposed a new approach using dynamic programming models based on Lagrangian relaxation. The method generated a lower bound via the solution of a single dynamic program (DP) with a one-dimensional state-space. The optimal bound was obtained by maximizing over the vector of multipliers.

Esmaili et al. [9], considered systems with an (*R*, *s*, *S*) inventory control policy with stochastic demand, lost sales, zero lead-time and a target service level to be satisfied. They

used a discrete time Markov chain and presented exact closed-form solutions regarding the distribution of the inventory on-hand level. They also determined the optimal parameter values of the (*R*, *s*, *S*) replenishment policy.

THE MODEL

In this study, a push-pull system like the one depicted in Figure 1 is analyzed using a continuous time, discrete state Markov chain.

It is assumed that K $(K \geq 1)$, unreliable suppliers/manufacturers P_1, P_2,...,P_K send material to a downstream buffer of finite capacity B. The production/transfer rate of supplier P_i is exponentially distributed with mean rate $\mu_i, i = 1, \dots, K$, respectively. The failure and repair rate of supplier P_i, i = 1,...,K is assumed to be exponentially distributed with mean rate p_i and r_i, respectively.

Downstream to the buffer there are M $(M \geq 1)$ retailers R_1, R_2,...,R_M. The replenishment rate (transfer rate) of each retailer R_i is exponentially distributed with rate μ_{R_i}, i = 1,...,M, respectively.

Each retailer R_i, i = 1,2,...,M, applies an (s_i, S_i) continuous review ordering policy. If the inventory level of retailer R_i is less than or equal to s_i, then an order is placed to increase the inventory level up to value S_i. In this case the order quantity of retailer R_i is $q_i = S_i - s_i$.

It is also assumed that each retailer R_i tries to satisfy an external demand that is Poisson distributed with parameter λ_i. The amount of products ordered by a customer is exactly one unit for all retailers.

Blocking of suppliers appears when one or more suppliers finish processing and the downstream buffer is full (Blocking After Service mechanism is assumed). When more than one suppliers are blocked, then supplier P_i has priority in unblocking over supplier P_j if $i < j$, i, j=1,2,...,K. When a retailer R_i places an order and the current number of stored parts in the buffer is less than q_i, then the order is partially fulfilled and the order quantity in this case is equal to the current number of stored parts in the buffer. When more than one retailer places an order and the current buffer level is less than the quantity ordered from the retailers, retailer R_i has priority over retailer R_j to fulfill its order if $i < j$ i, j=1,2,...,M. The remaining parts (if any) are used to partially fulfill the order of retailer R_j. Another major assumption is that there are no backorders, i.e., demand that can't be satisfied from inventory on hand at the retailers and the buffer is lost.

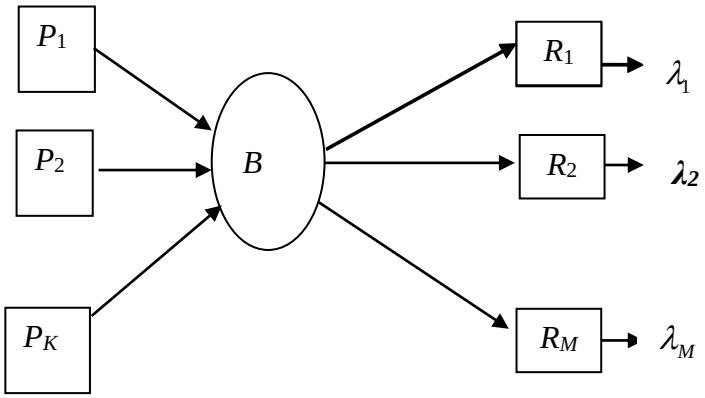

Figure 1: A push-pull merge system with K suppliers an intermediate buffer and M retailers

The state of each one of the P_i suppliers is denoted by $a_i \in \{0,1,2\}$, i = 1,2,...,K. If a_i =1, then supplier P_i is operational. If a_i =0, then supplier P_i is not operational (also called down). Finally, if $a_i = 2$, then supplier P_i is assumed to be blocked.

The number of parts that are stored in the intermediate buffer, plus the blocked parts of the suppliers is denoted by C, ($0 \le C \le B + K$).When C=0,...,B, then 0,...,B parts are stored in the intermediate buffer, respectively. When C=B+i, i=1,...,K then the buffer is full and i suppliers are blocked.

Let I_j be the current inventory on hand of retailer R_j, j=1,...,M. According to the assumptions of the model the feasible values of I_j are I_j = 0,...,S_j.

The state of the system is denoted by vector $S = \{a_1, a_2, ..., a_K, C, I_1, I_2, ..., I_M\}$. The vector of each system state has in total K+M +1 elements.

DERIVATION OF THE TRANSITION PROBABILITIES

The algorithm that generates the transition probabilities uses the following steps:

Step 1: Create the transition probabilities from states where no one retailer places an order

Step 2: Create the transition probabilities from states where at least one retailer places an order, but no one supplier is blocked

Step 3: Create the transition probabilities from states where at least one retailer places an order and at least one supplier is blocked

CONCLUSIONS

A Markov process model of a push-pull merge system with multiple non identical unreliable suppliers, an intermediate finite size distribution center and multiple non identical reliable retailers was examined in this paper. The contribution of this work is that the proposed method can be used for the performance evaluation and optimization of merge-assembly supply chains and help practitioners to make decisions about the optimal design and parameter's selection in order to reduce operational inefficiencies.

From the numerical experiments that have been conducted so far but cannot be presented in this paper due to space limitations, the algorithm yields numerical results with a general structure that agrees with our knowledge and intuition of how the system should behave. Moreover, important monotonic relationships between the system's parameters and the examined performance measures hold. These properties can be used by practitioners to forecast the service level of such push-pull systems.

This model could be used as framework for the analysis of larger scale supply chains with assembly/merging suppliers and retailers that follow the (s, S) inventory control policy.

Another area for further research could be the analysis of a similar system where the involved parameters (demand, processing, failure and repair rate) may follow phase type distributions.

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A Decision Support System for working time management through an ERP

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ABSTRACT

The digital transition of companies has made the use of software for the management of their commercial, logistical and financial activities part of their daily life, and the list goes on and on. Each sector of the company has a module that centralises the resources it uses within this software. Ensuring the homogeneity of the information, guaranteeing that it is updated in real time, allowing better management of processes and facilitated coordination between departments, is the raison d'être of the ERP, and it does this successfully. Nevertheless, in this ocean of information that occupies more and more space every day, the user may find himself faced with a difficult choice as to how to allocate his working time. Data storage and availability is provided by the software, but the exploitation of the data is a task for the user and his subjectivity. Thus, misinterpretation is possible, leading the user to allocate working time to a task that did not deserve it to the detriment of another task that would have been more beneficial. However, time has this very unpleasant property: when it has passed, it is definitely passed. The recommendation system we are working on is based on the following principle: when the user works on a task, the stopwatch records the time spent and counts it. We thus know precisely the time that has been allocated to each client (to enter a quote or prepare an order for example) or to each project (mainly for the planning part). It would make it possible, after defining the criteria according to which you want it to guide decisions, to propose to the user an allocation of his working time that satisfies the conditions initially specified, thus limiting the risks of inappropriate interpretation and generating a dead loss for the company.

Keywords : Recommender System, Time Management, ERP, TAM

INTRODUCTION

The notion of decision, whether individual or collective, is sensitive for the company because of the consequences, which flow from it. It is so difficult to accurately predict the uncertainty of these consequences that the wisest option in the eyes of the decision maker sometimes turns out to be the status quo, and postponing it to a later date. Thus, it happens that a decision is not taken, in order to avoid making a bad one. In all decision making, time is the key factor, and this resource is usually limited. Before IT offers tools capable of producing statistics in real time, the decision-maker and all those involved in the decision-making process had to think about all the possible decisions, measure all the possible consequences, and critically examine each of them for a chance to make a rational choice [7]. Today, business management software eliminates most of the tedious tasks involved in making the calculations used to measure the consequences of any variation in a given sector. Thanks to software, we can obtain a state of the current situation in real time, and sometimes even an anticipation of the future situation, therefore a forecast, but despite this significant advance, making a decision remains complex. Indeed, in order to rule, the decision maker must synthesize the information at his disposal to extract what he considers to be decisive. However, the volume of information is sometimes so large that it becomes harmful.
This is why it could be interesting to use a different approach, namely time, by counting the time spent by the user on a task, an action or a process, and by proposing decision alternatives which take into account this essential unit of measurement which is time.
In the following article, we will explain the interest that we could have in applying the power of decision support to time management in a professional environment. It begins with a presentation of the state of the art of employee working time management by an ERP, where we take stock of what is currently integrated in the most widespread software, followed by a reconciliation between time management and decision support [6], where we describe the type of choice that the manager is facing to manage the working time of his team and where we discuss what could relieve him in his decision-making, and finally, the exposure of the multi-criteria model intended to serve the recommendation system which will be developed later.

STATE-OF-THE-ART OF ERP

Most companies use software to manage their business. Standard management software may be perfectly suitable for a company that only needs basic functionality such as commercial management, inventory management or customer management. On the other hand, when a company wants to manage and monitor all the information and operational services that make up its business, it uses an ERP (Enterprise Resource Planning). The objectives of this tool, which is part of the digital transition of companies, are multiple:

- Ensuring centralization, security and rapid access to information
- Automate repetitive and time-consuming tasks (hunting for low added value)
- Improve organization among employees and communication between departments
- Plan tasks and coordinate [3] stakeholders
- Analyze performance and profitability in real time
- To have all the useful information on its staff, customers, products, suppliers and subcontractors

In addition, ERPs are also used for Time and Activity Management (TAM). Thus, department heads, whose mission is to organize the activity and guarantee the productivity of their department through the operational planning of their teams, are assisted by the software which allows them to offload a number of controls and data entry operations to concentrate on more strategic operations. TAM creates a climate of trust and transparency by making the monitoring of staff working time, both in terms of consultation and organisation, more reliable. Indeed, the accuracy of input information guarantees infallible processing on output.
The major challenge in setting up a TAM is optimal operational management, i.e. planning the right person, at the right time, for the right activity, while controlling the associated costs. To achieve this, it is necessary to globalise the management of all the company's processes, which is the very principle of ERP. The combination of ERP and TAM offers the company comfort and security in its operations and allows it to develop in an appropriate context.
Nevertheless, the provision of such a large amount of information and functionalities to steer the company can make it difficult for the user to assimilate. Even if the user is trained to use the tool in the context of his work, he may find himself faced with complex decision-making as the offer is so large. This is where decision support in the context of TAM would be useful.

DECISION-MAKING FOR TIME MANAGEMENT

In a company, the manager must make choices to define the overall strategy. Employees must then follow this strategy and direct their work accordingly. The decision-making process, which allows for rational arbitration by analyzing and describing alternative decisions and their consequences [5], [6], takes time. The ERP user is usually confronted with choices that may seem trivial but are nevertheless essential. However, the user is likely to make the wrong choice in allocating his working time on the ERP to best meet the criteria of the decision-maker (the manager).

Interpretation of the user's choice of leader

When a manager defines strategy, he or she sets the lines to be followed by each sector of the company. For example, the sales division knows its sales objectives, the purchasing division controls its budgets, or the communication division has its development axes.
Notwithstanding the knowledge of this information, the user must make decisions to adapt his work to fit this strategy. Indeed, it would be difficult for a department manager to carry out

the daily task assignment of his team members in an individualized manner. This could be misperceived by staff as infantilization and a lack of trust on the part of management. The employee knows that he or she has goals to achieve and it is up to the employee to organize his or her work and make the right choices to achieve them [6]. It is at this stage that the user will need to allocate time to select the task he wants to work on. He will analyze the progress of the operations in progress in his area and then determine the order in which he will process the pending tasks. It turns out that his collaborators act in a similar way to achieve the same objectives with the same schedule. As a result, the risk of a lack of coordination is high, and even if communication within the department is excellent, there is a high probability that the user's choices will not take into account all the constraints imposed by the decision-maker with the predefined level of weighting.

The accuracy of the ERP's suggestions to the user

Unlike the user, the software processes the constraints defined by the manager instantaneously and without any possibility of error. It analyses the information available in the company's database and compares it with the objectives to propose satisfactory recommendations in real time, taking into account suggestions that may have been made to other users previously, thus avoiding possible collisions in tasks or malfunctions in team coordination.

PROPOSAL OF A MODEL

In the case processing that will follow, the objective is to find the best activity, based on 3 criteria among several alternatives, each evaluated according to the combination of these criteria.

The criteria

The nerve center of ERP is the matching of resources and the real needs of the company. Thus, when a decision maker is confronted with a decision problem, the criteria must be able to be dynamically selected to take account of his requirements. Indeed, the number of criteria must be able to vary according to the type of choice with which it is confronted. On the one hand, the department of the company in which the user is located is decisive in the nature of the criteria to be used to carry out the classification of alternatives aiming to make a recommendation, on the other hand, the strategy imposed by the manager must take precedence over the manager's preferences. Consequently, certain criteria are essential and imposed in the model.
The problem being the management of the working time of the collaborators of the company, we selected the main criteria which the university works in management consider as being essential [1], [2]:

- Innovation
- Prospecting

- Sale

Evaluation of weights by AHP

AHP is a simple, fast, flexible, and easily adaptable decision support approach. In our case, the method of binary comparison matrices [3] makes it possible to arrive in a simple and efficient way at weight vectors which we will present in the following summary table. Beforehand, we followed the classic method of decomposing the problem and transforming judgments into numerical values (Saaty scale) [4].

Table 3.1: Definition of criteria weights [8]

Criteria / Criteria	Innovation	Prospecting	Sale	Priority
Innovation	1	1/3	1/3	0,14
Prospecting	3	1	1/3	0,23
Sale	3	3	1	0,60
Sum	7	4,33	1,67	

The matrix is based here on the experience of a manager of the commercial and marketing sectors of a medium-sized company according to his preferences on the criteria imposed by the manager in his overall strategy.

The alternatives

A recommendation can only be consistent by taking into account the attributions of each employee, which directly depend on belonging to the department for which he works. Thus, the alternatives available for the recommendation must be preselected according to the department of the user to whom they are addressed. It would be inappropriate for a user to be assigned a task that he is unable to perform due to incompatibility of skills. It is therefore essential to make a preliminary work of correspondence between the alternatives and the services of the company.
Among these alternatives, here are some examples:

- Loyalty Mailing of new customers
- Lead Referral Offer
- Welcome offer
- Discount for customers who have already achieved a high turnover

We must be aware of the limit of validity of the criteria [4] allowing to classify these alternatives, but apart from this certainty, the model works.

CONCLUSION / OUTLOOK

In the context of the digitalization of the economy, all companies are encouraged, both by state institutions and by the market, to use software to manage their business. To such an extent that this digital transition is part of regional support programs, direct or indirect aid schemes, in order to ensure the maintenance and development of the competitiveness of companies, and to encourage digital transformation. Artificial intelligence is one of the major digital innovations from which no country would wish to be excluded, given the high stakes involved.

Companies are at the heart of this transformation and are relying on artificial intelligence to gradually revolutionize the way they operate, notably by relieving them of the most tedious tasks in favor of others requiring more expertise.

In recent years, ERP systems have integrated functionalities whose performance and stability have made it possible to considerably improve the internal functioning of companies. However, none has proposed a recommendation system to manage the activity of employees.

After the selection criteria have been duly filled in and weighted, the system that we are going to develop will analyze previous data, allocate tasks by user, plan tasks for each user, recommend tasks to user, or the updating of the process in case of taking initiative.

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Improving urban mobility services through citizens participation in a socio-technical transition context

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ABSTRACT

The increasingly easy access to technology, namely in the case of Information and Communication Technologies, has been significantly changing the way people interact. In the urban mobility context, new business models have also changed how and why people move. These changes are the reason for the design of a new approach to urban mobility, based on an integrated service, joining different service providers and local citizens.

Some characteristics of urban mobility problems are suitable to be studied using a service design approach, since mobility systems involve multiple stakeholders, with different needs. Some stakeholders may benefit from interacting with other stakeholders other than the service providers, in a real co-creation process. Co-creation can be increased if these multiple interactions are well understood and supported by well-conceived tools.

We believe that an integrated information system (IS) developed with a service design approach can adequately respond to some current challenges in decision-making and information access, for transportation and mobility. Such an IS should be able to provide information to different groups of stakeholders, helping them to make better decisions, and improving the transportation network efficiency. The design of the IS should also include the design of tools to enhance communication.

To promote collaboration and participation, we have developed a methodology that supports the design of an integrated service to improve urban mobility management. This methodology includes the analysis of the stakeholders, the analysis of interaction channels, and the design of the information system that will support the service offer. In this paper, we focus on the interactions that citizens may establish among them, thus enabling the co-creation of information that supports their decisions. We apply this methodology in a case study defined in a metropolitan area in the north of Portugal.

Keywords: urban mobility, information systems, collaboration, stakeholders, decision-making, service design.

INTRODUCTION

Urban planning has been shaped by the evolution of technology. Now, these changes have also impacted business models and urban mobility. In the last years, we have witnessed changes caused by the evolution of information and communication technologies (ICT) and digitalization, along with an increasing climate change awareness. The adoption of different behaviours by local citizens reflects these changes. Spickermann et al. [1] mention this period as a *socio-technical transition* where organizational and institutional changes are implemented alongside technological developments.

We argue that an integrated approach to urban mobility may facilitate the deployment of new and better solutions. To implement it, we propose the development of an integrated, multichannel service, designed to promote the collaboration and participation of different groups of stakeholders. Such service is to be supported by an information system that facilitates access to more accurate information. In the end, more informed stakeholders will make better decisions. The development of the IS must include an analysis of the stakeholders and their interactions so that proper channels are designed. To promote information sharing, the IS should incorporate many-to-many interactions instead of simple interactions between citizens and service providers. Services based on many-to-many interactions enable value co-creation within complex stakeholders networks [2].

Quite often, urban mobility services focus on one-to-one interactions between local authorities and citizens, or between transportation service providers and citizens. To shift the focus to many-to-many interactions, it is essential to include the interactions between citizens. In the citizens' perspective, these interactions can simplify the process of obtaining information; and, in the view of service providers, these interactions can improve their service level, as more customers are fulfilling their needs.

In our study, we have developed a conceptual framework to design an integrated IS for urban mobility [3]. The main objectives of this IS are to support the design of urban mobility policies in a participatory environment, and information sharing between stakeholders to help multilevel decisions. To design proper interaction channels, we have developed a methodology that covers the analysis of stakeholders and their interactions, and the identification of suitable tools for communication. As part of the design of the IS, it is necessary to redesign some processes and develop tools, to include citizens' participation.

In this paper, we describe some preliminary results on the analysis of citizens' profiles and their interactions. Moreover, we discuss how facilitating those interactions can improve service levels and citizens' experience.

METHODOLOGY

We have adopted a multidisciplinary approach to city mobility, considering four dimensions: social, urban, technological, and decision-making. Being of a qualitative nature, this approach includes a literature review, experts' consultation, and questionnaires and interviews with the different groups of stakeholders. We use a metropolitan area in the north of Portugal as a case study.

The social and urban dimensions of our problem are addressed in the analysis of the groups of stakeholders, including the identification of the groups and their interactions in the urban mobility context. The technological dimension is covered in the analysis of existing methods and tools for communication in urban mobility services. Although the decision-making dimension is not directly studied, it is considered throughout the study, in the analysis of the processes that lead to different types of decisions.

In this paper, we present the example of a citizen using information from multiple sources, to support a simple decision-making process. We also describe some advantages for service providers to allow citizens to interact directly with other citizens.

STAKEHOLDERS' INVOLVEMENT IN SMART SUSTAINABLE CITIES

Stakeholders' involvement has been described as a precondition for sustainable mobility [4], and it is proposed by the guidelines for Sustainable Urban Mobility Plans (SUMP) [5]. The importance of involving stakeholders in the design of smart sustainable cities is twofold: (1) it improves public participation in policy design processes; and (2) it enhances knowledge co-creation by promoting information sharing and transparency [6]. Since solutions for smart sustainable cities are supported by technological tools, the involvement of stakeholders should also be included in the design of those tools to assure their success.

Stakeholders can participate with different levels of engagement, as discussed by Lindenau and Böhler-Baedeker [4]. Therefore, using a structured procedure to increase their engagement transforms stakeholders from passive to active actors, making them partners in the co-creation of solutions for smart sustainable cities [7].

The right tools must be available in order to achieve a participatory and collaborative environment. Web 2.0 technologies, such as wikis, blogs, and social networking services, have been used in government initiatives and have the potential to increase citizen participation. Nonetheless, their implementation requires an adaptation of organizational processes so that their adoption is really successful [8].

PRELIMINARY RESULTS ANALYSIS

Stakeholders' profiles

To enable the participation of stakeholders, it is important to learn who they are, and what are their needs. We have analysed several patterns of stakeholders, based on the literature and experts' consultation. From that analysis, three main groups of stakeholders were identified (planners, urban services, and citizens), with these groups being further divided into subgroups. In our context, the urban planners' group includes urban and mobility planners that design urban policies that will impact transport services. The urban services group covers passenger services (private or public), logistic service providers, and other urban services such as utilities' maintenance. The citizens' group represents the demand side of the transportation network. Since the focus of this paper is on the citizen to citizen interactions, here we only detail the profiles of this group (Figure 1).

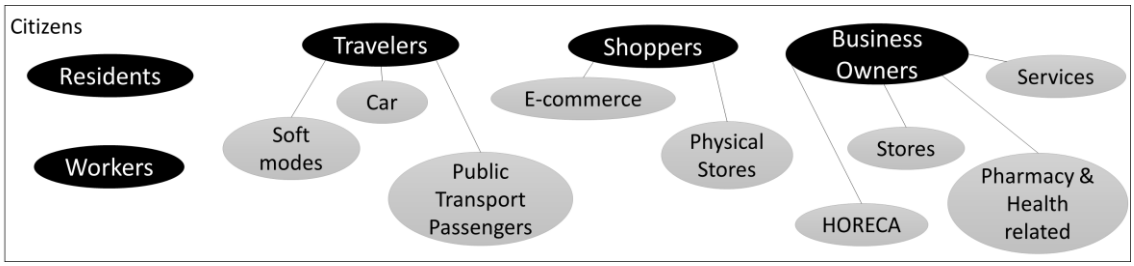

Figure 1. Citizens subgroups and profiles

The group mentioned here as *citizens* represents all stakeholders that only use the transportation system and have no decision power about the transportation offer. However, their behaviour may significantly affect the efficiency of the system. We have identified five

subgroups (residents, workers, travellers, shoppers, and business owners), which may encompass more than one profile. Differentiating the profiles helps to understand their concerns, and to identify the different needs that will depend on the motivation behind each journey. Different motivations will result in different behaviours since factors such as congestion, accessibility, parking, or public transport availability will influence citizens' decisions. Moreover, different motivations will require different interactions and different types of information.

Residents are the ones that live in the neighbourhood. If they have a car, they might not have a garage, and they will need to search for parking. Nonetheless, they will need parking during the night, while shoppers, workers and business owners need parking during the day. Moreover, commuting habits are changing due to the flexibility provided by technology, as proven by the amount of people working from home during the COVID-19 pandemic. Those people do not leave the neighbourhood during working hours. This can increase parking pressure and reduce the demand for public transport in specific neighbourhoods, in peak hours. On the other hand, even if residents have a car, the municipality should assure a good public transport offer so that they can reduce car dependency. Moreover, walkability cannot be ignored because it is expected that local activities are accessed by walking. And another factor that is recognized as impacting residents more than other groups is noise. During commuting trips, residents adopt a worker behaviour and may have similar concerns. However, the neighbourhood will be the destination for workers and the origin for residents.

Workers, shoppers and business owners have similar needs if they travel to the same destination. Their concerns relate to schedules of public transport or parking availability. The cost of parking has a significant impact on the behaviour of this group because they will use it every day, for a long period. This aspect reinforces the importance of the public transport offer in the region, as this would be a cheaper option that reduces concerns regarding parking costs. People in this group may also perform some local activities during lunch hours by using soft modes. Moreover, there is the specific case of business owners, that negotiate the conditions and timing of deliveries, thus impacting logistics operations. This will require a different type of information and regulations, since they will have specific goals according to their business sector (HORECA, health, retail, etc.).

The subgroup of travellers refers to passengers of transportation services, car drivers or users of soft modes. Anyone in one of the previously mentioned subgroups can be a traveller at a particular moment. However, since their role changes, their behaviour will also change. As travellers, people are concerned with the efficiency of the network, while as workers or residents, they will be more concerned with air quality and noise. Moreover, travellers can be in transit to go home, to go shopping or other leisure activities, or they can be commuting. This will also induce different behaviours during the trip.

Stakeholders' interactions

Regardless of having different motivations, as users of the transport system, all stakeholders share the same space and infrastructure. So, they may have information about the system that other stakeholders may need, depending on their specific perspectives of the network. To illustrate how citizens can interact and share information, we briefly present the case of the owner of a private car who wishes to shift to soft modes but needs information about relevant regulation. In reality, the availability of such information may have an important role in the adoption of new transport modes by many citizens.

The conventional process to find information concerning regulations includes searching for the information *online* (indirect interaction with the municipality) and contacting the

municipality directly, by using info desk channels. However, there are two possible moments of the process where the interaction may not be successful, decreasing the user experience. The first failed interaction may happen when the citizen (the system user) is searching for information and does not succeed to get it. This may be caused by several reasons such as: the user does not know where to search; the user finds the information but is unable to understand it; the information had not been made available by the municipality; the user finds some information, but it is not complete. If this step is not completed successfully, the user still needs to contact the municipality for questions. In fact, we have found that the municipality receives too many requests or complains and is often unable to answer in a fast way and in useful time. It is when a second unsuccessful interaction may occur. To overcome this issue, introducing the possibility of getting information through other channels has advantages for both the user and the municipality.

Since the process of contacting the municipality can be quite slow, due mainly to waiting times, promoting the contact among citizens can have considerable benefits. Moreover, for the municipality, this means that fewer requests will be received, and that will free human resources. As such, there are two main advantages in the service provision side: there will be more resources to assign to other tasks; and the same resources can answer to more requests, thus reducing waiting time for citizens that still need to contact the service providers. In the long term, redesigning the process of obtaining information can improve the overall experience for all. Some citizens will not need to contact the municipality, those who need to do it will be better served, and the municipality will provide a better service level and have better resources management.

An integrated information system for digital interactions

To redesign how people interact and share information, it is necessary to rethink the multiple information systems as one integrated information system (IS) through which different stakeholders can send and access information (Figure 2). This IS will provide multiple digital channels to support many-to-many interactions among stakeholders.

A central server and database that stores information from various sources and is accessible by the different users can create the ideal scenario for efficiently sharing information. There can be different software applications built on the IS (web, desktop, mobile) according to the activities performed by the users. These applications will have access to the same information.

Considering the aforementioned example, while searching for a specific regulation, a citizen can interact with the municipality or with other citizens, and the information will be the same. Interacting with other citizens can be the solution for the cases when a direct interaction with the municipality fails.

Other information can be available in the IS, such as local mobility services from public transport operators, and logistic service providers. The system will reduce vertical communications (citizen – institutions) and increase horizontal communications (citizen – citizen).

To support these many-to-many interactions, different tools may respond to different types of communication requirements. The case presented here does not require real-time information, as there is not an instantaneous decision depending on that information. However, in some cases, access to information needs to be faster, as when planning a trip and deciding the transportation mode and the route. In these cases, citizens may resort to different tools. These tools will also be useful for the municipality, when performing public consultation for new urban policies.

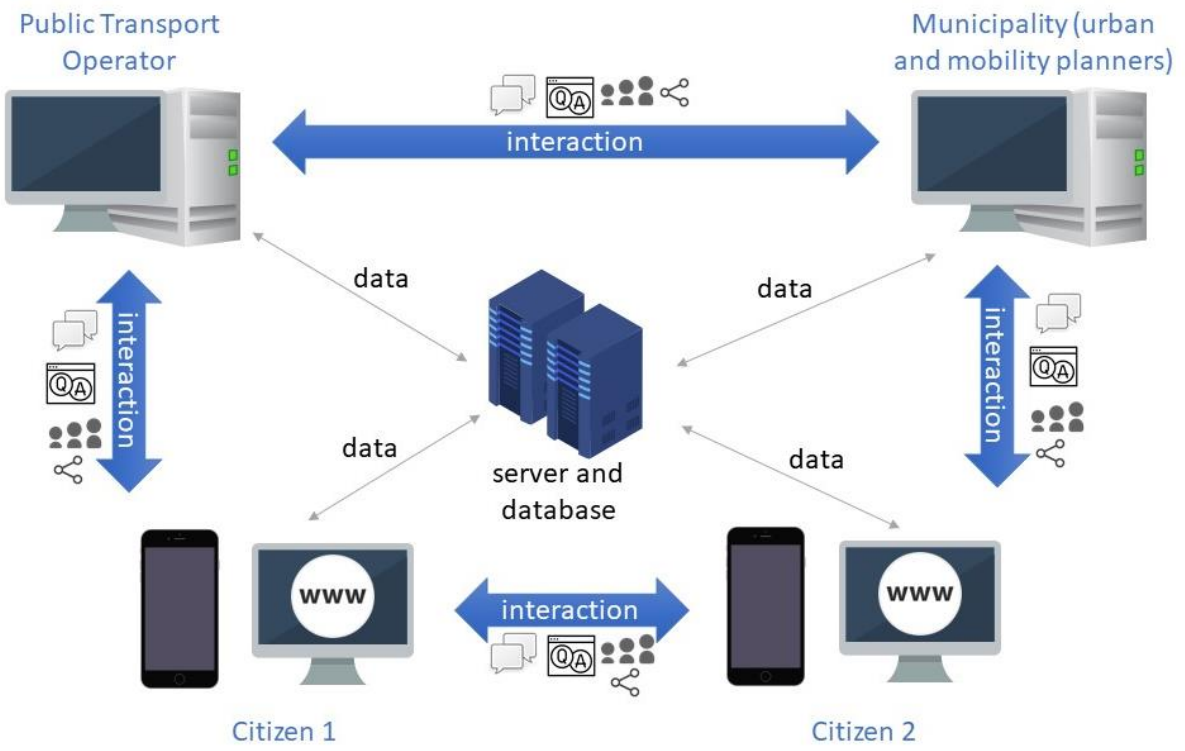

Figure 2. Integrated information system

We have identified four main potential solutions based on Web 2.0 technologies: chat rooms and messaging solutions; web forums; social networks; or mobile applications (Table 1). These solutions present different characteristics regarding the number of participants, type of interaction, and response time. These characteristics are, in our perspective, those that have the highest impact on the user experience. The type of interaction can be *direct* or *indirect*. A direct interaction means that there is someone on the other end, who will reply. An indirect interaction does not require an answer. In this case, the user may be posting information or consulting information already available.

Table 1. Interaction tools and their characteristics

Tool	Type of interaction	Participants	Moment
Chat rooms and messaging	Direct	One-on-one	Instantaneous
Social networks	Direct and indirect	Community	Continuous
Web forums	Direct	Community	Continuous
Mobile applications	Indirect	Community	Continuous

CONCLUSIONS

The complexity of stakeholders' interactions in an urban environment, and particularly for urban mobility, is raising new challenges in information sharing. However, technology developments allow redesigning decision-making and information sharing processes by explicitly including the participation of different stakeholders. In this work, we take advantage of digitalization, redesigning those processes and using a service design approach to develop an integrated IS where all stakeholders can get the information they need to support their decision-making processes. The integration of service design concepts helps to better understand the

value network that can be developed if the proper tools are used to enhance communication among citizens.

One of the processes where citizens can co-create value is *information sharing*. Since some citizens can already have information that may be useful to other citizens, we propose the development of mechanisms for citizens interaction as a way to improve info desk services' efficiency. Focusing on the perspective of citizens, this work is a contribution to the definition of stakeholders' profiles and tools that can be implemented to enhance their communication. Considering, for example, the case of a person searching for information regarding regulations, the participation of other citizens in the process can improve the overall service experience for citizens and the service level of the municipality.

Future research should include the perspectives of the municipality (e.g., policy design) and the transport operators (e.g., using qualitative data from citizens to improve infrastructure maintenance plans).

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Two Sides of Collective Decision Making - Votes from Crowd and Knowledge from Experts

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ABSTRACT

This paper deals with the role of experts and crowds in solving important societal issues. The authors argue that both experts and crowds are important stakeholders in collective decision making which should jointly participate in the decision-making process to improve it. Usually studied in different research areas, there have been a few models that integrate crowds and experts in a joint model. The authors give an overview of the advantages and disadvantages of crowd and expert decision making and highlight possibilities to connect these two worlds. They position the research in the area of Computational Social Choice (COMSOC) and crowd voting, emerging fields that bring great potential for collective decision making. COMSOC focuses on improving social welfare and the quality of products and services through the inclusion of community or clients into the decision-making process. Despite these altruistic goals, there are several shortcomings that call for the engagement of experts in voting procedures. The authors propose a simple participatory model for weighting and selection of voters and votes through the integration of expert rankings into crowd voting systems.

Keywords: Crowd, Experts, Collective Decision Making, Voting, Computa-tional Social Choice (COMSOC), Participatory Models.

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Using Multi-armed bandits for Ski injury resource allocation Decision Support System

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ABSTRACT

Resource allocation of equipment for mountain ski rescue service is a very challenging task for the ski resort management. Ski injury occurs and proper equipment needs to be allocated in order to intervene. In this paper, we propose a model for equipment allocation based on the context of the allocation process. Namely, those are ski slope features, skiing properties at the ski slope, weather, etc. For the problem at hand, we utilized contextual multi-armed bandits which find the probability to allocate equipment for the given context. The proposed model works on the hourly level for a given ski slope and learns the equipment allocation model based on daily ski-related data. The model was trained and tested on the Mt. Kopaonik, Serbia ski resort data and it has been shown that the proposed model needs no more than 20 days to learn a model which is better than the traditional equipment allocation models used in ski resorts.

Keywords: Ski injuries, Contextual multi-armed Bandits, Decision Support System, Resource allocation.

INTRODUCTION

Skiing is very popular, especially in Europe and the United States, with approximately 400 million skier visits worldwide [1]. Having that amount of ski visits and injury rate of approximately 0.2% [2] it is expected to have almost 800,000 ski injuries worldwide. This poses a severe threat to persons' health with injuries most often being a temporary or permanent movement disability. One way to soothe the damage of injury is timely identification of the ski injury and timely reaction from mountain rescue service.

Although ski-related sport and leisure are very popular industry decision-making process is seldom based on data at hand, but mostly based on opinions and experience. However, more and more ski resorts are implementing RFID readers in order to improve decision making [3]. In other words, based on RFID readers and surveillance cameras a huge amount of data about skiers is generated which can be used for informed decision making. One of the main challenges in ski resort management is equipment allocation of mountain ski rescue service. Mountain rescue service, as a main incidence response team, needs to carry a lot of equipment in order to respond to ski-related injury, but the resources are scarce and must be

distributed all over the ski resort at one point in time. The limitation of the resource is viewed in both manpower and the size of the backpack of a rescuer. Most often, mountain ski rescue service carries a basic set of equipment and if an injury occurs that they are not prepared for they call for a backup with proper equipment set.

A solution presented in this paper proposes the usage of multi-armed bandits for resource allocation of ski injury equipment. Multi-armed bandits are a stochastical framework in which a set of so-called arms are pulled in order to obtain maximal gain. In this paper arms present rescue equipment carried by mountain ski rescue service. Therefore, the model learns which equipment should be carried so intervention can begin without waiting for the proper equipment. Experiments are conducted on an hourly level for a specific ski slope. The benefit of this approach is that selected equipment is adjusting over time with the change of injury occurrence. Additionally, at the beginning of the learning process when data is not available proposed methodology can work and after some time it will be better compared to traditional approaches. In order to make a better decision on which equipment to select we utilize information about the ski resort or ski slope at the time when the decision must be made.

We would like to answer two research questions one being can we allocate resources of mountain rescue service in advance, without prior knowledge, and other being how much data (i.e. days) is needed to learn a model of resource allocation to be better than the traditional approaches.

The remainder of the paper is structured as follows. Section 2 provides a literature review on ski injury predictions. Section 3 provides a methodology of the research providing a brief description of the data, multi-task learning, and experimental setup. Section 4 presents results and discussion of the results, while Section 5 concludes the paper.

LITERATURE REVIEW

Ski injuries are a subject of interest for a very specific group of research. Most often, classical statistical analysis is conducted. More specifically, small-scale and case-control studies are performed where the effect of one variable is tested by comparing small subsample of skiers satisfying variable of interest and the remainder of the skiing population. As a result, one can find odds ratios or risk ratios for different properties of skiing, for example, differences in injuries regarding gender [4], skiing experience and equipment used [5], or quality of ski lifts and ski slopes as well as weather conditions [6].

Information about odds ratio and risk ratio is important for educational purposes, i.e. skier can be informed about the increase of odds of injury if the helmet is not used, or if snow conditions are not good. However, the obtained information is not suitable for real-time decision making. As a solution, one can find applications of data mining and machine learning models. Predictive models have shown better predictive performance compared to classical statistical analysis as shown in [7]. One can also find usage of simpler predictive models such as CHAID decision tree for an explanation of ski injuries [8] and also more complex methods aimed specifically for the explanation of predictions in ski injury predictive models such as SHAP and Lime [9]. The interested reader is referred to [10] for a more detailed literature review.

The downside of all research is that it requires historical data to be available at the moment of model learning. The research question that arose was what can one do if data is missing and the mountain ski rescue team needs to be allocated. In that case, one must choose wisely how to distribute the mountain rescue service and proper equipment on the ski resort. Therefore, we propose the usage of reward-based methodology for online learning of resource allocation called multi-armed bandits. Multi-armed bandits present a stochastic

framework that simultaneously performs exploitation and exploration in order to obtain the best reward. The reward can be defined as carrying proper equipment for the ski injury.

METHODOLOGY

In this section, we will present the data used in this research. Further, we will explain multi-armed bandits and, finally, provide experimental setup.

Data

The data used in this research was obtained from the ski resort Mt. Kopaonik, Serbia. This ski resort has in total 20 ski lifts, from which only three most difficult ones are used for the experiment. Those are Karaman greben, Mali karaman, and Duboka 1. In this research, we utilized all ski lift gate entrances from season 2005/2006 to season 2011/2012. Ski lift entrances are obtained using RFID checkouts of ski tickets which are needed in order to start skiing on the lift. This data was combined with ski injuries data and also with weather-related data. After integration, aggregation and preprocessing, the resulting dataset contains 110 input attributes and 20 label attributes while the number of examples depends on a ski slope. Input attributes present context based on which resource allocation will be performed (for the multi-armed bandit methodology) and those are characteristics of the ski slope, skiing population at the slope (i.e. a number of skiers, their time on track and number of slopes they skied in previous hours, weather) for one hour and one ski slope and weather conditions, while labels present the type of injuries for which specific equipment is needed in the following hour. Ski slope Karaman greben had in total 3,516 examples from which 12.83% of examples contained some type of injury, while Mali karaman and Duboka 1 ski slopes had 3,244 and 2,436 examples and 8.27% and 11.48% of examples with an injury respectively.

Percentages of injury types are presented in Table 1. As one can observe, the most common injury is knee injury which occurs in three or four percent of the cases, while notable injuries are shoulder, shin, and forearm.

Table 1: Percentage of injuries per ski slope

Slope	Karaman greben	Mali karaman	Duboka 1	Slope	Karaman greben	Mali karaman	Duboka 1
% Scalp	0.54	0.43	0.65	**% Thorax**	0.26	0.19	0.08
% Face	0.88	0.37	1.14	**% Abdomen**	0.14	0.09	0.041
% Neck	0.03	0.06	0.12	**% Hip**	0.26	0.03	0.20
% Shoulder	1.12	0.68	1.59	**% Thigh**	0.26	0.25	0.37
% Upper arm	0.17	0.12	0.20	**% Knee**	4.13	2.90	3.52
% Elbow	0.37	0.19	0.12	**% Shin**	1.14	0.83	0.98
% Forearm	1.03	0.52	0.65	**% Ankle**	0.46	0.25	0.37
% Wrist	0.88	0.68	0.33	**% Foot**	0.06	0.00	0.00
% Hand	0.26	0.15	0.12	**% Pelvis**	0.11	0.06	0.12
% Arm fingers	0.43	0.25	0.65	**% Spine**	0.26	0.22	0.16

Contextual Multi-armed bandits

In this paper, we utilize contextual bandits which are also known as associate reinforcement learning which is a specific formulation of multi-armed bandits characterized with an iterative process where an agent chooses from a number of choices with a stochastic reward. Mathematically, there are a fixed number of choices of equipment set for the ski rescue service k, from which model choose one as his action a_t at each round t. At the beginning of each round environment is explained with a set of features x^t which presents the

context of the resource allocation process at time t and it contains m features. The context in this paper presents information about the state of a ski slope at the time t such as a number of skiers at the ski slope, their daily activity level, weather data, etc. Each choice has its reward described with Bernoulli distribution which is a function of environmental features and can be described as $r_k^t \sim Bernoulli(f_k(x^t))$. The agent uses the history of contexts presented in matrix X, choices A and observed rewards R in order to learn which choice has the highest probability to return the best reward. Once the agent knows the context x^t the choice is made and the reward is calculated. Function $f_k(x^t)$, or more specifically r_k^t can be learned using historical data by any machine learning or data mining model. In this paper, we utilized logistic regression as it is most common for a given task. The objective is to maximize the rewards obtained in the long term without a time limit. The problem that occurs is that exploration and exploitation trade-off exists. Namely, the algorithm needs to explore choices in order to find the best reward but at the same time exploit the choice for the best reward. [11]

In this paper, we used four contextual multi-armed bandits. First, two algorithms are based on finding upper confidence bounds. Namely, those algorithms are *Bootstraped Upper Confidence Bound* and *Bootstrap Thompson Sampling*. Due to the lack of space algorithms are presented briefly explained. The aim of finding upper confidence bound is to find the best possible reward for a given context coming for a single choice (resource). In other words, by finding upper bound true expected reward can be found with high probability. However, a lot of exploration is needed in order to find upper bound especially with a small sample size. Therefore, a bootstrap procedure is used [11]. In the Upper Confidence Bound algorithm probability of resource is a good one is calculated from prior data directly using likelihood, while in the case of Thompson sampling expected probabilities for choosing resources are estimated from the posterior distribution using beta distribution. The third algorithm is the *Adaptive greedy algorithm with a decaying threshold*. This algorithm selects resource which has the highest probability of being the good one. However, if the random number is below threshold random action is chosen. This is done in order to explore different actions and calculate their reward. This threshold is decaying which means that, in the later stages, when data is available algorithms will seldom explore, and more exploit resources with higher probability.

The fourth algorithm is used as a baseline algorithm and it is called *Softmax Explorer*. This algorithm selects the resource using a softmax function. This means that there is no exploration, just exploitation.

Experimental Setup

We would like to answer two research questions one being can we allocate resources of mountain rescue service in advance, without prior knowledge, and other being how much data is needed to learn a model of resource allocation to be better than the baseline approach.

Namely, we trained four above-mentioned contextual multi-armed bandit models using logistic regression with ridge regularization as a base model. As a baseline approaches, we utilized two models, one is what will happen if mountain rescue always carries equipment for most common injury (standard equipment set) and another what will happen if random equipment is carried. The experiment is repeated three times, one time for each ski slope.

In order to answer to proposed research questions, we split data on a daily level for the three most difficult ski slopes. Data used for model training contained hour level data with information whether an injury occurred for each of 20 categories in the following hour. As a baseline model logistic regression with ridge regularization was used. Based on that model

and resource selected by each of four multi-armed algorithm resources were allocated for each hour of the following day. For each hour in one day (each example in the dataset), a reward was calculated using the formula presented in (1).

$$r_t = \begin{cases} 1, a_t = e_t \\ 0, a_t \neq e_t \end{cases} \quad (1)$$

where r_t present reward at time point t, a_t equipment set model predicted for time point t and e_t present equipment needed for time point t. If no injury occurred in time point t then no reward is gained. Typically, one is more interested in the overall goodness of the model over time. Therefore, the cumulative mean reward is calculated as presented in (2).

$$r = \frac{1}{|t|}\sum_{i=1}^{t} r_i \quad (2)$$

where r present cumulative mean reward, $|t|$ number of examples for which recommendation was made and r_i reward for day i. In this paper, evaluation is made using a cumulative mean reward where this evaluation metric is calculated on a daily level and presented on a figure. This measure will allow us to answer the second research question. Namely, by comparing cumulative mean reward for baseline approaches and trained models one can see after how many days the proposed approach delivers better performing models.

RESULTS

The results of the experiments are presented in Figure 1. Days are presented on the horizontal axis. Due to the clarity of the presentation, only the first 100 days are presented. On the vertical axis, one can find a cumulative mean reward. On the top left part of the Figure 1 ski slope Karaman greben is presented, on the top right part is Mali karaman ski slope, and in the second row Duboka 1 ski slope is presented. Although cumulative mean rewards seem low, it must be stated that multi-armed bandits always select some equipment (resource), preferably the one that gives the best gain and if the injury did not occur reward is not obtained. Having in mind that injuries rarely occur one can conclude that mountain rescue service carried an equipment set although it was not needed.

As one can observe results suggests that usage of contextual multi-armed bandits can improve resource allocation in ski resort incidence respond to team and further improve ski resort management. One can observe that traditional approaches are most often of lower cumulative mean reward compared to proposed approaches. If one chooses just the equipment for the most common injury (knee injury) expected reward would be around 0.04 (or 4%), and around 0.01 (or 1%) if random equipment set is carried. The proposed approach where characteristics of the ski slope and skiers, weather and other information are used as a context of the decision-making process for resource allocation improved performance of resource allocation up to 0.12 (or 12%) for all three ski slopes but after some time converges to 0.06 (or 6%) which can be considered as a great improvement. The difference is only Duboka 1 ski slope where the proposed approach performs slightly better compared to traditional approaches. Also, one can notice that the *Softmax* algorithm did perform lower overall compared to other approaches (except for Duboka 1 ski slope) meaning that contextual multi-armed bandits could be used for the given task.

Also, based on Figure 1 we can answer the second research question, how much data is needed to learn a model of resource allocation to be better than the baseline approach. As one can see the results can be seen soon after deployment of the model. For Karaman greben ski

slope every contextual multi-armed bandit beat naïve approach after 18 days, while for the Mali karaman ski slope 24 days were needed. For Duboka 1 ski slope some algorithms failed to beat the naïve approach. This may be due to difficultness of the ski slope. However, if one selects just the Thompson sampling algorithm (orange line) one can observe that it performed better than naïve approaches after one day for two ski slopes and needed 11 days for the third one.

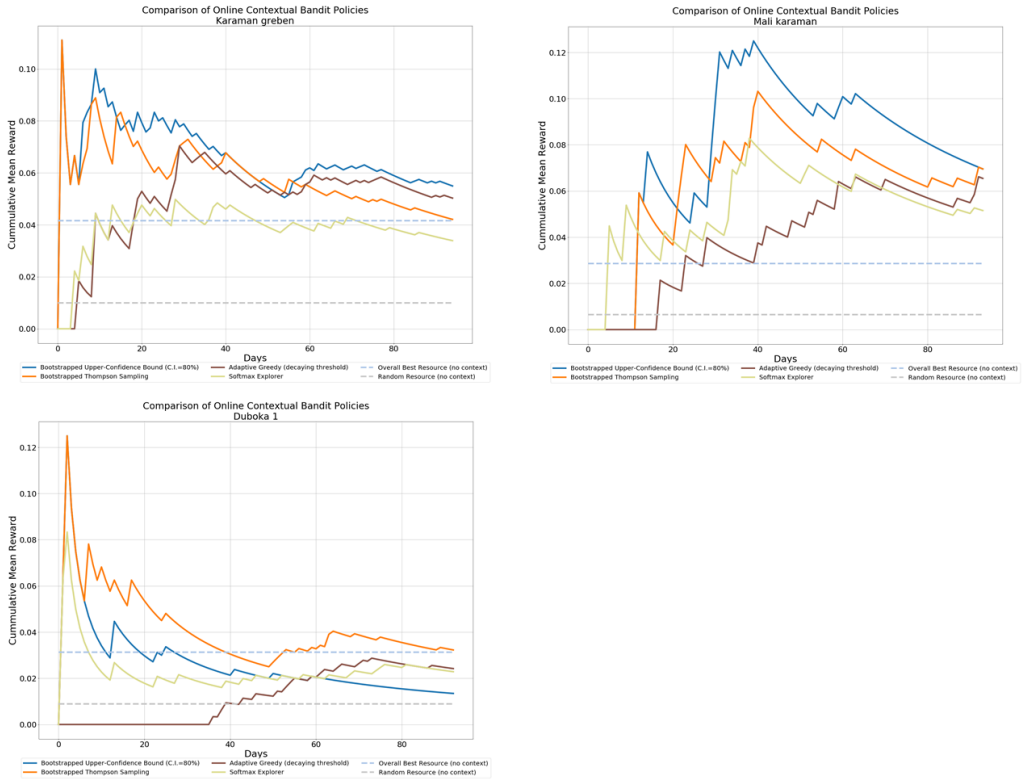

Figure 1: Results of the experiments

CONCLUSIONS

This paper proposes the usage of contextual multi-armed bandits for resource allocation for ski injury equipment. This is motivated by the fact that mountain ski rescue service has limited space and resources for carrying equipment and therefore intelligence solution is needed. In this paper, we trained and evaluated four contextual multi-armed bandits for equipment allocation on the Mt. Kopaonik, Serbia ski resort. Each multi-armed bandit used logistic regression as a baseline learner. The proposed approach was evaluated using mean reward which is calculated as a number of times ski rescue service carried resources needed for ski injury intervention.

We set two research questions one being can we improve resource allocation using the context of the decision and multi-armed bandits compared to using the most common equipment set and if we can how much time and data is needed to perform better than that approach. It has been shown that contextual multi-armed bandits can perform better compared to naïve approaches and it is needed no more than 20 days for the data at hand.

As a plan for future research, we plan to expand the approach for the whole ski resort, not just the most difficult ski slopes as used in this research and also to utilize multi-task models as baseline learners.

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VI
Miscellaneous

ConvGraph: Community Detection in Weighted Graphs

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Abstract: This paper proposes a new method, *ConvGraph,* to detect highly cohesive and isolated weighted graph communities, where the sum of the weights is significantly higher inside than outside the communities. The method begins by transforming the original graph into an induced graph. We then go on to apply artificial vision methods, i.e., convolutions, used to detect the optimal boundaries of images, in order to determine the limits of the communities identified by their weights rather than their topology. The last step of the method is to refilter communities that have a high level of density.

The quality of the communities detected by the proposed algorithm evolved through a number of synthetic graphs with highly cohesive and isolated communities.

INTRODUCTION

The community detection problem is not new. Over time, it has been solved in different ways in different branches of knowledge. There are different community detection methods:

- Methods based on graph topology: 1) data grouping methods (Friedman et al., 2001; Müllner, 2011): *single linkage clustering*, *average linkage clustering*, *k-means clustering*, *spectral clustering*; 2) modularity optimization (Newman, 2004): *Newman's greedy algorithm*, *metaheuristics* (simulated annealing, genetic algorithms), *extreme optimization* (Duch & Arenas, 2005); 3) density-based methods: *DBSCAN* (Ester, 1996), DENCLUE (Hinneburg et al., 2007), *OPTICS* (Ankerst, 1999), HICS (Achter, 2006), *DenShrink* (Huang et al., 2011), *DenGraph* (Falkowski et al., 2007), SCAN (Xu et al., 2007).
- Methods based on graph weights: 1) attraction of a community: ABCD (Liu et al., 2014); 2) node similarity function: ISCoDe (Jaho et al., 2011).

The biggest drawback of density-based algorithms in any real applications is that a huge distance matrix must first be calculated. Likewise, the resulting communities are not necessarily highly cohesive. This may output many communities that are, in actual fact, relatively isolated from the other vertices but uninteresting with respect to our search criteria.

METHOD

The proposed method consists of two algorithms. Algorithm 1 determines the communities based on weights and Algorithm 2 takes into account graph topology, with Algorithm 1 being applied to any higher density communities and their neighbours.

Algorithm 1: *Weighted graph communities*

Data: Weighted graph (*G*) and Laplacian kernel ($\frac{\partial^2}{\partial x^2}h$)

Output: Detected communities

Transform the weighted graph *G* into its induced graph *H*;

Apply the kernel ($\frac{\partial^2}{\partial x^2}h$) with a convolution to graph *H*;

Where a change of sign marks the boundary of two communities;

Select the communities with a significantly high weight ratio;

Display the computed communities in the original graph.

Induced graph: The nodes of the induced graph are the edges of the original graph. The edges of the induced graph indicate that both links in the original graph have a common vertex and their weights are the absolute value of the differences in the weights of the edges of the original graph that represent the nodes linked by the edge.

Algorithm 2: *High density communities*

Data: Weighted graph (*G*) and the set of communities *(C)*

Output: Set of expanded communities *(S)*

Compute the density $D(G_t)$ for each community $G_t \in C$;

If $D(G_t)$ > *threshold* then *Algorithm 1* is applied to G_t and its neighbours;

If a neighbour is identified with G_t, it is added to G_t.

$D(G_t) = \frac{\sum_{v_i \in G_t} c_i}{|G_t|}$, with $c_i = \frac{|e_{jk}|}{k_i(k_i-1)}, : v_j, v_k \in N_i$

c_i: the clustering coefficient of the vertex v_i is computed as the proportion of connections among its neighbours which are actually realized compared with the number of all possible connections.

k_i: the number of vertices, $|N_i|$, in the neighbourhood, N_i, of the vertex v_i

e_{jk}: edge connects vertex v_j with vertex v_k

RESULTS

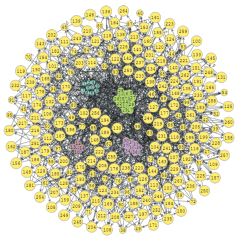

Figure 1: Weighted graph with four communities of interest (blue, brown, green and pink) with 10, 5, 15 and 0 vertices each, respectively, and 200 other vertices. Therefore, it has a total of 263 vertices and 795 edges with a real density of 0.0115.

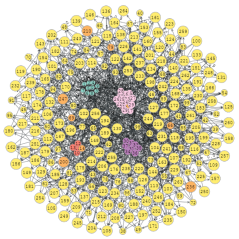

Figure 2: Graph detected by Algorithm 1 with a hit rates of 1, 0.8, 0.93 and 1, respectively, and two more communities.

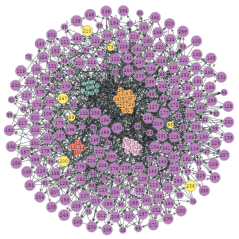

Figure 3: Graph detected by Algorithm 2 with a hit ratio of 1.

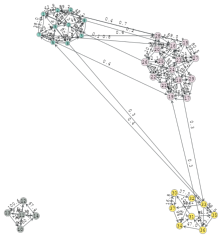

Figure 4: Detected communities.

Acknowledgements: This paper was supported by MTM2017-86875-C3-3-R

CONCLUSIONS

This paper proposes a new method, *ConvGraph,* to detect highly cohesive and isolated weighted graph communities, where the sum of the weights is significantly higher inside than outside the communities. This technique can be very useful, for example, in detecting tax fraud and money laundering. This approach is based on convolution-based filtering like boundary detection in computer vision.

A WEB-BASED DECISION SUPPORT SYSTEM FOR EMPLOYEE REDEPLOYMENT

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Abstract: The rapid and appropriate redeployment of employees among workplaces is a common task for companies that consist of many organizational units geographically distributed across the country. One of the problems is matching the employee education and skills to the work unit requirements. We present a web-based decision support system (DSS) for a real case study of employee's redeployment at different working units. The proposed decision support model can be used in general, given the configuration of the specific conditions of the different companies. Once defined, the DSS becomes the foundation of an automated process of candidate's evaluations for the selected working places that significantly accelerate the selection process and thus generates significant company operational savings.

INTRODUCTION

The employee redeployment and selecting the appropriate employee among many is a complex problem. It requires searching and finding the best match between the employees and selected organizational unit (OU) according to many attributes, such as education, skills, work experience, distance from the workplace, and many more. Hence, the problem can be formulated as a multi-criteria decision problem of choosing the most appropriate employee.

Attribute	Scale
Transfer evaluation of Employee	not recommended; acceptable; ***recommended***
Employee appropriate	not appropriate; appropriate; ***excellent***
Employee adequacy	not adequate; adequate; ***excellent***
Skills	insufficient; sufficient; ***excellent***
IT skills	insufficient; sufficient; ***excellent***
Employee IT skills level	insufficient; good; very good; ***excellent***
OU IT skills level	not required; good; very good; ***excellent***
Dactylography skills	insufficient; sufficient; ***excellent***
Employee Dactylography skills level	insufficient; good; very good; ***excellent***
OU Dactylography skills level	not required; good; very good; ***excellent***
Language knowledge	insufficient; sufficient; ***excellent***
Employee Language knowledge	insufficient; good; very good; ***excellent***
OU language knowledge	not required; good; very good; ***excellent***
Driving licence	insufficient; sufficient; ***excellent***
Employee driving licence status	does not have driving licence; has driving licence
OU driving licence status	driving licence not mandatory; driving licence mandatory
Personal	insufficient; sufficient; ***excellent***
Disability status	not appropriate; ***appropriate***
Employee disability status	none; persons with disabilities
OU disability status	no restriction; restricted for persons with disabilities
Educational field	not appropriate; ***appropriate***
Employee educational field	Bio and medicine; Economy; ICT; Law; Mechanical; Social; Technical; Transport
OU educational field	Bio and medicine; Economy; ICT; Law; Mechanical; Social; Technical; Transport
Educational level	insufficient; sufficient; ***excellent***
Employee's educational level	doctoral; master; bachelor; upper secondary; primary or lower secondary
Work position educational level	master; bachelor; upper secondary; primary or lower secondary
General work	insufficient; sufficient; ***excellent***
Work experience	insufficient; sufficient; very good; ***excellent***
OU work experience	not required; 5 years; 8 years; 10 years
Employee work experience	less than 5; >=5 and <8; >= 8 and <10; >= 10 and <=20; 21 or more
Work position	not appropriate; ***appropriate***
Employee workposition	Adviser; Assistant Director; Correspondent; Deputy Director General; Director General; Employee; Expert; Expert referent; Head of Office; Head of Regional office; Head of Service; Inspector; Senior expert
OU workpositions	Adviser; Assistant Director; Correspondent; Deputy Director General; Director General; Employee; Expert; Expert referent; Head of Office; Head of Regional office; Head of Service; Inspector; Senior expert
Workhours	not appropriate; ***appropriate***
Employee's educational level	doctoral; master; bachelor; upper secondary; primary or lower secondary
Employee workhours	8h - 1 shift; 24h - 3 shift
OU workhours	8h - 1 shift; 24h - 3 shift
Employee work experience	less than 40; 40+ years
Distance to workplace (OU)	not preferred; appropriate; good; ***preferred***
Applications roles	insufficient; acceptable; very good; ***excellent***
OU transfer ability	not suggested; suitable; ***suggested***
Outgoing OU transfer saturation	fewer; equal +/- 1; ***more***
Incoming OU transfer saturation	more; equal +/- 1; ***fewer***

Figure 1: DSS for employee redeployment

Table 1: Utility table for IT skills

	Employee IT skills	OU IT skills	IT skills
	50%	50%	
1	**insufficient**	**>=good**	**insufficient**
2	**<=good**	**>=very good**	**insufficient**
3	**<=very good**	***excellent***	**insufficient**
4	**not at all**	**not required**	***sufficient***
5	**good**	**good**	***sufficient***
6	**very good**	**very good**	***sufficient***
7	***excellent***	***excellent***	***sufficient***
8	**>=good**	**not required**	***excellent***
9	**>=very good**	**<=good**	***excellent***
10	***excellent***	**<=very good**	***excellent***

OBJECTIVES

Figure 1 presents attribute tree and attribute scales implemented in a DSS for employee redeployment. The DSS is developed from the requirements arising from a real governmental organization with more than 3000 employees, which are organised into more than 200 organizational units geographically spread across the country. The objectives of the proposed DSS are:

- to support the human resources (HR) management in finding the most appropriate employees for redeployment
- improve the responsiveness of HR departments regarding the employees' redeployment.

METHODS AND RESULTS

To implement the DSS, the DEX method was used, which allows usage of qualitative attributes. The attributes are aggregate in a utility functions, such as the one presented in Table 1. Such representations leads to understandable *If .. then* decision rules. Furthermore, the DSS is implemented as a web-based application, as presented in Figure 2. The DSS has been evaluated on the a subset of employees that have been redeployed among OUs and shows high accuracy in selection of the most appropriate employee.

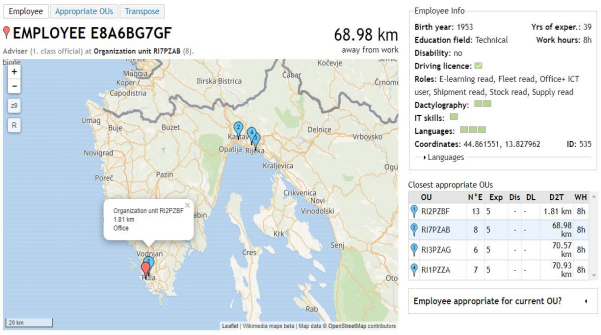

Figure 2: Snapshot from the web-based DSS for employee redeployment

CONCLUSIONS

Using DEX methodology we developed a DSS for employee redeployment. The model has been evaluated on 3000 employee redeployments. The results suggest that the DSS model accurately reflects the current practices of the organisation, it improves the responsiveness of the HD department and is considered as a valuable decision support tool.

Acknowledgement

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Supporting Severe Accident Management in Nuclear Power Plants

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CONTEXT

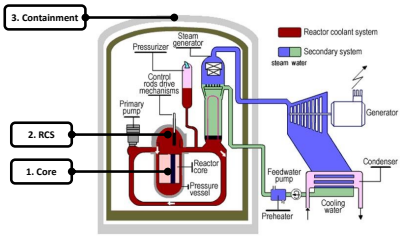
NARSIS:
New Approach to Reactor Safety ImprovementS
EU Horizon 2020 project, 2017-2021
http://www.narsis.eu/

OBJECTIVES

Improve systems, resources and training to enable effective responses to *severe accidents* in *nuclear power plants*.

Develop "*Severa*":
- a prototype demonstration-level *decision support system*,
- aimed at supporting the *Technical Support Center*
- while managing a *severe accident*
- and for *training*.

SEVERE ACCIDENTS AND MANAGEMENT



Nuclear Power Plant

Type: Pressurized Water Reactor

Barriers:
1. Reactor Core
2. Reactor Cooling System (RCS)
3. Reactor Containment

Severe accident: Rare circumstances that can cause:
- Severe core degradation
- Damage to the nuclear fuel, vessel and/or containment
- Release of radioactivity to the environment

Severe Accident Management:
- by *Technical Support Center*
- according to *Severe Accident Management Guidelines*

STAGES

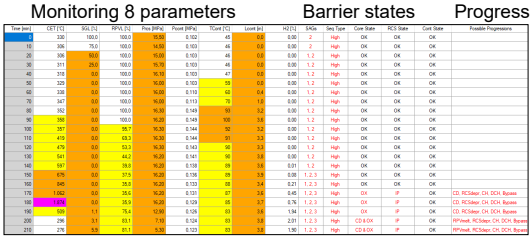
1. Monitor operating parameters
2. Access the state of barriers
3. Predict accident progressions
4. Identify recovery actions
5. Assess the feasibility
6. Predict consequences
7. Access actions, suggest the best
8. Implement selected action(s)

SOME USER VIEWS

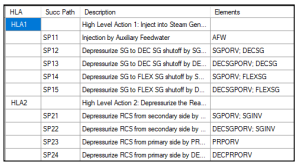
Monitoring 8 parameters

Barrier states

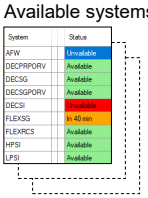
Progress



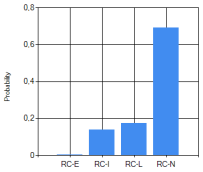
Possible actions



Alternatives:
Available systems



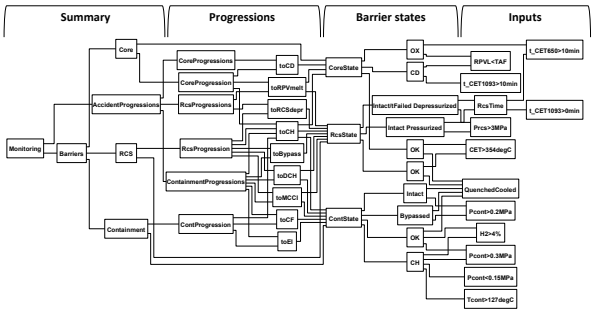
Assessment of radioactive releases



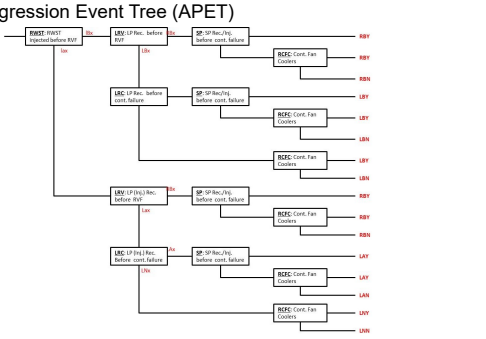
RC-E: Early release
RC-I: Release expected in several days
RC-L: Release not expected in several days
RC-N: Long-term concern

MODELS

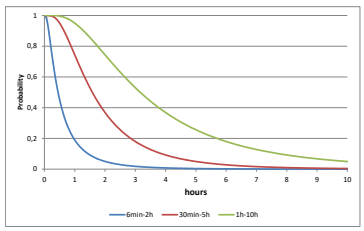
Qualitative hierarchical multi-attribute rule-based model (method DEX)



Accident Progression Event Tree (APET)



Probabilistic assessment of actions' success



Inverse cumulative lognormal distribution depending on the available *time window*

CONTRIBUTIONS

- Providing support in a difficult, time-critical and stressful situation
- Timely and useful information about the barriers and events
- Assessment: actions × systems → alternatives → consequences
- Operationalization of guidelines for a specific situation

Work in progress, to be completed in 2020 and validated in 2021.

Selecting Best Normalization Technique for MCDM Methods

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Abstract: One of the big challenges for Multi-Criteria Decision Making (MCDM) methods is to use an appropriate normalizing procedure. Most MCDM methods implement simple normalization techniques to produce comparable and dimensionless data from heterogeneous multi-source data in order to aggregate/rank alternatives. However, using different normalization techniques may lead to different ranking. So, selecting more suitable normalization technique is of paramount importance in the decision process. This study introduces a recommendation framework for supporting users/ decision makers to select data normalization techniques that better fit criteria, in different application scenarios, based on multi-criteria decision methods.

INTRODUCTION

- In most multi-criteria decision-making (MCDM) problems, criteria have different units.
- Normalization is a transformation process to obtain numerical and comparable input data by using a common scale.

RESEARCH QUESTION

Which normalization technique is more suitable for usage with MCDM methods?

OBJECTIVES

The major contributions of this study are:

i. Showing the importance of normalization process in MCDM decision models.
ii. Addressing the gap in literature about selection of the best normalization techniques for MCDM methods.
iii. Comparing the effects of different normalization techniques in MCDM methods.
iv. Developing an evaluation assessment framework to recommend the best technique to use with well-known MCDM methods.

FRAMEWORK STEPS

Step 1: Data types & Topology
- Determine the type of criteria values:
  - Ordinal number
  - Natural number
  - Skewed data with outlier
  - Real number
  + Float numbers in unit interwal [0-1]

Step 2: Normalization Techniques
- Test well-known normalization techniques:
- ***Linear***: Max; Max-Min; Sum
- ***Semi Linear***: Vector; Target based
- ***Non Linear***: Logarithmic, Fuzzification

Notes:
(1) Sum is not applicable if there is any zero in criteria values
(2) Logarithmic is not applicable when there are zeros or float numbers in any criterion

Step 3: Evaluation
- Compare the tested techniques with different metrics:
- ***Outlier detection***: Line chart/ Histogram/ scatter/ Box plot
- ***Measures of Location***: Max, Min
- ***Measures of scale***: ANOVA / Regression analysis (P-value, Standard error, T-test,...); Pearson/Spearman correlation
- ***Comparison metrics***: Minkowski distances; Standard Deviation; Mean Ks values (from Spearman/ Pearson Correlation); Ranking consistency Index (RCI); Mean squared error

Step 4: Selection of the Best Technique
- Selection of the best technique with:
- ***Plurality voting***: Selection of best normalization technique with the large number of first order/rank, in the different used metrics

Figure 1: Four steps of the (on-going) evaluation framework

ILLUSTRATIVE EXAMPLE

The decision matrix and results of selecting the best normalization technique for SAW method, adapted from Vafaei et al. 2020 (COMSIS), are:

Table 1: Input data

Alternatives	C1	C2
A1	30	0.3
A2	50	3000
A3	70	6000
A4	80	8000
A5	0.01	9000

Table 2: Final score and rank of alternatives using SAW with the seven normalization techniques

	Max		Max-Min		Vector		Sum		Target-AVG		Target-Med		Fuzzy-Trap	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
A1	0.1875	5	0.1875	5	0.1276	5	0.0652	5	0.6111	4	0.5416	3	0.25	5
A2	0.4792	4	0.4791	4	0.3214	4	0.1664	4	0.8528	1	0.6667	1	0.6165	3
A3	0.7708	2	0.7708	2	0.5153	2	0.2676	2	0.8056	2	0.5417	2	0.9	2
A4	0.9444	1	0.9444	1	0.6303	1	0.3277	1	0.6319	3	0.4792	4	1	1
A5	0.50006	3	0.5000	3	0.3265	3	0.1731	3	0.5014	5	0.3542	5	0.5001	4

Table 3: Results of applied metrics

	Manhattan	Euclidean	Chebyshev	STD	Mean Ks	RCI
Max	3.6110	1.3034	0.7569	0.2914	0.66732	45.6667
Max-Min	3.6113	1.3035	0.7570	0.2915	0.66733	45.6667
Vector	2.3988	0.8686	0.5028	0.1942	0.6728	45.6667
Sum	1.2525	0.4522	0.2625	0.1011	0.6680	45.6667
Target-Avg	1.7944	0.6503	0.3514	0.1454	0.3283	31.3333
Target-Med	1.3747	0.5076	0.3124	0.1135	0.0480	31.3333
Fuzzification	3.7998	1.3575	0.7500	0.3035	0.7181	41.6667

Table 4: Ordering of normalization techniques with respect to the metrics and using plurality voting

	Manhattan ↑	Euclidean ↑	Chebyshev ↑	STD ↑	Mean Ks ↑	RCI ↑	Plurality Voting
Max	3	3	2	3	5	1	1
Max-Min	2	2	1	2	4	1	2
Vector	4	4	4	4	2	1	1
Sum	7	7	7	7	3	1	1
Target-Avg	5	5	5	5	6	6	0
Target-Med	6	6	6	6	7	6	0
Fuzzification	1	1	3	1	1	5	4

CONCLUSIONS

We used a general evaluation framework, which includes several metrics for outlier detection, measures of location, measures of scale and comparison metrics and a numerical example, to perform the assessment of selecting the best normalization technique for SAW method. To recommend the best normalization technique, the plurality voting method was applied for each normalization technique with respect to the mentioned metrics in the framework. Results showed that Fuzzification is the best technique and Max-Min is the second best for SAW.

We plan to finish our assessment framework by adding more metrics and generalize it for the most well-known MCDM methods.

A DSS for improving the inconsistency in AHP

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Abstract:

This paper presents a DSS for revising the judgements and improving the inconsistency of an Analytic Hierarchy Process (AHP) pairwise comparison matrix when the Row Geometric Mean (RGM) is used as the prioritisation procedure and the Geometric Consistency Index (GCI) is the inconsistency measure. The procedure employed guarantees that both the judgements and the derived priority vector will be close to the initial values. In any case, the DSS is able to adapt to the requirements of the decision maker, such as limiting the modified values to an interval or improving inconsistency by modifying the lowest number of judgements, among others. The running of the DSS is shown applied to a numerical example.

INTRODUCTION

- **AHP (Analytic Hierarchy Process)**
  - Discrete Multicriteria Decision Making Technique widely employed
  - Decision-makers incorporate preferences using pairwise comparison matrices (A =(a_{ij}))
  - Allows some inconsistency when eliciting judgements
- **Consistency:** Internal coherence of the judgements in a pairwise comparison matrix
  - A pairwise comparison matrix A is consistent (cardinal transitivity) if $a_{ij} \cdot a_{jk} = a_{ik}\ \forall i,j,k = 1,\dots,n$
- **Measures of inconsistency**
  - Consistency Ratio (CR) for the EV prioritisation procedure
  - Geometric Consistency Index (GCI) for the RGM prioritisation procedure

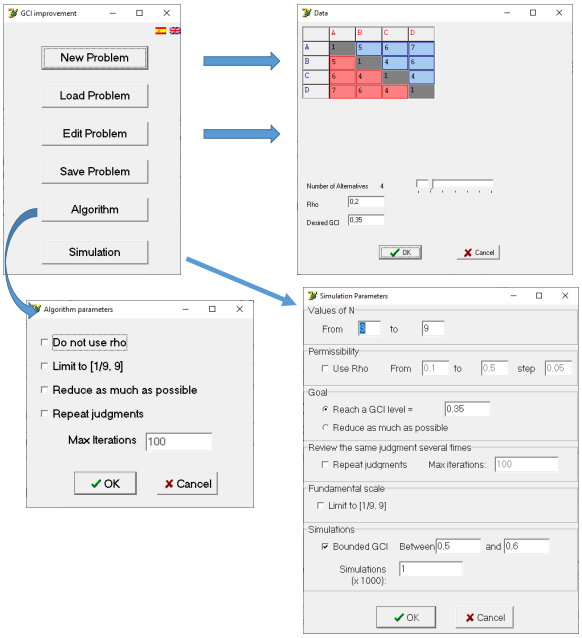
$$GCI = \frac{2}{(n-1)(n-2)} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} log^2 \left(a_{ij} \frac{w_j}{w_i}\right)$$

- **Thresholds for the GCI** (max inconsistency allowed)
  - 0.31 for n=3, 0.35 for n=4, and 0.37 for n>4
- **Permissibility**: percentage of relative change allowed

OBJECTIVES

- **Help decision-makers** to **reduce** their **inconsistency**
  - Guaranteeing both the judgements and the derived priority vector will be close to the initial values
  - Suggesting the minimum permissibility necessary to get an allowable inconsistency (below threshold)
- **Provide a DSS** that implements a procedure for **improving inconsistency** when measured with the GCI (Aguarón et al., 2020)
  - Sequential procedure that identifies the judgements that improve the GCI faster and with greater intensity
  - Modify the judgements within the permissibility range set by the decision maker and if accepted by them
- **Adapt** the DSS to specific **requirements** of decision-makers
  - Limit the modified values to an interval
  - Modify the lowest number of judgements (eliminating permissibility)
  - Get the maximum possible reduction of the GCI

DSS SOFTWARE



NUMERICAL EXAMPLE

Source: Saaty (2000)

- PCM with 6 alternatives and initial GCI = 0.790 > 0.37
- Minimum permissibility to be able to get a GCI < 0.37: 29.32%
- Permissibility set by the decision maker: 30%

Table 1: Initial pairwise comparison matrix

	A1	A2	A3	A4	A5	A6	Priorities
A1	1	4	3	1	3	4	0.316
A2		1	7	3	1/5	1	0.139
A3			1	1/5	1/5	1/6	0.036
A4				1	1	1/3	0.125
A5					1	3	0.236
A6						1	0.148

GCI = 0.790
Judgement to modify: (5,2)
New value accepted by DM: 3.486

Table 2: Pairwise comparison matrix after first iteration

	A1	A2	A3	A4	A5	A6	Priorities
A1	1	4	3	1	3	4	0.317
A2		1	7	3	1/3.85	1	0.146
A3			1	1/5	1/5	1/6	0.036
A4				1	1	1/3	0.126
A5					1	3	0.227
A6						1	0.148

GCI = 0.738
Judgement to modify: (1,3)
New value accepted by DM: 3.9

Tables 3 and 4: Final pairwise comparison matrix after 13 iterations and relative changes

	A1	A2	A3	A4	A5	A6	Priorities
A1	1	3.08	3.9	1.3	2.31	3.08	0.307
A2		1	5.38	2.31	1/3.85	1	0.141
A3			1	1/3.85	1/5	1/4.62	0.040
A4				1	1/1.3	1/2.31	0.122
A5					1	2.31	0.240
A6						1	0.150

GCI = 0.369

Relative changes	A1	A2	A3	A4	A5	A6	Priorities
A1	0	23.08	30	30	23.08	23.08	2.8
A2	30	0	23.08	23.08	30	0	1.6
A3	23.07	29.95	0	30	0	29.99	11.1
A4	23.08	30	23.08	0	23.08	30	2.7
A5	30	23.08	0	30	0	23.08	1.6
A6	30	0	23.08	23.08	30	0	1.6

CONCLUSIONS

Based on the theoretical results provided in Aguarón et al. (2020), this poster describes the application of the DSS Software developed to improve the inconsistency in AHP to a particular situation related to obtaining the minimum permissibility necessary to get an acceptable inconsistence threshold.

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- Aguarón, J.; Escobar, M.T.; Moreno-Jiménez, J.M. (2020): Reducing Inconsistency measured by the Geometric Consistency Index in the Analytic Hierarchy Process. Forthcoming.
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Advanced technologies applied to the optimization of transport operations: an analysis of the determining factors

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Abstract: Road freight transport represents a very important part of industrial and logistics activity, both at national and international level. The use of new technologies allows optimizing transport operations in economic, social, environmental and technological terms. The aim of this work is to develop a methodology for the selection of technologies that allows the optimization of transport operations. A previous study of the current technological advances applied to transport operations is needed. A procedure to compare the application of technologies using the Analytic Hierarchy Process (AHP) is developed. The participation in the study of several experts is required to establish the hierarchy and weights of the most influential factors in this selection process. The analysis of the results allows the prioritization of alternatives that lead to an optimization of transport operations.

INTRODUCTION

Freight transport is a fundamental link in the supply chain. A tranport operation can have different nature: supply, internal transport, and distribution.

Technologies are used as facilitators of optimization in transport operations. Different studies (e.g. DHL, 2018, NextNet, 2019) have identified some common technologies (see Figure 1).

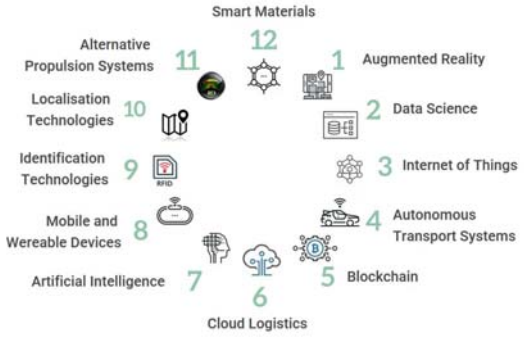

Figure 1: Twelve technologies as facilitators of optimization in transport operations

OBJECTIVES

The introduction of new technologies in the freight transport sector is an obvious fact, but it is also evident that the quality and optimization of the services (understanding as the transport operations themselves) will depend on their correct application. The main objective of this work is to identify and select those new technologies that allow optimizing different transport operations.

METHODS

The twelve technologies identified from literature have been grouped according to functionality (Figure 2).

Figure 2: Technologies grouping according to functionality

A second grouping is performed according to time horizon based on the Technology Readiness Level (NexNet, 2019) and the Trend Assessment (DHL, 2018). 7 technologies ready to be launched or already available (see Figure 3), and 4 applications (A) in the transportation sector were identified: A1. Propulsion system of the vehicle; A2. Route optimization; A3. Load optimization; A4. Traceability and security.

Figure 3: Technologies already available

The Analytic Hierarchy Process (AHP) has been used for the multicriteria selection process. It consists of three stages (Saaty, 1980): Modelling, Valuation, and Prioritization and Synthesis. Judgements were aggregated using the RGM method. Five experts were involved. Inconsistent matrices (CR>0.1) were linearized using the procedure provided by Benitez et al. (2014).

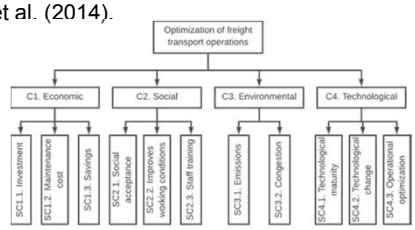

Figure 4: Hierarchy of the problem

RESULTS

Table 1: Priorities of the model and alternatives

	C1			C2			C3		C4			
	0,4646			0,1310			0,2207		0,1837			
	SC1.1	SC1.2	SC1.3	SC2.1	SC2.2	SC2.3	SC3.1	SC3.2	SC4.1	SC4.2	SC4.3	
Local	0,1481	0,3338	0,5181	0,2322	0,5116	0,2563	0,3031	0,6969	0,1641	0,1895	0,6464	
Global	0,0688	0,1551	0,2407	0,0304	0,0670	0,0336	0,0669	0,1538	0,0301	0,0348	0,1187	**Score**
A1	0,6333	0,4890	0,3553	0,6454	0,1284	0,2666	0,5390	0,0929	0,4002	0,5626	0,0604	0,3313
A2	0,1562	0,2695	0,3038	0,1413	0,4136	0,3585	0,2635	0,6037	0,2250	0,1340	0,4701	0,3475
A3	0,0940	0,1550	0,2602	0,1207	0,2924	0,2449	0,1372	0,1853	0,1336	0,1268	0,3354	0,2106
A4	0,1165	0,0865	0,0807	0,0926	0,1656	0,1300	0,0603	0,1180	0,2412	0,1765	0,1341	0,1107

w(A2=0,3475)> w(A1=0,3313)> w(A3=0,2106)> w(A4=0,1107)

CONCLUSIONS

The preferred alternatives for the optimization of transport operations are route optimization (A2) and the propulsion system (A1). The selection of an appropriate strategy is specially important since it impact benefits, e.g. A2 is linked to an increase of benefits derived from the number of operations, and emissions, e.g. A1 allows a decrease of them.

Decision Analysis in e-Cognocracy using Dynamic Social Networks

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Abstract: *E-Cognocracy* is a model of cognitive democracy that, combining representative and direct democracy, allows the citizen to co-create and co-decide (citizens, associations, politicians) in making public decisions regarding the Government of Society. *E-Cognocracy* allows the identification of social leaders, that is, those people who, with their opinions, influence the preference structure of citizens. It also can be used to measure the *reputation* of the actors involved in the considered e-participation experience. This work shows the result of combining the indicators that measure the reputation with emotion analysis techniques in a dynamic representation of the network of followers created during the discussion in a forum. This analysis allows to reveal hidden attributes and behavior patterns of the actors.

INTRODUCTION

Social network analysis uses graphical data visualization techniques in which it combines different visual elements to represent the relationship between variables. The most common are the color and size of the nodes, and also on many occasions the color and thickness of the edges.

In addition, the design allows to highlight the relative importance of the network nodes according to their position.

INDICATORS

Trust τ_{ij}: measure of the favorable or unfavorable opinion that one person P_i has about another P_j.

Importance I_{ij}: measure of the interest that a comment c_i has for a person P_j.

Reputation ρ_i: $\rho_i(t+1) = \dfrac{\sum_{j=1}^{n} \rho_j(t)\,\tau_{ij}(t)}{\sum_{j=1}^{n} \rho_j(t)}$

VARIABLES

- **Reputation:** represented by node size.
- **Importance:** represented by edge size.
- **Preferred alternative:** represented by node color.
- **Emotion:** represented by edge color.

CASE STUDY

Multi-criteria selection of the best public transport strategy in Zaragoza (Spain).

Decision technique: Analytic Hierarchy Process (AHP).

ALTERNATIVES:
- **A1 (Tram):** Second line of the current tram.
- **A2 (Tranbus):** Tram and bus.
- **A3 (Aratrén):** Tram and commuter train.
- **A4:** None

67 decision makers were invited to participate in the process, which took place in two rounds of voting with a debate between them through a forum (in Spanish).

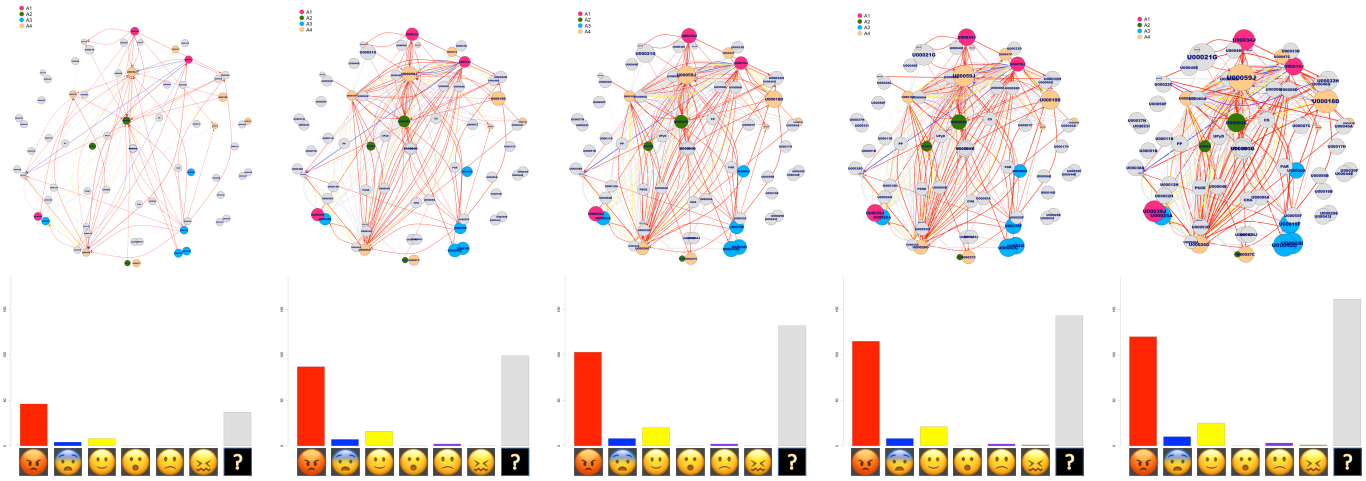

Figure 1: Evolution of the social network (5 out of 307 timestamps)

DATA COLLECTION

Data (forum comments and preference structures) were collected between Apr 21st and May 15th, 2015, using the software *Social Cognocracy Network*, developed by the GDMZ.

For the analysis of emotions, the dictionary created by the *Stem* project (https://cran.r-project.org/package=Stem) was used.

CONCLUSIONS

This poster describes a visual analytic tool designed for the application of emotion and social network analysis techniques to the study of the behaviour of decision makers in the application of the *e-Cognocracy.*

The tool allows to explore the temporal evolution of the network formed by the participants and their interactions in the forum.

Serious Game linked to a crowdsourcing app for leveraging citizens' engagement in sustainable mobility planning

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Abstract: Despite the large international experience for promoting sustainable mobility, SUMP's adoption rate in European and especially in MED cities remains notably low. Seeking within reasons potentially blocking the adoption of acceptable and thus effective plans, public rejection and public indifference cannot be overlooked. This is exactly the origin of the idea behind MOTIVATE app development. Focusing on citizens' involvement in the development and implementation of SUMPs, the MOTIVATE app tries to capture citizens' and visitors' mobility habits & needs (crowdsourcing initiative) while triggering their interest via the provision of rewards (game). MOTIVATE interactive learning environment (awareness raising game on sustainable mobility) is an integral part of the MOTIVATE app that accompanies the whole initiative connected to travellers' real behaviour shift towards sustainable modes of transport (cycling, walking, PuT). The current work aims to present the test-bed case of Thessaloniki (GR) that exploited with considerably encouraging results the MOTIVATE app.

INTRODUCTION

The MOTIVATE app is a cloud-based tool that collects data and provides first level overview of daily trips and travellers' opinions. The platform through the providing services ***aims to***:

- support the participatory approach of decision making process
- provide insight into real travellers' needs
- increase travellers' interest in the mobility planning process
- transform travellers' into active agents of Sustainable Mobility adoption
- raise awareness in terms of sustainable mobility

THE MOTIVATE APP

The app consists of ***four*** services:

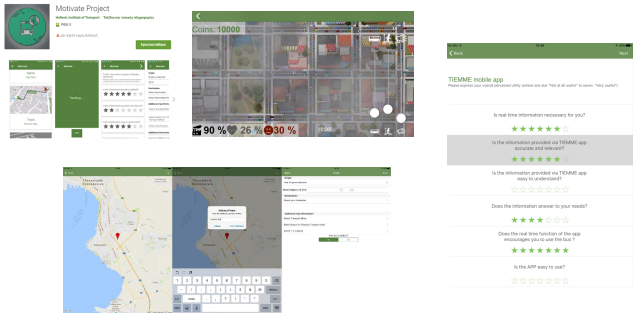

Figure 1: The MOTIVATE app

A. **Trip Diaries/Frequent trips**: the service aims to collect information regarding the mobility patterns and behaviour of all the end users (citizens and visitors). The daily trips are declared by any user either on real time (GPS enabled) or after the trip (frequent trips). This service enables the development of a valuable and highly cost effective data library concerning the daily mobility patterns of the city.
B. **Evaluation of existing transport measures**: the service aims to collect information from the end users regarding specific mobility measures and transport services already operate in the city. The users are asked to rate the performance of the existing mobility measures and transport services giving a clear view of their satisfaction from their current operation.
C. **Preference on future transport interventions**: the service aims to collect information from the end users, regarding their perceptions in specific mobility interventions by rating their importance.
D. **Game**: a game is provided to the end users aiming to make them more familiar to sustainability and attract them to the app.

TRANSFERRING THE APP TO THESSALONIKI CASE

Test beds of MOTIVATE app were Ioannina & Rhodes (GR), Almada (PT), Siena (IT), Larnaca (CY) (period from 2018-2019) where previous engagement levels were low. Having identified the opportunities from the testing phase of MOTIVATE app at the project partner-cities, the developer of the app, HIT/CERTH - being in parallel the technical consultant of Thessaloniki's Sustainable Mobility Plan (SUMP)- further tested the effectiveness and the usefulness of the MOTIVATE app in the city of Thessaloniki (GR, Region of Central Macedonia).

RESULTS

The MOTIVATE app was launched in Thessaloniki in September of 2018, through the European Mobility week and its pilot testing phase lasted for one month.
The first category of outputs concerns the evaluation of the existing transport measures or services or the assessment of the planned ones. More than 100 users participated. A second category of outputs, concerns trip diaries collection; almost 800 trips were collected and assessed.
A further evidence of success, is the similarity of results between the household survey data and the data collected from the MOTIVATE crowd learning platform.

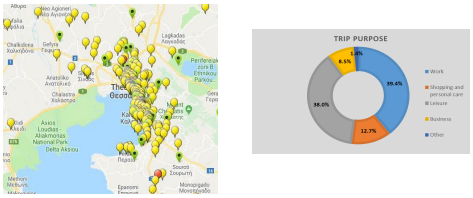

Figure 2: Data for the case of Thessaloniki via MOTIVATE app

CONCLUSIONS

The transferring experience of the MOTIVATE platform in the city of Thessaloniki verified the opportunities arising from crowd-sourcing initiatives exploitation; an ICT based tool enabling citizens' participation in mobility planning accompanied by a well-structured promotional strategy (campaigns, gaming, rewarding system) for attracting users, can bring a new era in city planning. Through the short testing period in Thessaloniki, a good level of interaction among the travellers (citizens and visitors), decision-makers and mobility stakeholders has started. Additionally, the evaluation of the outcomes has showed that ICT-based data collection tools could offer relief from expensive and time-consuming surveys with reliable results. It is however, imperative for keeping alive the travellers' interest and participation to provide them with regular updates of the platform and additional personalized tips and rewards.

ICDSST 2020 PROCEEDINGS – ONLINE VERSION
THE EWG-DSS 2020 INTERNATIONAL CONFERENCE ON DECISION SUPPORT SYSTEM TECHNOLOGY
I. Linden, A. Turón, F. Dargam, U. Jayawickrama (editors)
Zaragoza, Spain, 27-29 May 2020

Global Portuguese Scientists (GPS): an academic social network to assess mobility in science

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ABSTRACT

International scientific mobility has a significant impact on mobile researchers, the co-creation and sharing of knowledge, and the competitiveness of individual research institutions and nation states. Despite the political importance of mobility in science, there is no systematic effort to analyze and characterize the phenomenon. We argue that information provided by a social network may contribute to fill in this informational gap. This work presents the Portuguese academic social network GPS (Global Portuguese Scientists - https://gps.pt/), and analyses the data stored along almost one year after its launch (between November 2016 and September 2017), in order to explore its potentials in mobility studies. Using an unique data set containing the research experiences entered by the Portuguese researchers registered on the platform, the results of this empirical research provide interesting insights into the international dimension of the research careers of community's members, focusing on four main questions: i) how many users are on GPS; ii) who are they (in term of sex and age); iii) what have they been doing (position held, scientific research area, duration of each research experience); iv) where have they been working (country, continent, distance from Portugal). A descriptive and inferential statistical analysis is presented, both to i) describe the evolution of the number and characteristics of GPS scientists registered on the platform and ii) establish associations across the variables in each of these major dimensions in order to characterize mobility patterns of the GPS scientists. More specially, the intent is to understand whether there are significant differences in the profile of Portuguese researchers (both in term of socio-demographic characteristics and the kind of research they have been doing abroad) depending on the location where they carried out their research activities. The results of this empirical research provide interesting insights into the international dimension of the research careers of community's members, allowing to characterise the spatial patterns of the mobility of Portuguese researchers, and giving the opportunity to monitor the academic path of the Portuguese scientists across the world.

Keywords: Academic Social Network; Mobile Portuguese Researchers; Data Collection; Empirical Research

1. INTRODUCTION

This work presents the Portuguese academic social network GPS (Global Portuguese Scientists which aims to virtually connect the Portuguese researchers who have experienced a period abroad for research purposes), by exploring some aspects of their spatial mobility episodes through descriptive and inferential analysis.

The major difference between previous empirical work, concerning Portuguese researchers [1, 2, 3 and 4] and our analysis is based on the instrument used for studying the geographic mobility of Portuguese researchers. As detailed in the next section, the GPS platform allows us to perform CV-based research by exploiting the data concerning the educational and professional experience provided by the registered members.

This short version of the paper is organized as follows: section 2 describes the GPS platform, both in terms of its functionalities, the information gathered and the way in which data are uploaded; the technical aspects, which allowed a user-friendly environment to be built, are also explained in this part of the paper; section 3 focuses on the data analysis and provides quantitative information regarding the general characteristics of the research experiences carried out by the GPS community members; finally, section 4 wraps up the paper by highlighting the contribution of the GPS platform in social science and discusses the direction of the possible future usage of GPS data.

2. THE GPS PLATFORM AS A DATA SOURCE

The GPS platform (https://gps.pt/) is organized according to a common structure in social network sites (SNS). This structure encompasses three complementary levels that roughly relate to different platform contexts: communities, groups and profiles.

Communities are a macro-organizing entity that registered users can be associated to. By default, all GPS users are associated with the 'general community'. The platform's administrators have the possibility of creating additional communities, but it was decided to limit that feature to the creation of specific communities that are representative of the scientific associations that are partners of the GPS initiative. The ability to communicate with their peers which is provided by the GPS platform is aligned with one of the most common uses of social networking sites, which is very well-known by this particular group of people and by other expatriate or sojourner groups for that matter [5] and that research highlights as 'the positive influence SNSs have on generating interpersonal support and social capital' [6].

Communities inside GPS can also organize themselves in groups (in September 2019, 154 groups were registered in the GPS platform). As in other SNS platforms, groups in GPS represent an entity that typically ties together users with a common background, interest or characteristic and are digital spaces in which members can have a more restricted and focused exchange of information. The larger groups in GPS have 150-200 members, which is recognized in the literature as Dunbar's number, the cognitive limit to meaningfully manage social relationships [7].

Finally, users of the GPS platform are able to create a profile where they share relevant personal and professional information about themselves. On SNS, the profile is a very important feature and can be described as 'unique pages where one can "type oneself into being"' [8]. On the GPS platform, besides the typical 'about me' information where users share personal and mandatory information related to their name and birth date, they can also fill in information about the place they call home, and a personal photo. Users are also able to share professional information on their profile page. By doing so, the platform aims to complement some of the shortcomings associated with paper-based CV such as the lack of a coherent data structure that leads to undesirable levels of content heterogeneity and missing information fields in paper-based CVs.

In the professional information fields, GPS members can choose their scientific fields according to the classification system adopted by the official Portuguese scientific agency, which is made up of six categories: (a) Agrarian Sciences, (b) Medical Sciences, (c) Natural Sciences, (d) Social Sciences, (e) Engineering and Technology; and (f) Humanities. Besides this classification system, the platform also provides, for all scientific fields, the option to select 'other subarea', allowing the introduction of more specific niches that are not typically provided by official taxonomies.

Members of the platform can also insert locations and the name of the research institutions where they are or have been working on research-related tasks. In the 'Insert Location' dialogue box the platform members can search a location, insert beginning and ending dates for their stay in that location or signal that location as their current location. They can also describe their scientific experience at that workplace and select, from a predetermined activity field list, their work position according to eight different categories: (a) PhD researcher, (b) PhD student, (c) Non-doctoral researcher, (d) Researcher/visiting professor, (e) Leadership functions, (f) Research technician, (g) Science communicator or science manager, (h) Other.

In order to guarantee the reliability of the georeferenced locations, the GPS platform uses the Google Places API Web Service. This service allows the retrieval of previously validated locations and minimizes redundancies when inserting this type of information. However, this service also has its drawbacks because it does not allow, for instance, to filter the type of locations users can choose. In a first phase of deployment we restrained the search for location to a set of classifiers that limited the results to universities and teaching and/or research institutions. But this decision brought along its own limitations such as excluding scientists working in museums. The following decision was to open the results to all locations that were searched, which has brought its own set of problems, mainly related to presenting results that are less relevant to scientific activities (for example, shops and other services) and also allowing the possibility of associating scientists of the same institution through a multiplicity of different locations with obvious implications in future search actions.

GPS members also have the possibility of including a set of links in their profile related to personal, professional or scientific information like ORCID. This decision also allowed us to underline the added-value of the GPS platform: the ability to highlight its members' scientific paths, roles and workplaces. Last, but not least, GPS members can complete their profile with their contact information: address, phone, site URL and email.

The platform also has an element that, typically, SNS do not have: a homepage. The platform's homepage is informative by nature, allowing any visitor to know more about the objectives of this social network in particular, its main features and some general statistics about members. A map feature, that uses the Google Maps JavaScript API, allows the georeferenced visualization of the workplaces of all the Portuguese scientists registered on GPS. In the aforementioned map it is possible to filter the locations by year, including a 'today' option that shows the locations where, on that given day, the registered scientists undertook their scientific activity. It is also possible to filter the results by scientific areas and countries. If the user chooses a given location, the query produces a list of scientists residing in that location, according to the above-mentioned filters.

All data inputted by GPS members is stored in a graph database that uses *neo4j* technology. For the statistical analysis, developed and partially presented in this work, an exportation routine was created in order to export data to a CSV file where all information regarding each scientist is saved in a spreadsheet line. Data exported was limited to users labelled as GPS scientists (i.e. scientists that have one or more experience outside Portugal, for a minimum duration of three months each).

3. BRIEF CHARACTERIZATION OF THE GPS COMMUNITY

In this section, a summary of the statistical analysis will be presented. Since the users must specify the starting and finishing date (if the professional experience is concluded) of each research experience, we could identify for any date what the researcher's scientific activity was at that moment. The dates considered in the analysis are the 1st of January 1990, 1995, 2000, 2005, 2010, 2015, and 13 September, 2017.

The analysis presented below provides a general description of the GPS community, and emphasizes on the following aspects: *who the GPS scientists are*; *what job they have being doing* and *where they have being working*. Through the application of a bivariate analysis, it was possible to establish associations across the variables in each of these three major dimensions, in order to characterize mobility patterns of the GPS scientists.

3.1. Data analysis

How many Users are on GPS?

During the first 10 months of existence, the GPS platform has brought together 1,679 Portuguese scientists spread out around the world, totalizing 3,951 research experiences, which means that, in average, each member took part in more than two research experiences which could be either in Portugal or abroad. As expected, the number of GPS scientists increased during the period analysed, resulting in an almost duplication of records every five years; with the exception of the first period (60%) and the last two years of the last period (26%). Considering the national or international dimension of the scientific experience, it is possible to confirm that GPS scientists have increased their presence abroad. The percentage of members with at least one experience in a foreign country increases throughout the whole period, except in 2010. While in 1990 about 35% was abroad, the percentage in 2017 raises to 80%. On the contrary, the percentage of GPS scientists with only one experience in Portugal decreases considerably, shifting from 54 to 14%.

Who are the GPS Scientists?

The information gathered from the GPS platform enables us to analyse the GPS members in terms of age and sex. Among the 1,679 GPS scientists, there is a relatively equitable distribution of men (49.7%) and women (50.3%). However, the equity was not the same over time: in 1990, women represented only 27.9%; in 2010, female researchers accounted for 45.3%; in 2015 they represented the same percentage; and only in 2017 were female scientists more representative. It is worth considering the evolution of the number of female members and their type of activity.

The ages of our sample varied from 20 to 81, with an average age of 36. It is curious that there is constancy in the average ages in the period between 1990 and 2015 – ranging between 31 and 33; 2017 is the only year in which the global pattern changes with an average age of 36. It is worth mentioning that the average age is higher among men (37.6 years) than among women (34.5 years).

What have they been Doing?

In this dimension, three major characteristics were analysed: (a) the position held during each research experience, (b) the scientific research area associated to the GPS scientist, and (c) the duration of the research experience. The results show that the most representative categories in 2017 are *PhD researcher* (38%) and *PhD student* (25%). These two categories have a very different evolution pattern, with opposite trends after 1995, which led to, between 2000 and 2005, a higher percentage of *PhD students*. On another less preponderant level *Non-doctoral researcher* and *Leadership functions* scientists take the stage, with a significant decrease of importance of the former (-22%) and a slight increase of the latter (+1%), when the overall period is considered. In 2017, these two categories represented approximately 10% of the total of experiences.

The analysis of the research areas associated to each GPS scientists was done base on a field that is not mandatory and there is no restriction in the number of research areas included in this category. This allows those researchers that are, or were, working in multi or interdisciplinary fields the possibility to mention all the research areas they think are more relevant or closed to the research work developed throughout all their experiences. In this sample, 964 users (57.4%) identified only one scientific area, while 579 users (34.5%) selected two or more scientific areas. The category Natural Sciences is the most representative scientific domain, both among the GPS scientists who mentioned only one disciplinary area (47.8%) and those who considered one or more areas of research (59.4%).

On average, each of the 1,679 GPS scientists had registered approximately two stays abroad during their professional trajectory, with an average duration of 38.4 months in each experience. This value is slightly higher for men than for women: 41 months and 35 months in each case. The activities associated to the longer periods are: *Leadership functions*, *PhD researcher* and *Science communicator or science manager*; while the shorter periods include activities such as *Research technician*, *Non-doctoral researcher* and *Visiting researcher/professor*.

Where have they been Working?

Up to 2017, a total of 79 countries (excluding Portugal) were registered in the GPS platform and the 11 most popular destination countries themselves hosted the 79% of the research experiences. The UK is the most popular destination with 785 research experiences (20%), followed by the USA with 573 experiences (15%). The other non-European country in this list is Brazil, which shares the Portuguese language, hosting 2% of all experiences.

Through the analysis of the geographical distribution of the research experiences over time, it is possible to observe that the weight of Portugal decreases, from 61% in 1990 to 34% in 2005, and to 15% in 2017. It means that, as already mentioned before, the number of Portuguese researchers that had or have an experience abroad has increased significantly in the last two decades. France, during all this period became less and less predominant. In 1990, it was the first country (excluding Portugal) with more experiences (13%), as was overtaken by United Kingdom in 1995 (14% vs. 12%) and by the United States in 2000 (15% vs. 10%), falling into third position. In 2015, France is already in fourth place, with Germany taking third place, a ranking that was kept in 2017.

Considering Lisbon as the reference point for Portugal, each research experience abroad took place at an average distance of 3582 km. Analysing the distance by sex, is possible to pinpoint that men stayed further away from Portugal than women did (3,730 km and 3436 km). When performing the same exercise by activity, it seems that *Visiting researcher*/*professor*, *Leadership functions* and *Science Communicator* or *Science manager* are those work positions, on average, that were carried out further away from Portugal; while the scientific positions such as *PhD Student* and *Non-PhD Researcher* are, on average, closer to Portugal.

3.2. Inferential Analyses of the GPS Community

Using the most appropriate parametric and non-parametric inferential tests, this section will present the main characteristics that emerged when considered the research experiences carried out outside Portugal by the GPS scientists, by crossing the variables included in the three dimensions analyses in the previous sub-section. In order to simplify the presentation of this cross-dependence study and highlight the most interesting results of the academic mobility studies, the paper only presents a part of the inferential tests developed (the authors excluded all the figures and tables from this short version). The socio-demographic characteristics (age and sex), the work position, the scientific research areas, that characterize each research experience, are compared in 10 different geographical units: macroscale approach considering the six major regions, *i.e.*, the continents; and a microscale approach considering the four most popular destination countries representative of the Portuguese diaspora, that is the USA, the UK, Germany and France. It worth mentioning that the level of significance is not dependent on the magnitude that a value may have in a specific geographical unit, but rather based on a comparative analysis of the weight that a value of a specific variable has in other territorial contexts.

Starting with the region with the highest number of research experiences, Europe (56% of the total, not including Portugal), there are significant differences when comparing this continent with the other regions. There is a predominant presence of women; specifically, more than 3% of women than what should be expected when comparing the overall sample. The young people (less than 30 years) and PhDs students are also characteristics that differentiates the European continent; for the former the value is 64%, while for the latter the value is 28%, corresponding to a difference of 5% and 3%. In Europe, there were no scientific research areas identifiable as significant, which means that there is no specific pattern of demand for specific research areas.

The generic pattern of GPS scientists in the North American continent changes significantly, when compared with Europe. While in this part of the world the portion of GPS men is 57%, the distribution of the GPS scientists by sex is approximately fifty-fifty in the overall sample. Another characteristic that differentiates this region is the age structure; it captures fewer young scientists, in this case with less than 25 years old, than the average (12% comparing with the global average of 25%) but there are more scientists between 26 and 40 years old than expected (79% comparing with the global average of 67%). The distance from Portugal might justify the scarce attractiveness of North America in the early

stage of the scientific career and the expenses associated with the stay. Job positions that reflect a state of greater scientific maturity, such as *PhD Researchers*, *Researcher/visiting professors* and *Leadership functions* scientists, are more representative here than in the other regions of the world, 5%, 5% and 2% more. *Medical Sciences* and *Social Sciences* are the most significant scientific areas in North America, with approximately more than 3% when compared with other regions.

There are some similarities between South America and North American in regards to the main characteristics of the research experiences. For example, male scientists are the most representative group (59%), and the predominant age group is made up with researchers between 31 and 55 (72%). *Researcher/visiting professor* is the unique work position that assumes particular evidence in this region with 22% (note that this value for the overall sample represents just 7%). Among the scientific areas, *Social Sciences* and *Engineering and Technology* are also relevant, just as in North America, but in this case, *Humanities* emerges as a significant additional scientific area.

In Asia the GPS members are predominantly men, 11% more than what would be expected, and the majority of the scientists belongs to the age group between 31 and 64 years old. This fact confirms the argument that older age groups are in places farther of Portugal. Moreover, it is also evident that *Researcher/visiting professor* is the most representative scientific position in this region (9% more than the average) and *Social Sciences* and *Humanities (6 and 10%* more than the overall sample) are the two major scientific research areas.

The 57 research experiences hosted in Oceania are predominantly carried out by women between 31 and 50 years old. It is worth pointing out that the relevance of this age group is 27% more than the overall average. The most significant research activity is *Researcher/visiting professor*, similar to what happened in Asia and, with the exception of *Medical Sciences* and *Engineering and Technology,* all the other scientific research areas have a significant importance in this region.

The research experiences carried out in Africa are characterized by the fact that they are held mostly by women between 31 and 64 years old, a somewhat different reality when compared with the rest of the continents. The most representative work position and scientific research areas in this part of the world are those that have the lowest relevance in the total sample. *Social sciences,* for instance, represents 22% more than the average.

The main characteristics of the four most important destination countries of the Portuguese diaspora are the following. UK and the USA are characterized for hosting GPS members that have roughly the same features: scientists between 26 and 30, PhD researchers and the significant scientific research area is *Social Science*. The USA distinguishes itself according to three other characteristics, namely, people between 31 and 40 years old, *Researcher/visiting professors* and *Medical Sciences* the main scientific research area. In Germany and France there are also remarkable similarities, namely in the age of the GPS members (the younger age groups considered in the analysis) and in the work position they developed (both having a single significant scientific position, *PhD Students*). They are different in relation to the representativeness of the sex and the scientific research areas; in Germany GPS members are predominant women (more than 10% of the average), while in France the percentage of men is higher. Regarding the research areas, Germany does not have any specific core scientific area while France attracts Portuguese researchers from *Natural sciences* and *Engineering and Technology*.

4. CONCLUSIONS

The main objective of this paper is to present an explanatory analysis about the characteristics and the patterns of geographic mobility of Portuguese researchers registered on the GPS platform (https://gps.pt), which is a Social Network Site, that allows to build a clearer picture about where, when and on what Portuguese scientists have been working in recent years, distinguishing the different disciplines of research and the work positions of the researchers. As a social network platform, the main objective of the GPS is to stimulate networking among the Portuguese academic diaspora, allowing this community the share ideas, discuss common topics of interests, related with their work or off-topics they think are relevant, and to find contacts, according to different search criteria. However, we consider

that the collection and the analysis of the data provided by the GPS members, throughout time, offer stimulating opportunities to study the main spatial mobility patterns of the Portuguese academic researchers around the world, and monitor their professional research career. Further insights on the geographic mobility of Portuguese researchers are offered by the European Commission's MORE surveys. Despite their great contribution in monitoring the European Research Policy, current technologies offer the possibility to go beyond the survey approach, by building a dynamic data gathering system able to monitor the population under study.

In the literature, the analysis of academic mobility has been conducted in several ways. The most common approaches are to study this phenomenon based on surveys, applied exhaustively on researchers that are studying or working abroad - a kind of cross-sectional analysis. However, in our study is possible to highlight, in a dynamic manner, the scientific activity of Portuguese researchers, taking into account their different scientific fields. In fact, the GPS platform offers an unique understanding of the scientific mobility phenomena, in an ongoing process, bearing in mind that additional efforts should be done to maintain the platform as a point of interest amongst current users and extend the number GPS members to ensure the reliability of the results.

In summary, the GPS platform creates and promotes an intense environment of collaboration, but at the same time, it is a powerful tool for mobility studies and for science policy-making. Specifically, it provides a longitudinal data analysis to characterize the phenomena of the scientific mobility (where the main results were presented and discussed in section 3) and offers insights about the long-stay migration and the scientific labour force spread around the world and analysing scientific returns.

The scientific mobility and particularly the large-scale migration of highly qualified and skilled people will, in the long run, have a strong impact in terms of knowledge on countries with a weak scientific and technological system. For this reason, the effective use of this kind of information is essential for designing effective policies that stimulate brain gain or encourage and support the temporary mobility of scientists in pursuit of training, access to new knowledge and networks.

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An innovative approach for project launch decision-making in risk and multi-criteria situations

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ABSTRACT

The realization of infrastructures and the deployment of processes can follow project formalism. Generally, a project goes through a design and a realization phase. Between these two phases, there is a crucial milestone: Launching the project, which is not at all an easy decision and constitutes a real problem. The main reasons to this are the numerous numbers of criteria (For Technical, Economic, Social, Environmental dimensions) and risks in the sense of feared event. Criteria and risks are most of the time not considered due to lack of time (for formalization) and the difficulty to handle them. The objective of this paper is to propose a relevant approach to make the decision of launching the project or not. The proposal outlined is innovative in that it can consider indicators based on several appropriate criteria, the associated risks and their ways of management. The fact to consider several criteria and risks, increases the probability of making the right decision. The proposed approach allows managing risks by determining acceptable scenarios, thus maximizing project aptitude to fulfil the objectives.
Keywords: Risk, Multicriteria, Project, Scenario, Decision, Criteria

INTRODUCTION

Nowadays, the building of most infrastructures and the deployment of most processes take the form of a project. After the design phase, the main issue is to decide whether the project can be launched or not. During this phase, the decision is either to launch the project in its actual configuration, abandon it or redefine it. According to [1], 90% of all major projects (of more than 1 million euro) fail due to bad decision-making. Making the right decision is thus the key element for the project's success [2], [3]. To make these decisions, stakeholders need a decision process, with metrics that indicate the likelihood of the project's success [4]. Thus, a project is likely to succeed if its assessed metrics are pertinent to the context and if they suit the project objectives.

The aim of this paper is to help stakeholders at the project launch phase, by proposing an approach based on a decision process and metrics on which they can rely. So that they can decide whether the project is qualified to be launched or not. There are few studies in the literature addressing this particular issue – which is also called the "go/ no go" question [5]. Most authors are more interested in the bid/no bid question [6], [7]. There is, however, a real need to consider this particular problem of go/ no go for the project launch. This decision is very often based on limited criteria – mainly the cost and the duration [8], [9], [10], [11]. This method can no longer be recommended, because customers are becoming increasingly demanding. Otherwise, cost and duration alone are insufficient as criteria to characterize the project success likelihood. Other criteria that take account of dimensions such as technical,

environmental, social and regulatory requirements must be integrated in the assessment. Generally speaking, ignoring these dimensions widens the gap between what was planned and what was achieved and leads to the project failure. Another reason for project failure is the occurrence of non-identified and unpredicted events (risks). Thus, to make correct decisions in the launch phase, there are two main difficulties: (a) the need to integrate several criteria [12] and (b) the consideration of risk [13], [14]. Authors such as [15], [16] and [17] have addressed some aspect of these problems, but not all of them. For instance, [15] focused only on risk while [16] focused on criteria and [17] analysed only the project indicators. [18] and [19] proposed a decision framework without investigating risks.

The major drawbacks of these proposals are the lack of (1) a generic framework that can take into account several types of criteria, and several risks, and (2) an aggregation model to characterize the project from the characteristics of its tasks. A multi-objective programming approach proposed by [19] does not provide guarantees for the existence of the criteria, unlike our proposal which is based on aggregation functions. Finally, the evaluation of the project in a context of risk, investigated by [20], [21], [22] does not consider risks at the task level, as our proposal does. There is thus a real scientific need to find a framework that provides an indicator that includes several risks and criteria for the project launch issue. We make the hypothesis that the use of more and better-adapted criteria and risks may lead to an improved decision-making.

The innovation in this paper, in comparison to the shortcomings of the literature, lies in providing (a) a method for considering several criteria, risks and their treatment strategies, (b) an aggregation of these criteria from low level (on the task) to the level of the whole project, (c) indicators that include a wide range of appropriate criteria that are complementary to the cost and duration factors, (d) relevant indicators that make it possible to determine whether the project can be launched or not. Thus, it becomes possible for the stakeholders to make the right decision. This, in turn, leads to a reduction in the failure rate, saving time and money.

This paper begins with the presentation of our proposal. This consists of a description of the analytical process and a conceptual model. The latter describes the main concepts. Then the methodology to assess the risk impact on identified criteria is described, along with the aggregation procedures. Finally, some indicators for project success likelihood are proposed. Finally, our perspectives are outlined in the conclusion.

PROPOSAL

This section describes our proposal to handle the problem of deciding on the project launch in a situation involving risk, while considering several criteria. We propose a process that can be followed by stakeholders to determine if they can launch the project or not. The proposal provides relevant indicators that evaluate the success likelihood in a risk situation. Figure 1 shows the overall process. It consists of 3 steps that may be iterative: Data collection and modelling, Calculation, and an Analysis for decision-making. Every step has two levels: risk level and strategy level. The term Risk refers to any disturbing event. At the risk level, only risks and their impacts are considered. The strategy level also considers the identified strategies to manage risks.

The first step consists in characterizing the Tasks, Risks, their Impacts and the project's Objectives using several Criteria. Based on expertise and/or data, an analyst performs this characterization. It leads, in the second step, to a model of the project including risks. From this model, the Risk Scenarios (ScR) are generated and evaluated. A risk scenario is a combination of occurrence/ none occurrence of risks. Then a Risk Resulting Impact (RRI) is assessed for every generated risk scenario that affects a task. The value of the Risk Resulting Impact is aggregated to the task to obtain a Task Resulting Value (TRV). At the end, the Task Resulting Value of all tasks are aggregated from tasks to the project level to obtain a Project

Resulting Value (PRV). Project Resulting Value is a set of aggregated criteria that characterize the project for every risk scenario. Based on the Project Resulting Value and the objectives, a Scenario Success Indicator (SSI) is assessed for every pairing of (risk scenario, type of criterion). After this, a Scenario Success Indicator is assessed for every risk scenario for all criteria. From the Scenario Success Indicator, the step of analysis classifies the project into one of these three categories: Fully Acceptable, Acceptable, and Not Acceptable. Fully Acceptable means that the project, in its actual configuration, meets the objectives. Thus, the project can be launched. Not Acceptable means that the objectives are not respected, and the gap is too wide. In this case the project must be redefined and characterized again - or abandoned. Acceptable refers to a situation where the project does not fulfil the objectives, but some risk management strategies could be used to drop it into the objective's domain. In such a situation, preventive and corrective strategies for risk handling are characterized. From the new project model, including the management of risks, Treatment Scenarios (ScT) are computed for every risk scenario. A new Scenario Success Indicator is assessed, and the analysis categorizes the project and makes the decision to abandon, launch, redefine or characterize the project once again. Data collection/Modeling (1) and the Analysis (3) are performed by a stakeholder with the help of our built- in tool. The calculation (2) is totally performed by the tool.

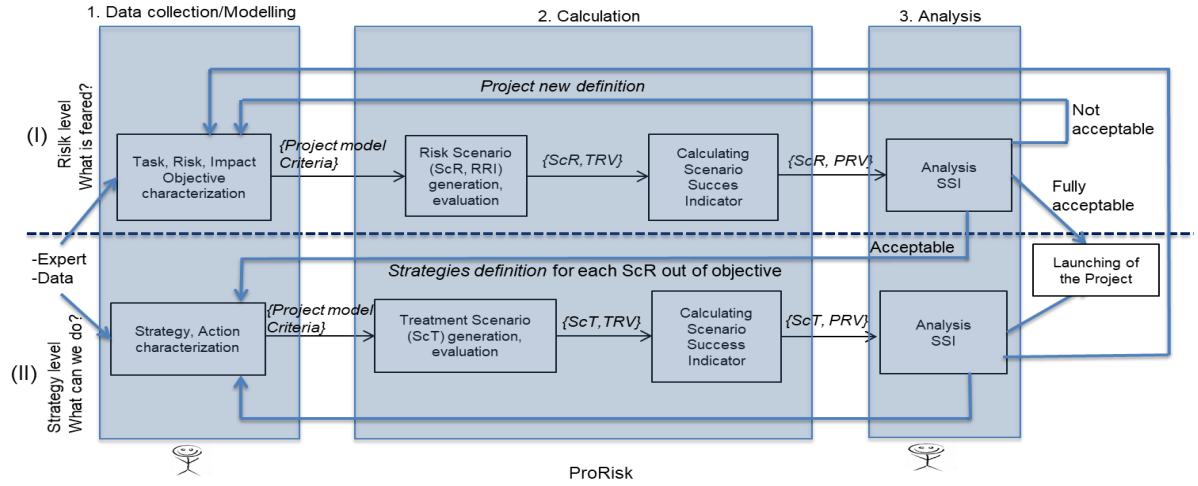

Figure 1: Decision-making process of project launch

Data collection modelling

Data is collected for six concepts: Project (P), Task (T), Risk (R), Impact (I), Strategy (St) and Action (A). A project consists of many Tasks. During task realization, Risks can occur. Risk is used in the sense of an undesirable event characterized by an occurrence probability which impacts on the project objectives [23]. A Risk affects one or many task criteria depending on the value of its Impact. Strategy aims to manage risk. It can reduce the impact of risks as well as the probability of their occurrence. Strategy consists of a series of Actions. An action can add new tasks to the project, remove or modify existing ones. The first innovation in the paper is to characterize each concept by several criteria representing a relevant dimension: Technical, Economic, Ecological, Social, Regulatory etc. The second innovation lies in performing an analysis by including the objective on the identified criteria. Therefore, an objective for every criterion is defined according to four values: a minimum unacceptable (MINU), a minimum acceptable (MINA), a maximum acceptable (MAXA) and a maximum unacceptable (MAXU).

Calculation and aggregation procedure

This section presents the aggregation procedure used to assess a success indicator. The third innovation in this approach is to begin by low-level information (values of criteria and impacts on tasks) then move to a higher level (the project level by assessing the Project Resulting Value for every risk scenario). For this purpose, let us consider a set of tasks $\vec{T}$, and Risks $\vec{R}$. A single task T, and Risk R are characterized by a set of criteria type $\vec{C}$. To manage Risks, sets of corrective and preventive strategies are available. $\vec{C}$, $\vec{T}$, $\vec{R}$, are vectors composed of several elements. A risk R has a set of impacts $\vec{I}$ (one for every criteria). For r = $|\vec{R}|$ risks, 2r risks scenarios are generated from our built-in tool. A risk scenario could be composed of a single risk, several risks or the situation where there is no risk (None). In the following part of this section, the proposal is described for one criterion. For risk scenarios composed of several risks, and impacting a single Task, their resulting impact corresponds to the Resulting Risk Impact (RRI). In the literature, the impact of a risk scenario composed of several risks is handled by summing their impacts. However, the "sum of value" model is not suitable to characterize all situations. For instance, both fire and flood can cause delays in a project. Their impact can be determined separately from a model or through data/expertise. But the simultaneous occurrence of fire and flood leads to a resulting impact different from that of the sum of fire and flood. For this reason, the Resulting Risk Impact ($\overrightarrow{RRI}$) of Risk Scenario (ScR), is calculated as follows:

$$\overrightarrow{RRI} = \mathrm{M_{RRI}}(\vec{I}) \qquad (1)$$

where MRRI is a model. $\overrightarrow{RRI}$ is a set of aggregated criteria that characterize every risk scenario.

In the same way, the impact of a risk scenario on a criterion for a single task, that of the global project are aggregated. At the end, we calculate a Scenario Success Indicator (SSI) associated to every pairing of risk scenario i and criterion j according to the following formula:

$$SSI(ScRi,j) = \begin{cases} 1 \; if \; PRVij \in [MINAj, MAXAj] \\ 0 \; if \; PRVij \geq MAXUj \; or \; PRVij \leq MINUj \\ 1 - \frac{PRVij - MAXAj}{MAXUj - MAXAj} \; if \; MAXAj \leq PRVij < MAXUj \\ 1 - \frac{MINAj - PRVij}{MINAj - MINUj} \; if \; MINUj \leq PRVij < MINAj \end{cases} \qquad (4)$$

In equation (4) the value of MINUj, MINAj, MAXAj, MAXUj are given for a criterion j. PRVij is the Project Resulting value for the risk scenario i and the criterion j. The global Scenario Success Indicator for all criteria depends on its occurrence probability P. It is assessed as shown below.

$$SSI(ScRi) = \begin{cases} 1 \; if \; \forall j, PRVijc \in [MINAj, MAXAj] \\ (1 - Pi) \times \prod_j SSI(ScRij) \; else \end{cases} \qquad (5)$$

According to equation (5), the value of a Scenario Success Indicator is necessarily between 0 and 1. 1 is the best value and 0 the worst.

Analysis and use of the indicators for decision-making

According to the values of the Scenario Success Indicators, the decision on the project launch is determined as follows:

The project is in a *Fully Acceptable* situation, if the values of all scenario success indicators are 1 (one). In this situation the project can be launched.

$$\forall i \; SSI(ScRi) = 1 \qquad (6)$$

The project in a *Not Acceptable* situation if the values of all scenario success indicators are 0 (zero). In this situation the project needs to be abandoned or defined again.

$$\forall i \; SSI(ScRi) = 0 \qquad (7)$$

If some risk scenarios exist for which $SSI(ScRi) \in \;]0,1[$, the project is in an *Acceptable* situation. In this situation, the project is not so bad that it must be abandoned, but not good enough to be launched either. Then, some strategies must be redefined. The bottom part of the process in Figure 1 is followed and new Scenario Success Indicators are assessed. To avoid infinite loop (in the case where the project is in Acceptable situation again and again), the new value of the Success Indicator is compared to a threshold $\widehat{SSI_t}$. The threshold is the minimum acceptable value of the Success Indicator after the incorporation of strategies. Then, the project can be launched if $\exists i / \; SSI(ScRi) \geq \widehat{SSI_t}$.

CONCLUSION AND FUTURE WORKS

The objective of this paper has been to propose an approach to determine the likelihood of project success, to take the decision to launch, abandon or redefine the project by relying on an innovative indicator. For this purpose, we have proposed success indicators by identifying and aggregating several criteria, risks and strategies. We then proposed a methodology to assess risk impacts, strategies and the aggregation of criteria in all possible configurations. This approach is a way to evaluate the project from criteria defined to assess tasks. Finally, we proposed success indicators and decision procedures to determine whether the project could be a launched or not. Besides the proposal of the process, our contribution is based on three activities: (1) A project evaluation model (2) During data collection/modelling, we propose a project model that includes risks (3) During characterization, we propose the integration of several criteria; For the scenario evaluation framework, aggregation functions are proposed. Indicators to evaluate project success complete these functions; Finally, a methodology to categorize scenarios is proposed in the last part.

We have observed that (a) risk occurrence may compromise fulfilment of the project objective and consequently affect its launch, (b) the more risks included in the risk scenarios, the lower the success indicator is, (c) the inclusion of several criteria might change the analysis process and have a consequence on the launch decision (d) in some cases, a risk could become an opportunity. These findings demonstrate the need for an indicator on which to rely for decision-making in risk and multi-criteria situations. They confirm the initial hypothesis: the use of more and better-adapted criteria, including risks, may lead to a different launch decision. As a perspective, our aim is to look at the problem of relationships inside the criteria and risks.

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Decision Aids: Users' Motivation and Its Implication

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ABSTRACT

Thorough preparation for the negotiations is considered critical for the achievement of successful relational and substantive results. Careful specification of the preferences is one of the most important preparation activities. To facilitate this process preference elicitation aids have been designed and implemented in decision and negotiation support systems. This paper shows that users' intrinsic motivation affects the use of simple elicitation aid and elicited preferences. The hierarchical model of motivation identifies ten kinds of motivations. Using the logistic regression model we identify those motivations that allow distinguishing negotiators who do not make errors from those who make them. Three kinds of motivation have a significant impact on the negotiators' classification. For the remaining kinds of motivation, the impact is significant only jointly with another kind. The study shows that the users' interest in learning is a significant direct and indirect motivator. Therefore, an impartation of the learning aspect of an experiment may have a positive effect in experiments in which DSS and NSS are used.

Keywords: negotiation support, preference elicitation, experiments, motivation, logistic regression

INTRODUCTION

In an earlier study, Wachowicz et al. [1] analyzed users of a negotiation support system interpretation of preferences, which were presented to them as text as well as one of two graphical formats: circles and bars. They observed that bars help the users to express preferences more accurately than circles. They also noted that users may be categorized into two groups. The smaller group (about 22%) were the users who made no ordinal errors, i.e., they maintained the direction of preferences; a larger group (about 78%) made one or more ordinal errors.

This paper present the results of subsequent negotiation experiments which aimed at uncovering the possible reasons for the errors made by the users of the Inspire online negotiation support system (NSS). The experiment settings, the case, and the reward structure, which provided extrinsic motivation, were the same as in [1]. The difference was in the data about the users, which we collect using three research instruments. These instruments were used to measure the users' intrinsic motivation, which included their willingness to put the effort in the understanding of the negotiation case, diligence, and their interest in the use of the system and the negotiation. Because preference elicitation is one of the key activities in the preparation for negotiation, we studied motivation at the stage of preparation when the users formulate the scores that reflect preferences they will use in the negotiation.

Recent studies on intrinsic motivation in the context of negotiation were undertaken in two directions. One extends the concept of motivation beyond social motivation; it proposes a hierarchical model of motivation comprising three levels: global, contextual and situational [2]. Global motivation is viewed as the need to construct a truthful representation of a problem or task, i.e., epistemic motivation. Contextual motivation is social motivation, and the situational motivation identifies the needs and objectives of the negotiators, it is their identity motivation [3]. Recent studies have shown the relationship between these three levels of motivation [4, 5].

The second direction, discussed here, extends studies on motivation from the negotiation conduct to negotiation preparation. The analysis of experiments that focused on the preparation for the negotiation showed that some negotiators make errors during the preference elicitation phase [1]. This observation led to experiments in which the instruments used to measure the three kinds of motivation were administered. The results obtained from a structural equation model (SEM) showed the impact of motivation on negotiation preparation [6]. The effects were, however, weak and not greater than 0.221.

The paper's purpose is to provide a deeper insight into the impact of intrinsic motivation on the NSS users' preparation for negotiations. In the experiments, the users should be able to specify the preferences accurately, however, we observed that the majority of them made ordinal errors in the specification. We used a logistic regression model to differentiate between two classes of the negotiators: those who made ordinal errors and those who did not make them in order to assess to what degree motivational change impacts the chance that the negotiators move from one class to another.

EXPERIMENTS

The experiments, the three research instruments used to measure motivation, and the data obtained for this study were discussed in detail in [1, 6]. We analyzed the impact of motivation on ordinal errors made in the preference specification activity. To this end, we used the following research instruments to measure intrinsic motivation: Rational-Experiential Inventory [7]; Thomas-Kilmann Questionnaire [8], and Substantive, Relational, Learning (SRL) scale [9].

There were 181 negotiators who provided the required information. Out of 181 participants, we found that 62 (34.3%) were ordinary accurate (OA) and 119 (65.7%) were ordinary inaccurate (OI). The question that we put forward is: Does the motivation of the OA group differ from the motivation of the OI group?

METHOD

To determine the motivational differences between OA and OI groups we used logistic regression. Before the construction of the logistic regression model the predictors (i.e., variables that describe motivations) were rescaled. All predicting variables were centered around their mean value and rescaled so that the mean value was zero.

From the three research instruments we obtained 10 predicting variables:

1. *Rational* and *Experiential* approaches to problem-solving, which characterize epistemic motivation [7];
2. *Accommodating*, *Avoiding*, *Cooperating*, *Compromising*, and *Competitive* approaches to social problems, including negotiations, which characterize social motivation [8]; and
3. *Learning*, *Relational*, and *Substantive* goals that the negotiators want to achieve given a concrete negotiation problem, they characterize identity motivation [9].

The motivational model is hierarchical, therefore epistemic motivation my affect social and identity motivation, and social motivation may affect identity motivation. This suggests that there may be interactions between the predictors; such interactions were found in the SEM model [6].

RESULTS

Statistical package SPSS 26 was used to determine the parameters of the logistic regression model. The model and its fit are discussed below.

Logistic regression model

The dependent variable of the model is ordinal accuracy transformed into binary variable *Accuracy*. *Accuracy* = 0 for the ordinal accurate (OA) negotiators and *Accuracy* = 1 for the ordinal inaccurate (OI) negotiators. The model is as follows:

$$logit(P(Accuracy) = \beta_0 + \sum_{j=1}^{10} \beta_j X_j + \sum_{j=1}^{9} \sum_{i=j+1}^{10} \beta_{ji} X_j X_i$$

where: X_j are ten predicting variables listed in Section 3, $j = 1, \ldots, 10$; β_j ($j = 1, \ldots, 10$) and β_{ij} ($j = 1, \ldots, 10$; $j = 1, \ldots, 10$; $i \neq j$)

The parameters of the logistic regression model are shown in Table 1. Only three predictors have a significant impact on the negotiators' classification: their analytical approach (variable *Rational*), and their *Learning* and *Relational* goals. The remaining predictors do not have significant impact but their joint impact with other predictors is significant, e.g., *Rational* motivation impacts classification jointly with *Relational* and *Substantive* goals.

The negative value of the intercept indicates that the *average negotiator*, i.e., one whose all motivational variables are at the average level, is 2.150 times more likely to belong to class OI than OA. This is the reciprocal of $Exp(\beta)$, which is the odds ratio (OR).

Similarly, $Exp(\beta)$ associated with the predicting variables describes their odds ratio (OR) under the assumption that the value of one variable increases by one and the values of all other variables do not change.

If the *average negotiator's* significant motivation variable (i.e., *Rational*, *Learning* and *Relational*) increases by one unit, then the relative chance of such negotiator to be ordinary accurate increases *Exp*(*β*) times, under the condition that the other variables in the model are held constant. For example, the chance of the negotiator, whose *Rational* value increased by 1, to be in class OA increases 1.716 times.

In the logistic model with interactions OR includes the impact of the focal variable and the variables with which it interacts [10].

Table 1. Parameters of the logistic regression model

Variables and interactions	***β***	**Std. error**	**Wald**	**df**	**Sig.**	***Exp*(*β*)**
Rational	0.540	0.277	3.799	1	**0.051**	1.716
Accomodating	-0.163	0.142	1.333	1	0.248	0.849
Cooperating	-0.043	0.128	0.112	1	0.738	0.958
Compromising	0.068	0.134	0.254	1	0.614	1.070
Competitive	0.025	0.112	0.051	1	0.821	1.026
Learning	0.633	0.336	3.555	1	**0.059**	1.884
Relational	-0.533	0.249	4.594	1	**0.032**	0.587
Substantive	-0.233	0.391	0.355	1	0.551	0.792
Rational by Relational	0.730	0.293	6.219	1	**0.013**	2.076
Rational by Substantive	-1.040	0.487	4.554	1	**0.033**	0.353
Accommodating by Learning	-0.338	0.163	4.303	1	**0.038**	0.714
Accommodating by Substantive	0.579	0.283	4.189	1	**0.041**	1.784
Cooperating by Learning	-0.480	0.203	5.581	1	**0.018**	0.619
Cooperating Relational	-0.367	0.157	5.474	1	**0.019**	0.693
Cooperating by Substantive	0.677	0.264	6.553	1	**0.010**	1.968
Compromising by Learning	-0.382	0.194	3.863	1	**0.049**	0.683
Compromising by Substantive	0.539	0.257	4.394	1	**0.036**	1.714
Competitive by Relational	-0.159	0.076	4.424	1	**0.035**	0.853
Competitive by Substantive	0.404	0.212	3.620	1	**0.057**	1.498
Constant	-0.766	0.220	12.087	1	**0.001**	0.465

Note: The reference group is OI; OA is compared with OI. Standard errors smaller than 2 indicate no numerical errors in data.

For instance, the formula for the estimated odds ratio for the effect of *Rational* controlling for the predictors *Relational* and *Substantive* is given as:

$$OR_{Rational}(OA) = exp(0.540 + 0.730 \times Relational - 1.040 \times Substantive) \quad (1)$$

where: 0.540 is the estimated *β*-coefficient of *Rational*; 0.730 and -1.040 are the estimated *β*-coefficients of the interaction terms Rational by Relational and Rational by Substantive. The variable *Rational* does not appear in the equation because its value changes from 0 to 1, i.e., *Rational* = 1.

Table 2 shows that the impact of changes in the odds ratio for variable *Rational* ($OR_{Rational}(OA)$) when the values of the two interacting variables (*Relational* and *Substantive*) also change. The values lower than 1 shown in Table 2 show the change in the motivational profiles when the chance of making no errors decreases. That is, when the level of *Substantive* goal remains no lower than the extent of the *Relational* goal and the *Rational* approach is higher than average, the negotiators become more prone to making ordinal errors than not to making them. These values are obtained from (1) under the assumption that all other motivations remain at their average levels.

Table 2. The odds ratio for *Rational* and its interactions with *Substantive* and *Relational*

Values of modifiers		**Relational goal**		
		Lower (-1)	Average (0)	Higher (1)
Substantive goal	Higher (1)	0.3	0.6	1.3
	Average (0)	0.8	1.7	3.6
	Lower (-1)	2.3	4.9	10.1

An extreme situation is for a negotiator with substantive goals higher than average (1) and relational mode lower than average (-1). Such a combination of interacting terms makes an increase in Rationality (+1) to result in reducing the chances for the negotiator to be ordinal accurate. More specifically, such a negotiator is 1/0.3 = 3.33 times more likely to fall into the OI class than the average negotiator. However, if relational motivation increases and the substantive goals decrease, the effect of the increase on rationality is converse, i.e. it increases the chances for falling into the OA class. It gives (at the extreme point) 10 times higher chances to build the scoring systems with no ordinal errors.

Similar analyses may be conducted for other focal variables and their interacting terms.

Model fit and its predictive performance

The results of the Omnibus Tests of Model Coefficients ($\chi^2(19) = 48.001$, $p < 0.001$) show that the model fits the data significantly better than a null (intercept-only) model.

To determine the fit of the model we used pseudo-R^2 statistics proposed by Cox and Snell, and by Nagelkerke. The R2 are: Cox and Snell R2 = 0.233; and Nagelkerke R^2 = 0.322.

The pseudo-R^2 values are treated as rough analogs to the R-square value in regression models [11]. Pseudo-R^2 statistics are typically much lower than the R^2 statistics in linear regression. We conclude that the explained variation in the dependent variable based on our model ranges from 23,3% to 32.2 %, depending on reference methods, either Cox & Snell R^2 or Nagelkerke R^2, respectively.

Non-significant results obtained from the Hosmer and Lemeshow test (p = 0.329) indicate a good model fit.

Out of 119 OI negotiators, 108 are correctly classified by the model, i.e. its specificity is equal to 90.8%. Out of 62 OA negotiators only 28 are correctly classified by the model, which makes the sensitivity of the model equal to 45.2%. As the sensitivity is greater than 1, we conclude the model has good discriminatory powers. The overall prediction accuracy of the model is 75.1%.

CONCLUSIONS

The logistic regression model allows us to identify the kinds of intrinsic motivation that differentiate between those negotiators who make and those who do not make ordinal errors in undertaking one of the most important tasks, that is, preparation for negotiations. The model allows us to determine the odds of negotiators making ordinal errors, i.e., those belonging to class OI, and those who are ordinary accurate (belong to class OA). The model's fit is satisfactory and it has good prediction accuracy. However, the accuracy of belonging to class OI is twice as high as the accuracy of belonging to OA prediction.

We should point out that the estimated model parameters and the identified interactions are specific to the way data was prepared. Centering of the factor values resulted in a particular reference profile of the average negotiator that became the starting point for the interpretation of the model's results. For example, the model shows that the negotiator's rationality is a

significant variable; its change from the average value significantly changes the odds ratios to be assigned to OA. If non-centered values of factors had been used, rationality could have become non-significant. The changes in lower ranges of rationality would not have had a significant impact on the changes in the odds of classification.

Typically, in DSS and NSS experiments there is little direct interaction between the participants, and the experimenter has little ability to exert direct control. This study shows that intrinsic motivation may strongly affect the results. We cannot reject the argument that extrinsic motivation was insufficient, however, this should not be the case for the following three reasons: (1) the reward was a 25% of course grade; (2) the reward was the same for all students; and (3) participants were graduating students majoring in Operation Research and Information Technology program.

Participants of many experiments are students. This study also shows that students' interest in learning is a significant direct and indirect motivator. Therefore, an impartation of the learning aspect of an experiment may have a positive effect in experiments in which DSS and NSS are used. Learning or increasing once expertise may also be a significant motivator for professionals who use DSS and NSS. To determine their motivation more experiments need to be conducted,

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