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Editorial

Editorial for the Special Issue "Advances in Holography and Its Applications" in Photonics

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1. Introduction

Holography was first introduced by Dennis Gabor as a method to improve microscopic imaging [1] and has matured since then into one of the most versatile and forward-looking branches of modern optics. Today, holography has a wide range of applications, such as imaging in digital holography [2], color holography [3], beam shaping for non-imaging light control [4], or holographic data storage [5].

This Special Issue, "Advances in Holography and Its Applications," collates five contributions that embody this progress. They collectively illustrate how innovation in algorithms, materials, and recording methods continues to expand holography's capabilities.

2. Overview of the Articles in This Special Issue

The articles included in this Special Issue illustrate the versatility of holography, covering a broad range of application fields, from high-resolution imaging and interferometry to stereogram production with artificial intelligence and Holographic Optical Elements for structured light and optoelectronics.

Subtraction Method for Subpixel Stitching: Synthetic Aperture Holographic Imaging.

Image stitching is a high-resolution imaging technique that combines multiple smaller images with overlapping regions, as used by Wei et al. [6] in two cases through the Subtraction Method (SM), a fast, subpixel accuracy displacement method. They first use two 2D images captured by a 4-f imaging system, followed by four in-line digital holography images. The overlapping region then provides a synthetic aperture. The results show enhanced image quality with a computation time that is 2.5 times faster than the correlation method, without reduced pixel-shift estimation accuracy. This work highlights how computational tools can significantly improve holographic imaging capabilities.

The Application of Digital Holographic Speckle Pattern Interferometry to the Structural Condition Study of a Plaster Sample.

Digital Holographic Speckle Pattern Interferometry (DHSPI) is a well-established technique used to study the subsurface condition of objects by measuring sub-micrometer mechanical displacements [7]. Kosma and Tornari [8] apply this technology to the structural analysis of a plaster-based material. A sample is heated with infrared radiation in a controlled manner and its natural cooling is monitored, while digital holograms are recorded (1) before heating and (2) during the cooling process. Post-processing image analysis then provides information about subsurface conditions.

Since this is a non-invasive technique, it is appropriate for heritage conservation work for materials like fresco samples, which are plaster-based.

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From Text to Hologram: Creation of High-Quality Holographic Stereograms Using Artificial Intelligence.

The production of holographic stereograms is a long and complex process that involves taking images of an object from different angles, meaning that specialized equipment, post-processing software, and expertise are required. Gentet et al. [9] propose a novel method to simplify this process using artificial intelligence. Through AI-generated prompts, detailed perspective images are obtained and later interpolated and upscaled, eliminating the need for 3D models and reducing the overall duration of the process. The final high-quality, full-color holographic stereograms can be printed using the previously developed CHIMERA holoprinter [10].

Holographic Multi-Notch Filters Recorded with Simultaneous Double-Exposure Contact Mirror-Based Method.

Zhuang et al. [11] present an article in which the properties of reflection Holographic Optical Elements (HOEs) as multi-notch filters are explored. Two holographic reflection HOEs are recorded simultaneously on the same photopolymer material, with a contact mirror included in the recording apparatus. The resulting multiplexed holograms reflect two separated spectral ranges with central wavelengths at 531.13 nm and 633.01 nm and diffraction efficiencies ranging between 50 and 70% for reconstructed perpendicular incidence. The study also analyzes how the recording parameters (recording wavelength, angle, photopolymer thickness) govern the resulting filter properties, which could be used in optoelectronics, sensing, and wavelength-selective photonic systems.

Infrared Optical Vortices Generation with Holographic Optical Elements Recorded in Bayfol HX200 Photopolymer.

The last article of this Special Issue also addresses Holographic Optical Elements (HOEs). Paredes-Amorín et al. [12] propose a method of recording an HOE with a plane wave and an object wave, which are modulated with a Spatial Light Modulator (SLM), such as an optical vortex. Therefore, the disadvantages of SLMs are mitigated (low damage threshold, high costs, etc.) when using an HOE (lightweight, recorded in photopolymer) in optical communication systems operating at around 1550 nm. Even though the recording of the HOE is carried out with visible light, the resulting HOE provides sufficiently high efficiency when illuminated at 1550 nm during the reconstruction stage, obtaining an optical vortex in the resulting diffracted beam.

3. Conclusions

Taken together, the articles in this Special Issue reflect a rapidly evolving field. They range from algorithmic and computational innovation for imaging purposes, practical fabrication strategies for optical components, and novel approaches for generating structured light. Such diversity underscores the enduring strength of holography as both a scientific discipline and an enabling technology. Future work could further improve computational techniques to reduce processing times and resources, as well as recording materials that would generate higher HOE efficiencies.

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