DOI: 10.4218/etr2.12168

GUEST EDITORIAL

WILEY ETRI Journal

Special Issue on Digital Holographic 3D Imaging: Capture, Display, and Evaluation

Holography has been fascinating people for almost 70 years (since Gabor's invention in 1947) as a true three-dimensional (3D) imaging technology that can replicate 3D scenes in free space. Holography has also led to important developments in physics and technology as manifested by fundamental ideas proposed by renowned scientists and holographers, such as Emmeth Lieth (off-axis holography), Yuri Denisyuk (reflection holography), Stephen Benton (rainbow holography), and Adolf Lohmann (computer-generated holograms). Their ideas have been established as essential concepts and have advanced considerably the field of optical and digital holography during the past fifty years. The 21st century is the age of digital technology and tremendous progress in optoelectronics and micro/nanotechnology has been accomplished. This progress has opened the doors for true holographic applications in important areas such as holographic 3D displays with photorealistic visualization, 3D quantitative imaging in biomedicine, optical metrology using digital holographic interferometry, microscopy, and tomography. Successful applications and true holographic products in the market have advanced holography to a level at which standards setting organizations must be involved to guarantee interoperability between devices and applications.

In this special issue, we have selected several publications that represent the current state-of-the-art in digital holographic imaging covering new optoelectronic devices/materials, and their applications and full technology chains from the capture/generation of content, to processing, manipulation, and compression, including novel displays and holographic microscopes, tomographs, and the quantitative evaluation of complex amplitude data.

The invited paper "Recent advances on metasurface hologram technologies" by Gun-Yeal Lee, Jangwoon Sung, and Byoungho Lee, outlines the recent progress in metasurface holograms of artificially fabricated subwavelength structures. These holograms have been considered as novel holographic devices that have shown an unprecedented ability to control electromagnetic waves. Various metasurface holograms, such as complex amplitude, multicolor, polarization-multiplexed and active holograms, have been compared in terms of features, benefits, and remaining challenges. Additionally, the authors discuss their roles as elements in the introduction and use of high-performance wavefront engineering in holographic displays and in many other photonics devices.

In the second paper entitled "Evolution of spatial light modulator for high-definition digital holography" by Ji Hun Choi et al., a report is presented on the fabrication methods, device performance, and holographic results of liquid crystal spatial light modulators fabricated on glass substrate (SLMoG) as a good alternative to liquid crystals on silicon (LCoS) SLM. A series of SLMoG with different pixel pitches (3 μm, 7 μm, and 20 μm) have been produced and tested with a special focus on a pixel size of 3 μm that represents currently the smallest pixel pitch of SLMoGs for digital holograms. It is shown that this provides good image quality and an approximate horizontal diffraction angle of 10° for light with a wavelength of 532 nm.

The paper "Reducing speckle artifacts in digital holography by the use of programmable filtration" by Yongjun Lim et al. addresses the important problem of speckle artifacts reduction in binary-type holographic displays. The authors propose the adoption of programmable filtration in a general 4-*f* optical configuration to selectively filter signal spectral components in the frequency domain of a viewing-window-based holographic display. The method is utilized to effectively reduce the speckles during reconstruction of point-cloud–based computer-generated holograms.

Another important challenge in holographic displays is to deliver an enlarged viewing zone. One of the recently proposed solutions to achieve this is the rainbow holographic display that allows the reconstruction of large 3D orthoscopic objects. However, the display provides views where color and resolution are changing with the movement of an observer's eye, thereby influencing his visual perception.

The fourth paper on "Visual perception of Fourier rainbow holographic display" by Hyon-Gon Choo, Maksymilian Chlipala, and Tomasz Kozacki, addresses this problem using the Wigner Distribution. The view-dependent appearance of the image—including the multispectral field-of-view, viewing zone, and the resolution of holographic view—is investigated numerically and experimentally by considering the observer and the display parameters.

In the fifth paper entitled "Computational load reduction by avoiding the recalculation of angular redundancy in computer-generated holographic display" by Jia Jia, Jhen-Si Chen, and Daping Chu, a new method is proposed to reduce the computational load during the calculation of computer-generated holograms of 3D objects by avoiding the recalculation of redundant information. In this method, the hologram is divided into several subholograms which record and reconstruct different views of 3D objects. The subhologram is generated from its adjacent, calculated subhologram, by adding the holograms of difference images between adjacent pair of views.

The next two papers are devoted to microscopic and tomographic applications of digital holography with a special focus on their biomedical applications. The invited paper "Holographic tomography: hardware and software solutions for 3D quantitative biomedical imaging" by Arkadiusz Kus et al., demonstrates the current concepts in holographic tomography realized within a limited angular range (LAHT) with illumination scanning. The processing path outlined in this work presents a complete instrumental/numerical solution dedicated specifically to the imaging of biological cells. In particular this overcomes the main metrological limitations of LAHT, including "missing cone" problem and anisotropic resolution of the reconstruction along the optical axis.

The paper "Digital holographic microscopy with extended field of view using tool for generic image stitching" by Piotr Stępień, Damian Korbuszewski, and Małgorzata Kujawińska, describes procedures which address future applications of DHM in digital phase pathology and statistical analysis of cell cultures. Data processing strategies that lead to successful phase image stitching in DHM for the extension of its field of view are presented and compared.

The eight paper "Off-axis self-reference digital holography in the visible and far infrared region" by Vittorio Bianco et al., presents a simplified digital holographic setup that spills out the reference beam from the object beam itself. It allows the reconstruction of good quality holograms of objects captured under visible and far infrared light exposure, based on its aim to allow visualizations through fires. It also preserves the quantitative nature of the holographic signal. Accordingly, metrological applications are also considered.

Finally, the paper "JPEG Pleno: providing representation interoperability for holographic Applications and Devices" by Peter Schelkens et al., refers to the JPEG Pleno initiative that intends to provide a standard representation framework to facilitate the capture, representation, and exchange of light field, point cloud, and holographic imaging modalities. The authors focus on holographic modalities, discuss cases of their main uses, elaborate on potential coding technologies, and address the problem of visual quality assessment of holographic data covering both the visual quality metrics aspects and the subjective assessment methodologies. The paper ends by inviting interested parties to join JPEG Pleno initiative and support the standardization activities in holography that is necessary for future commercialization of this technology.

The Guest Editors thank all the authors, reviewers, and the editorial staff members of the ETRI Journal for making this special issue a success. We are most pleased to have been part of this effort and for ensuring the timely publication of these high-quality technical articles.

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Małgorzata Kujawińska received her PhD and DSc in applied optics from the Faculty of Mechatronics, Warsaw University of Technology in 1982, and 1990, respectively. Since 1976 she has been with the Warsaw University of Technology, Poland, where she is currently serving as the Head of the Photonics Engineering Division at the Institute of Micromechanics and Photonics. She also worked at the National Physical Laboratory, UK (1986–1989). Professor Kujawińska is a Fellow of SPIE. She had served on the Board of Directors of SPIE and had been the 2005 SPIE President, Vice-President of ICO and Vice-President of the European Technology Platform Photonics21. She received several awards, including the SPIE 2013

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Byoungho Lee received his PhD degree from the University of California at Berkeley in Electrical Engineering and Computer Science in 1993. Since September 1994, he has been with the School of Electrical and Computer Engineering, Seoul National University, Rep. of Korea where he currently serves as the Head. Professor Lee is a Fellow of SPIE, OSA, and IEEE, a Member of the Korean Academy of Science and Technology, and a Senior Member of the National Academy of Engineering of Korea. He received several awards, including the National Science Badge of Jinbojang. He has served on the Board of Directors of OSA. Professor Lee is the President-elect of the Optical Society of Korea, and is on the editorial board of Advances in Optics and Photonics and Light: Science and Applications. His current research interests include 3D imaging, digital holography, augmented/ virtual reality, metasurfaces, and nanophotonics.

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