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Focus issue introduction: 3D image acquisition and display: technology, perception and applications

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Abstract: This Feature Issue of Optics Express is organized in conjunction with the 2023 Optica conference on 3D Image Acquisition and Display: Technology, Perception and Applications which was held from 14 to 17[208] of August as part of the 2023 Imaging and Applied Optics Congress in Boston, Massachusetts, United States. This Feature Issue presents 27 articles which cover the topics and scope of the 2023 3D Image Acquisition and Display conference. This Introduction provides a summary of these published articles that appear in this Feature Issue.

1. Introduction

The Optica conference on "3D Image Acquisition and Display: Technology, Perception and Applications" was part of the Optica Imaging and Applied Optics Congress 2023 which was held from 14 to 17th of August in Boston, Massachusetts, United States. This Optics Express feature issue on "3D Image Acquisition and Display: Technology, Perception and Applications" is organized in conjunction with this 2023 Optica 3D conference.

The conference participants were encouraged to submit their work as a journal article to this feature issue. Likewise, this feature issue was open to all original contributions in related areas of the 3D field. The main goal of this feature issue is to bring together contributions by outstanding international leaders, researchers, and engineers from a broad range of interdisciplinary fields to present their work in the science, technology, and applications of 3D image collection and display technologies. The feature issue is intended to provide in-depth coverage of the advances as well as the technical developments in 3D imaging and display technologies that are of great interest to a broad range of Optica Publishing Group readership in 3D imaging, visualization, and displays, augmented and virtual reality, near-to-eye displays and head mounted displays, medical applications, defense and security, and manufacturing.

We are thankful to the authors of this feature issue for their fine contributions, and the anonymous reviewers for their efforts and hard work. We regret that we could not accommodate all the submissions to this feature issue per the peer review guidelines of the Optics Express and Optica journals. We thank Ms. Carmelita Washington and other staff from the Optics Express Manuscript Office for their assistance and support during this process. We thank the Editor in

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Chief James Leger for giving us the opportunity to organize this feature issue. In the next section, we present a categorization and summary of 27 articles that appear in the feature issue [1–27].

2. Overview of featured articles

The scope and topics of this feature issue and the 2023 3D conference cover a broad array of research topics related to the 3D field. The topics covered by the featured articles may be broken down into four sub-areas, and each of the featured articles is categorized and summarized as follows.

2.1. 3D sensing and imaging technologies

The sub-area of 3D sensing and imaging technologies covers advancements in 3D sensor technologies, 3D information acquisition methods and optical architectures, LIDAR sensing and imaging, structured illumination, 3D imaging in scattering media, 3D technology for autonomous driving and intelligent systems, optical design of 3D information acquisition systems, user interface technologies for 3D systems such as depth sensing.

S. Goswami, G. Krishnan, and B. Javidi reported numerical simulation and statistical methods to assess the noise-susceptibility of coherent macroscopic single random phase encoding lensless imaging by analysing how much information is lost due to the presence of camera noise [1].

T. Kaariainen and J. Seppa presented the design of a 3D camera based on laser light absorption by atmospheric oxygen at 761 nm using a current-tunable single frequency distributed feedback laser for active illumination and demonstrated a distance accuracy of better than 4 cm between the distance range of 4 m and 10 m [2].

L. Jovanov and W. Philips reported a new volumetric method for noise removal in optical coherence tomography which outperformed reference methods both visually and in terms of objective measures [3].

Y. Huang, G. Krishnan, S. Goswami, and B. Javidi resented a diffuser-based lensless underwater optical signal detection system using one-dimensional integral imaging convolutional neural network for signal classification [4].

R. Josh, K. Usmani, G. Krishnan, F. Blackmon, and B. Javidi reported an integrated dual-function deep learning-based underwater object detection and classification and temporal signal detection algorithm using 3D integral imaging under degraded conditions such as in turbid water [5].

D. Yang, T. Xu, Y. Zhang, D. An, Q. Wang, Z. Pan, G. Liu, and Y. Yue demonstrated an innovative object detection framework based on the fusion of depth and active infrared intensity images with a time-of-flight camera with a classification accuracy of 98.01% using K-Nearest Neighbor [6].

P. Chiang, C. Cheng, and C. Lin reported a method to suppress blooming interference in structured light systems by adaptively reducing camera oversaturated energy [7].

Z. Lai, Z. Jia, S. Guo, J. Li, and S. Han presented a targetless calibration algorithm for extrinsic calibration between hybrid-solid-state-LIDAR and mechanical LiDAR systems involving heterogeneous laser scanning models [8].

N. Madali, A. Gilles, P. Gioia, and L. Morin presented an end-to-end approach for recovering an RGB-D scene representation directly from a computer-generated hologram using its phase space representation [9].

S. Matsuda, M. Shoda, N. Yoneda, M. Kumar, W. Watanabe, T. Murata, and O. Matoba presented a 3D fluorescence imaging method through a scattering medium by combining numerical digital phase conjugation propagation with iterative phase retrieval [10].

Y. Zhang, K. Chen, and S. Yang demonstrated a new method for terahertz super-resolution 3D reconstruction with sparse 2D data input by seamlessly integrates conventional computed tomography techniques and variational framework with the core of the adapted Euler-Elastica-based model [11].

S. Aarav and J. Fleischer reported a depth-resolved speckle correction imaging method by capturing speckled images at two detector distances and exploiting the scaling properties of the axial memory effect, eliminating the need for access to the object side of the scatterer [12].

2.2. 3D display and visualization technologies and human factors

The sub-area of 3D display and visualization technologies and human factors addresses development in 3D display hardware and software technologies, wearable display methods and technologies, 3D information display methods and optical architectures, as well as perception, human factors and visual comfort of 3D information displays.

G. Meng, D. Galor, L. Waller, and M. Banks presented an interactive software tool for display designers that predicts how a viewer perceives motion artifacts for a variety of stimulus, display, and viewing parameters [13].

J. R. Alonso, A. Fernandez, and B. Javidi proposed a method for controlling the spatial perception of the displayed stereo pairs in augmented reality devices by synthesizing the desired point of view of each image of the stereo-pair along with their parallax setting, aiming to alleviate the vergence-accommodation conflict [14].

H. Lee, J. Jung, S. Hong, and H. J. Choi presented a concept of multiplexed reginal projections to integrate the lightfield retinal image through rotating transitions of refined and modulated elemental images for robust compensation of eye pupil variance [15].

2.3. Image processing for 3D acquisition and display applications

The sub-area of image processing for 3D acquisition and display applications embraces research focusing on novel algorithms and deep learning and artificial intelligence for 3D systems and 3D system calibration and registration methods.

S. Rabia, G. Allain, R. Tremblay, and S. Thibault presented a method for synthesizing orthoscopic elemental images from complex real-world scenes using a custom neural radiance field model while avoiding distortion and depth inversion [16].

S. Zheng, L. Lu, H. Yingsa, and S. Meichen presented a deep learning framework for reconstructing 3D surface of objects from a series of 3D images for photoacoustic tomography and demonstrated excellent 3D reconstruction performance both visually and on the basis of quantitative evaluation methods [17].

G. Krishnan, S. Goswami, R. Joshi, and B. Javidi introduced a 3D integral imaging-based image descattering and recovery using physics-informed unsupervised CycleGAN (Generative Adversarial Network) [18].

K. Song, Y. Bian, F. Zeng, Z. Liu, S. Han, J. Li, J. Tian, K. Li, X. Shi, and L. Xiao presented a masked attention network for photon-level single-pixel 3D tomography to eliminate interference from different layers of the sample and enhance the resolution of the system [19].

M. Chen, P. Rao, and E. Venialgo presented depth estimation method based on deep learning in LIDAR sensors using single-photon avalanche diodes[20].

X. Song and L. Wang proposed a deformable dual-stage hybrid network with a deformation extraction stage and depth mapping stage for single-shot fringe projection profilometry based on phase-height model [21].

J. Duan, Y. Hao, J. Liu, C. Cheng, Q. Fu, and H. Jiang reported an end-to-end learning method that can predict accurate, physically based model parameters of polarimetric BRDF from a limited number of captured photographs of the object [22].

C. Hu, G. Yang, and H. Xie presented the design of a computer-generated hologram compression and transmission system using a hybrid neural network based on quantum compensation for

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hologram compression and using a quantization method and Huffman coding for hologram encoding [23].

2.4. Applications of 3D image acquisition or display technologies

The sub-area of applications of 3D image acquisition or display technologies emphasizes advancement in virtual reality and augmented reality systems, autonomous vehicles, entertainment and enterprise applications, defense and security, healthcare applications such as biomedicine, microscopy, endoscopy, medical and scientific visualization.

S. Su, Y. Yang, and H. K. Chiang reported the development of an integrated dual-modality 3D bioluminescence tomography and ultrasound imaging system to achieve 3D imaging of small animal tumor [24].

C. Chen, Z. Fu, S. Ye, C. Zhao, V. Golovko, S. Ye, and Z. Bai reported a semi-automatic precise labeling process to achieve high-precision 3D reconstruction of pulmonary lesions and surrounding blood vessels using computerized tomography images [25].

M. Li, K. Huang C. Zeng, Q. Chen, and W. Zhang introduced a 3D retinal vessel segmentation and reconstruction method for optical coherence tomography angiography images with only 3D vessel labels and demonstrated the use of the 3D reconstruction results to determine the relationship between the location of arteries and veins [26].

T. Hormel, G. Liang, X. Wei, Y. Guo, M. Gao, J. Wang, D. Huang, S. Bailey, T. Hwang, and Y. Jia described a swept-source optical coherence tomography device that can capture up to a wide field of view in a single shot and can identify conventional pathologic features such as non-perfusion areas outside of conventional fields of view [27].

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