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Metaverse: Optics & photonics

The term "Metaverse," combining "meta" (meaning beyond) and "universe," is becoming widely recognized across different sectors of society, including the general public, industry sectors, and academia. Despite its growing popularity, the concept of the Metaverse often conjures up associations primarily with advanced computer technologies such as virtual reality (VR) and blockchain. This special issue, however, seeks to broaden and refocus our understanding of the Metaverse by emphasising the crucial role of optics and photonics – essential areas for creating the "what you see is what you get" experience.

Optics and photonics are fundamental to the visual and interactive elements that define the Metaverse, providing critical insights into how light and vision can be manipulated and harnessed to bridge the gap between real and virtual environments. By exploring these optical and photonic advances, we can better appreciate the intricate interplay of light and vision that makes immersive and interactive experiences possible, paving the way for new applications and discoveries in the Metaverse. This issue seeks to showcase a curated collection of cutting-edge research in these fields, highlighting interdisciplinary work that has the potential to lead to groundbreaking and drive transformative innovations. This approach not only deepens our understanding of the Metaverse's technological foundations but also underscores the significant role of visual technologies in shaping its future development.

The topics covered in this special issue were open to a broad array of advanced optical and imaging technologies, including (in no particular order): wearable devices, magnifiers, free-space combiners, waveguides, retinal projection/scanning, contact and intraocular lenses, 3D imaging and sensing, computational imaging, holography, LIDAR, bio-inspired devices, biophotonics, retinal implants and bionic eyes, vision sciences, visual optics, and computational human vision.

This special issue comprises 29 contributed papers including review papers. The submission to this special issue was enthusiastic, with the authors from around the world including those of international leading universities and important industrial players. The closing date was extended to accommodate the demand. Based on the primary focus, they are summarised into the following five categories to illustrate their approaches and applications:

1. Advanced Display Technologies: Many of the papers discuss innovations in display technology, including integral imaging displays [1,11], holographic displays [2,7,15], augmented reality (AR) near-eye displays [5,6,25], and 3D light fields [4,19]. These technologies aim to enhance visual experiences by improving depth perception, resolution, field of view, and image quality.
2. Optical Components and Design: Several studies focus on the design and fabrication of optical components such as waveguides, microlens arrays, and photonic crystal structures. These components are crucial for manipulating light in specific ways, such as controlling polarization [21], expanding the eye-box in displays [6,13], or improving the efficiency and uniformity of light distribution [7,8,9,10,24,27,29].
3. Holography and 3D Imaging: A recurring theme is the use of holography for generating and displaying 3D images. This includes methods for fast hologram generation [2,14], improving image quality [18,23], and enabling real-time interaction with holographic systems [16]. Some studies also explore novel techniques for encoding and reconstructing 3D information [26].
4. Interdisciplinary Applications: Many of these technologies are applied in interdisciplinary contexts, ranging from AR and VR to laser applications and wearable sensors [20]. The integration of optical technologies with other fields, such as bioinspired designs [3,17,22] or neural networks for encoding light fields [10,28], showcases their broad applicability.
5. Enhanced Visual and Interactive Experiences: The ultimate goal of these innovations is to enhance visual experiences, whether through AR, VR, or other forms of immersive media [12]. This includes improving depth cues [1,11], colour accuracy and visual comfort [25], as well as enabling new forms of interaction, such as voice control or dynamic light manipulation [16].

We hope that this special issue provides a valuable source of information on the latest research in the area of optics and photonics for Metaverse applications and encourages researchers to continue working and contribute. We are grateful to the warm support of our authors for submitting their high-quality papers and to the reviewers for providing essential professional and timely feedback on the manuscripts. Last but not least, we want to thank the publisher for approving this special issue, to the Editor-in-Chief, Prof Erwin Hack, for guidance, and to Stella Duo for the great support throughout the process.

Declaration of competing interest

No conflicts of interest

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