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Editorial

Special Issue on Optical Camera Communications and Applications

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Optical Camera Communication (OCC) is a groundbreaking technology that combines optical signals and image sensors for data transmission. This innovative approach enables data transmission via light and transforms traditional cameras into intelligent communication devices. With its unique capabilities and wide-ranging applications, OCC has garnered significant attention from researchers, industry professionals, and technology enthusiasts alike. By modulating light emitted by the LED or display, information can be encoded and transmitted to a receiver. Simultaneously, the camera's image sensor captures incoming light signals, decoding them into meaningful data. OCC opens up exciting possibilities for high-speed, secure, and energy-efficient data transmission. This Special Issue (SI) aims to explore the advancements, challenges, and diverse applications of OCC, shedding light on its transformative potential across various domains, including display-to-camera (D2C) communication and indoor positioning.

The study in [1] addresses the challenge of calibrating dual PTZ cameras, which are useful in various applications such as 3D reconstruction, reconnaissance, tracking, and target recognition. The proposed calibration method establishes a relationship between the camera's intrinsic and extrinsic parameters and its feedback parameters (pan, tilt, and zoom values) that are obtained from previous calibrations at specific angles and zoom levels. This allows for precise calibration at any focal length and posture, enabling the efficient and accurate use of dual PTZ cameras in unmanned systems. Reference [2] introduces a quantum chromodynamics (QCD)-inspired OCC system using a 2D multicolor LED matrix. The system enables MIMO communication and supports rotations up to 90 degrees. Using simulations and prototype evaluations, the system demonstrates highly sucessful reception rates, tolerable bit error rates, and promising performance compared to existing OCC systems. The study in [3] investigates the effects of the atmosphere on satellite–ground FSO communications, which are crucial for high-bandwidth satellite communications. The analysis considers various atmospheric conditions and derives FSO channel elements such as fog attenuation, refractive indexes, coherence lengths, turbulence models, and angle-of-arrival fluctuations. Simulation results show that using a wavelength of 1550 nm is optimal for mitigating turbulence effects, and larger receiver apertures help reduce angle-of-arrival changes, thus improving channel performance.

D2C communication is another application of OCC, in which the display serves as the transmitter, encoding information in the form of visual patterns or signals displayed on the screen, and the camera acts as the receiver, capturing and interpreting those patterns using optical sensors. This SI gathered multiple papers on D2C communications. The study in [4] introduces DeepCCB-OCC, a deep learning-driven system for complementary-color-barcode-based OCC. It utilizes deep neural networks, including the you only look once (YOLO) model, for the seamless detection of color barcodes on electronic displays. Similarly, ref. [5] presents a machine learning-based display field communication (DFC) scheme for unobtrusive D2C communication. The proposed scheme utilizes spectral domain-based data-embedding techniques and robust channel coding to overcome data errors in the

D2C channel. For the first time, real-world experiments for DFC are performed, achieving error-free performances up to a distance of 1 m. Deep learning techniques are employed for data restoration, providing robustness against geometric distortions, noise, and different input images. In another study, ref. [6] introduces an iterative pilot-based reference frame estimation scheme for improving the data rate in 2D-DFC. By inserting pilot symbols within the transmit image frames, the proposed scheme compensates for distortion in the received frames and estimates the data pixels of the reference frames. Multiple iterations, utilizing both original and virtual pilots, allow for the accurate estimation of all reference frame data pixels. Simulation results demonstrate a significant increase in achievable data rate, nearly doubling the performance of the 2D-DFC communication scheme while maintaining display unobtrusiveness.

The work in [7] focuses on designing a wide spectrum zoom system for in vivo fluorescence imaging devices operating in the visible light spectrum to NIR-II spectrum. The system achieves desirable performances in terms of the modulation transfer function (MTF), distortion, and aberration correction, meeting the requirements for each optical element. Reference [8] presents a cost-effective visible light positioning (VLP) system for indoor positioning, combining LED flat panel lights and barcodes. The proposed "pseudo-two-light positioning" algorithm, assisted by angle sensors, achieves centimeter-level positioning accuracy. Finally, ref. [9] addresses thermal deformation challenges in a laser communication satellite by reducing optical axis angle fluctuations via optimization design and adaptable isolation. The work enhances the stability and efficiency of laser communication systems.

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References

1. Mao, K.; Xu, Y.; Wang, R.; Pan, S. A General Calibration Method for Dual-PTZ Cameras Based on Feedback Parameters. *Appl. Sci.* **2022**, *12*, 9148. [CrossRef]
2. Vasantha, G.; Salvi, S. Quantum-Chromodynamics-Inspired 2D Multicolor LED Matrix to Camera Communication for User-Centric MIMO. *Appl. Sci.* **2022**, *12*, 10204. [CrossRef]
3. Maharjan, N.; Devkota, N.; Kim, B.W. Atmospheric Effects on Satellite–Ground Free Space Uplink and Downlink Optical Transmissions. *Appl. Sci.* **2022**, *12*, 10944. [CrossRef]
4. Kim, M.T.; Kim, B.W. DeepCCB-OCC: Deep Learning-Driven Complementary Color Barcode-Based Optical Camera Communications. *Appl. Sci.* **2022**, *12*, 11239. [CrossRef]
5. Kim, Y.J.; Singh, P.; Jung, S.Y. Experimental Evaluation of Display Field Communication Based on Machine Learning and Modem Design. *Appl. Sci.* **2022**, *12*, 12226. [CrossRef]
6. Kim, B.W.; Singh, P.; Jung, S.Y. Iterative Pilot-based Reference Frame Estimation for Improved Data Rate in Two-Dimensional Display Field Communications. *Appl. Sci.* **2023**, *17*, 9916. [CrossRef]
7. Guo, S.; Fang, L.; Chen, F. Design of Zoom Optical System from Visible to NIR-II for Vivo Fluorescence Imaging Device. *Appl. Sci.* **2023**, *13*, 1421. [CrossRef]

8. Feng, M.; Wang, Y.; Li, M.; Liu, S.; Huang, G.; Li, P. Design of OCC Indoor Positioning System Based on Flat Panel Light and Angle Sensor Assistance. *Appl. Sci.* **2023**, *13*, 4745. [CrossRef]
9. Shi, Y.; Chen, S.; Yu, M.; Wu, Y.; Yu, J.; Zhang, L. Thermal Deformation Stability Optimization Design and Experiment of the Satellite Bus to Control the Laser Communication Load's Acquisition Time. *Appl. Sci.* **2023**, *13*, 5502. [CrossRef]

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