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Editorial

Special Issue on "Visible Light Communication (VLC)"

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Due to its appealing advantages, including abundant and unregulated spectrum resources, no electromagnetic interference (EMI) radiation and high security, visible light communication (VLC) using light-emitting diodes (LEDs) or laser diodes (LDs) has been envisioned as one of the key enabling technologies for 6G and Internet of Things (IoT) systems [1–3]. Despite its many advantages, VLC faces several key technical challenges such as a limited bandwidth and severe nonlinearity of opto-electronic devices, link blockage, user mobility, etc. [4]. Therefore, significant efforts are needed from the global VLC community to further develop the VLC technology.

This Special Issue aims to provide an opportunity for global researchers to share their new ideas and cutting-edge techniques to address the above-mentioned challenges. A total of 16 selected papers are published in this Special Issue, representing the fascinating progress of VLC in various scenarios, including general indoor scenarios [5–8], underwater scenarios [9–12], and other potential scenarios [13–16], and the emerging application of machine learning/artificial intelligence (ML/AI) techniques in VLC [17–20].

VLC for general indoor scenarios: In order to improve the spectral efficiency of bandlimited VLC systems, Hong, H. et al. proposed a hybrid, adaptive bias, optical orthogonal frequency division multiplexing (HABO-OFDM) scheme, which has been shown to outperform benchmark schemes in terms of peak-to-average-power ratio (PAPR) and power efficiency [5]. Moreover, Nie, Y. et al. further proposed a pairwise coding (PWC)-based, multiband, carrierless amplitude and phase (*m*CAP) modulation with chaotic, dual-mode index modulation (DM) for secure bandlimited VLC systems [6]. The spectral efficiency of the system can be greatly improved by combining *m*CAP with DM and the signal-to-noise ratio (SNR) imbalance caused by the low-pass frequency response can be mitigated by applying PWC coding. As VLC systems built upon lighting LEDs need to fulfil the dual functions of lighting and communication, dimming control should be taken into consideration. To achieve constant transmission efficiency, Guo, J.-N. et al. proposed a dimming control scheme based on extensional constant weight codeword sets and provided a low implementation complexity decoding algorithm for the scheme [7]. A practical VLC system usually needs to serve multiple users; hence, efficient multiple access schemes should be employed in multi-user VLC systems. Since the BER performance of VLC systems using non-orthogonal multiple access (NOMA) is poor, due to the unequal distances between adjacent points in the superposition constellation (SC), Wu, T. et al. proposed a novel scheme to improve the BER performance by adjusting the parameters to change the shape of SC at the transmitter and by simultaneously adjusting the parameters of successive interference cancellation (SIC) decoding at the receiver [8].

VLC for underwater scenarios: For the underwater VLC system using on–off-keying (OOK) modulation, Zhang, J. et al. systematically studied the bandwidth limitation due to the transceiver and underwater channel through experiments and simulations [9]. The obtained results show that the maximum likelihood sequence estimation (MLSE) detection has great potential to improve the performance of bandwidth-limited communication systems. Moreover, Li, C. et al. proposed and demonstrated a high-sensitivity, long-reach, underwater VLC system using a commercial blue LED source, a photon counting receiver and OOK modulation [10]. Receiver sensitivities of −76 dBm, −74 dBm, and −70 dBm were achieved for 1 Mbps, 2 Mbps, and 5 Mbps data rates over a 10 m underwater channel, respectively, and a more than 100 m distance can be transmitted for a 2 Mbps data rate in pure seawater at 1 W transmitted power. For the underwater VLC system using OFDM modulation, Wei, Z. et al. proposed a dual-branch, pre-distorted, enhanced, asymmetrically clipped, direct current biased, optical orthogonal frequency division multiplexing (PEADO-OFDM) scheme for underwater VLC systems [11]. The simulation results show that PEADO-OFDM can increase the spectral efficiency, enhance the tolerance against ISI, and improve the bit error rate (BER) performance. Furthermore, Li, H. et al. proposed and experimentally demonstrated a simple sampling frequency offset (SFO) estimation and compensation scheme for OFDM-based underwater VLC systems [12]. The experimental results show that the proposed scheme can achieve a high estimation accuracy with low computational complexity.

VLC for other potential scenarios: Besides, general indoor scenarios and underwater scenarios, VLC is also applicable to many other potential scenarios. Specifically, VLC can be used to realize high-accuracy positioning and navigation in indoor environments. Martínez-Ciro, R.A. et al. presented an indoor visible-light positioning (VLP) system based on red–green–blue (RGB) LEDs and a frequency division multiplexing (FDM) scheme, where the received signal strength (RSS) technique is adopted to estimate the receiver position for multi-cell networks [13]. Simulation results demonstrated an average positioning error of less than 2.2 cm for all chromatic points. Moreover, VLC can also be applied in vehicular communications by utilizing the headlamps or taillights of vehicles to transmit data. Zhan, L. et al. investigated the performance of vehicular VLC employing mirror array-based intelligent reflecting surface (IRS) [14]. By optimizing the number of mirrors in the IRS, the energy efficiency (EE) can be successfully maximized. In addition, VLC can be integrated with other communication technologies to establish a hybrid system. Particularly, Liu, B. et al. proposed a hybrid millimeter-wave/VLC system and compared the propagation characteristics, including path loss, root mean square (RMS) delay spread (DS), K-factor, and cluster characteristics, between mmWave and VLC bands based on a measurement campaign and ray tracing simulation in a conference room [15], while Le-Tran, M. et al. demonstrated a 294-Mb/s hybrid fiber/wireless link based on a single visible LED over a 1.5-m polymer optical fiber (POF) and 1.5-m free-space distance [16].

The application of ML/AI in VLC: Aiming to mitigate the adverse effect of nonlinearity in VLC systems, Park, Y.-J. et al. proposed a predistortion approach using coefficient approximation without sampling the LED transfer function, and further utilized the bidirectional long short-term memory (BLSTM) approach to train the LED distortion correction without knowing the LED modeling at the transmitter side [17], while Cao, B. et al. proposed a pilot-assisted reservoir computing (PA-RC) nonlinear equalization algorithm for nonlinearity mitigation at the receiver side [18]. In addition to bandwidth limitation and nonlinearity, inter-symbol-interference (ISI) due to multipath reflection is another issue that needs to be addressed in high-speed VLC systems. Li, L. et al. constructed a neural network (NN)-based transceiver to compensate for the varying ISI effect in VLC systems [19]. The application of multiple-input multiple-output (MIMO) transmission in VLC systems is a natural and efficient way to enhance the system capacity, and the combination of MIMO and index modulation can convey additional bits. To improve the BER performance of the OFDM-based generalized LED index modulation (GLIM) system, Le-Tran, M. et al. proposed a deep neural network (DNN)-aided active LED index estimator (IE) for improving the GLIM-OFDM detector performance [20].

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