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Editorial

Editorial for the Special Issue on Underwater Wireless Communications and Sensor Networks Technology

Syed Agha Hassnain Mohsan

Ocean College, Zhejiang University, Zheda Road 1, Zhoushan 316021, China; hassnainagha@zju.edu.cn

In the scientific, military, and industrial world, the deployment of robust, reliable, secure, and efficient wireless communication links is of particular importance. From this perspective, underwater wireless communication (UWC) has received substantial global research interest due to its high bandwidth, compact antennae, low latency, cost-effectiveness, and low power consumption. The main contributions and key initiatives of UWC focus on several application scenarios, such as offshore exploration, surveillance environment, disaster prevention, ecological protection, telemetry, real-time video transmission, diver-to-diver communication, and oceanographic studies. In the uneven underwater environment, optical wireless communication tends to be more competitive compared to its radio frequency (RF) and acoustic counterparts. It uses optical links to further enhance the transmission distance, robustness, strong anti-electromagnetic interference ability, reliability, and flexibility of UWC networks. Despite these appealing advantages, the harsh underwater environment poses several obstacles to optical signals such as absorption, attenuation, link misalignment, and unstable turbulence. Therefore, significant research focus has been dedicated to this research domain, resulting in novel designs, architectural frameworks, new protocols, and innovative breakthroughs.

With the aim to disseminate the ongoing developments in the specialized domain of UWC and sensor network technology based on theory and experimental demonstration in the areas of energy-efficient designs, innovative strategies, channel modeling, channel estimation, network routing, modulation schemes, localization and positioning, advanced signal processing, multi-access techniques, and security mechanisms, a Special Issue of the *Journal of Marine Science and Engineering* has been dedicated to "Underwater Wireless Communications and Sensor Networks Technology".

This Special Issue aims to highlight the latest activities of leading researchers and practitioners from diverse domains, who are engaged in stimulating research innovations, exploring recent advancements, unlocking innovative applications, and addressing potential technical uncertainties. This Special Issue presents eight articles covering most of the current topics in UWC and sensor network technology, from channel polarization to routing protocols, from link misalignment to the effects of turbulence in underwater wireless optical communication (UWOC), and one offering an architectural framework for multi-degree-of-freedom UWOC with improved transmission performance.

UWOC can attain a transmission distance of hundreds of meters, ensuring data rates in Mbps or even Gbps, with high-speed and low-power-consumption features. However, UWOC systems are prone to several issues such as ocean turbulence, unstable transceiver end, and so on, causing limited communication ranges and reduced communication reliability. Thus, it is critical to establish a reliable and stable communication link to further extend the transmission distance of UWOC systems. Yang et al. [1] theoretically investigated orbital angular momentum (OAM) through bi-photon-entangled airy beams in uneven oceanic turbulence. They validated that oceanic turbulence under salinity fluctuations and increased strength have adverse impacts on the OAM. Zhang et al. [2] modeled the information capacity of UWOC links with pointing errors and the carrier of a perfect Laguerre–Gaussian (PLG) beam in weakly turbulent and absorbed seawater. Further, they

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numerically analyzed the impact of channel characteristics on the propagation of PLG beams. They validated that pointing errors substantially degrade the performance of optical transmission systems. Li et al. [3] used power the spectrum inversion technique to develop ocean turbulence channels. The OQM transmission characteristics were investigated, and mode adaptation was performed. In addition, they implemented a polarization coding scheme into the underwater OAM communication system. The presented results indicate a reduced bit error rate (BER) and extended communication distance.

Since the mobility of the UWOC system is restricted by the transceiver alignment, several works have focused on the multi-degree-of-freedom (MDOF) UWOC, massive multiple-input multiple-output (MIMO) systems, space–time block coding (STBC) technology, improved-order successive interference cancellation, and sub-channel correlation enhancement. In this regard, Liu et al. [4] proposed an MDOF UWOC system with enhanced transmission performance and high flexibility. The authors experimentally demonstrated a hardware pre-equalization circuit to extend the modulation bandwidth of the LED from 5.03 MHz to 50 MHz. The reliability of the proposed system was validated through the BER performance and eyes diagram of the receiving signal. Fu et al. [5] introduced an improved order successive interference cancellation (I-OSIC) algorithm based on the STBC technique to overcome the sub-channel correlation improvement issue, which is caused by the combined impact of link misalignment and turbulence in the underwater optical MIMO systems. The proposed I-OSIC algorithm can accurately trace the pointing error and uses the minimum interference criterion to reorder receiving signals. Li et al. [6] proposed an adaptive diversity technique based on STBC to solve the sub-channel correlation improvement issue for an underwater optical massive MIMO system. The authors used STBC technology to mitigate random fading or optical signals due to turbulence. In addition, they used adaptive processing to affectively alleviate the channel correlation due to misalignment. The adaptive diversity algorithm significantly reduced the complexity and enhanced the reliability of the optical massive MIMO system.

Prolonging the UWC network lifetime in order to observe the environment and analyze the oceanographic data is an interesting research area for marine experts. Rahman et al. [7] investigated several routing protocols in terms of end-to-end delay, energy consumption, the packet delivery ratio (PDR), and the number of alive nodes. The simulation analysis of the presented study validates that reliability and adaptive cooperation for efficient UWSNs using sink mobility (RACE-SM) outperforms other routing schemes in terms of various performance metrics. Razzaq et al. [8] proposed an architectural framework based on algorithms as a realistic approach to the development of an Internet of underwater things (IoUT) system. They also discuss recommendations for, and potential partners in, constructing a smart ocean in order to monitor and protect the underwater environment. To analyze the system's performance, a case study is presented to assess the proposed solution, its agility, and it usability in effectively exploiting sensor data, algorithm execution, and queries.

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