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Editorial

From Sensing Technology towards Digital Twin in Applications

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Sensing technology drives innovation in digital technology, especially in data acquisition [1], machine learning [2], digital twins [3], sustainable material-based electronics [4], and human–machine interaction. With the aid of these new technologies in industry [5], a researchers need to reach a general consensus on their use going forward.

A digital twin refers to the multiphysical, multiscale, and probabilistic simulation mapping of complex products in the physical world and virtual environments, with the aim of reproducing their real-world applications [6]. With the help of various types of sensors, building digital twins has wider applications, ranging from satellites and manufacturing to smart homes [7–10]. On the one hand, the development of these sensors is significant for data collecting and distribution in a digital twin [11–13]. Sensor data serve as the foundation for establishing and maintaining a digital twin model; their integration with the digital twin concept allows for the synchronization of physical objects with their corresponding virtual representations. On the other hand, creating a digital twin enables gaining a comprehensive understanding of the physical entity's behavior and characteristics, even under changing conditions, which facilitates the real-time monitoring and analysis of the object [14]. Once massive sensors with a variety of functions are integrated into the real scene, the digital twin creates a virtual world that can be controlled by the Internet of Things and used to monitor physical objects [15–18]. This is a useful framework for representing and simulating how physical objects interact in target environments [19,20]. Therefore, sensing integrated into digital twin technology has been studied and extensively applied in many traditional industrial fields, such as automatic driving [21], smart cities [22], medical care [23], intelligent robots [24], etc.

This Special Issue features eight research and review articles demonstrating the most recent advances in physical sensing in machine learning, human–machine interfaces, data confusion, and various potential applications of sensors within digital twin innovation, which should give readers a glimpse of the challenges, opportunities, and development trends in this area.

Five research articles explore novel sensing technologies and detecting approaches for equipment and systems. Constantinoiu et al. (contribution 1) present several techniques for evaluating shallow-water bathymetry, employing marine unmanned systems (MUSs) equipped with cutting-edge and creative sensors such as Light Detection and Ranging (LiDAR) and multibeam echosounder (MBES). Through comparing the accuracy, precision, speed, and operational efficiency of each satellite-derived bathymetry (SDB) technique, the authors enable the reader to easily understand the effectiveness and utilization of these approaches. To enhance sensing performance in magnetic induction switches, Zhang et al. (contribution 2) designed a core unit consisting of a magnetic sensing component and a signal conditioning circuit; it has the capacity to precisely determine the direction of

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magnetic fields using a permalloy layer with the anisotropic magneto-resistance (AMR) effect. An interface circuit based on a trans-impedance amplifier (TIA) was also designed for measuring and controlling the output signal of the sensing device. To preserve and effectively utilize SERS substrates, Song et al. (contribution 3) proposed a novel technique that uses 3D printing and a ballpoint pen to create them on different kinds of paper. This method ensured a high enhancement factor, maximizing the utilization of the substrate and demonstrating excellent SERS sensitivity and spectral reproducibility. To reduce the impact of gear component malfunction or failure, Lee et al. (contribution 4) implemented an outlier detection approach to detect and classify defects. This study focused on the autoencoder long short-term memory (AE-LSTM) model for abnormality identification, which achieved an accuracy rate of 94.42% in recognizing malfunctioning gearboxes within an extruder machine system. Meanwhile, Patel et al. (contribution 5) described a non-destructive technique that uses K-mer frequency encoding to detect cable flaws. The method of detection combines magnetic leakage detection equipment with artificial intelligence, including cable signal acquisition, K-mer frequency encoding, and artificial intelligence-based identification, achieving an identification accuracy rate of 91% through repeated sampling.

As for innovative applications of sensing technology in digital twins, Lin et al. (contribution 6) used ZigBee web technology to develop a monitoring system for intensive care units (ICUs) that can create an interface based on user needs. The suggested GUI makes it possible to monitor a patient's many vital signs, effectively reducing the required costs and time so that patients can achieve timely and appropriate treatment. To reduce the spread of disinformation, Shushkevich et al. (contribution 7) proposed a method to tackle fake-news detection (FND) in practical scenarios, using multiclass classification to analyze a corpus including unknown themes: true, false, partially false, and other categories. The contributions of this study include exploring three BERT-based models, enhancing results via ChatGPT-generated artificial data for class balance, and improving outcomes using a two-step binary classification procedure, with experimental results demonstrating superior performance compared to existing methods. Wu et al. (contribution 8) analyzed the mapping form of both teaching and cue data on users' cognitive abilities using an experimental method. The findings demonstrated the substantial influence that distinct cue display designs and instructional content have on users' learning outcomes, which is of great significance for virtual education research in digital twins.

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List of Contributions:

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