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Editorial: Acquisition and application of multimodal sensing information, volume II

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Editorial on the Research Topic
Acquisition and application of multimodal sensing information, volume II

With advancements in sensor technology, these devices are now essential in diverse fields from industrial production and space exploration to healthcare and environmental monitoring. As the foundation of data acquisition, sensors measure physical parameters (e.g., temperature, pressure, speed) and convert them into electrical signals. High-performance sensors with high sensitivity, resolution, and real-time capabilities are highly sought after. Coupled with computer-based signal processing, multi-sensor systems enhance applications like intelligent transportation, smart cities, and UAVs. Optical trace gas sensor as a super-sensitive detection method has been developed in many fields, such as non-invasive medical diagnosis, manned spacecraft, chip manufacturing and smart grid (Jing et al.; [1–3]). Futhermore, the sensors based on neural networks have become a research hotspot ([4]; Hu et al.). This Research Topic-Volume II comprises several original research and review works, which are summarized below:

In the first article, Jing et al. proposed a non-resonant photoacoustic SO_2 gas sensor utilizing a 273 nm deep-ultraviolet light-emitting diode. Due to its divergent beam, the LED has a output power of ~10 mW with an emission angle of 60°, which is unsuitable for the traditional photoacoustic gas sensors such as a resonant photoacoustic cell or a quartz tuning fork. The sensor achieved a minimum detection limit of 725 ppbv with a 1s integration time.

In the second study, Cheng et al. developed a Molybdenum disulfide (MoS_2) nanosheets sensor for NO_2 gas sensing. Engineering MoS_2 nanosheets into a 3D network microstructure through the self-assembling of MoS_2/SiO_2 microspheres effectively mitigated the stacking effect. Compared to pure 2D MoS_2 filim (single- or few-layer), MoS_2 nanosheets had increased its surface area per footprint with a sensitivity of 0.297 ppmv, which was 6.15 times greater than that of the pure MoS_2 nanosheets.

In the third article, Hu et al. introduced a point cloud simplification strategy based on probabilistic membership. Their approach initially developed a curvature-based feature extraction scheme to identify the set of feature points, which demonstrated superior performance. By integrating K-means clustering with possibilistic C-means, the method effectively preserved point cloud features while offering flexibility in balancing feature retention and the degree of simplification. Experimental results demonstrate the superior performance of this strategy.

In the fourth work of this Research Topic, Liu et al. proposed a data fusion-based method to update assembly parameters for spacecraft assembly process state changes. By integrating 3D point cloud data with fiber optic sensor data, they developed an assembly parameter update method for thermal protection systems (TPSs) under different assembly states. Experimental results demonstrated that this method achieved high performance for different assembly state simulation components, enhancing spacecraft TPSs' assembly accuracy and efficiency, and providing auxiliary guidance for the spacecraft thermal protection assembly process.

In the fifth contribution, Wang Minshuai presented a mini review on the significant advancements in organic solar cells with ternary additives. The author explored how ternary additives optimize the morphology of Organic photovoltaics (OPVs) and impact device performance. OPVs offer a cost-effective and scalable alternative to conventional silicon-based solar cells, benefiting from lightweight, flexibility, and tunable optoelectronic properties. Ternary additive-based organic solar cells are particularly promising, combining high solar energy conversion efficiency with robust structural integrity, making them suitable for a broad spectrum of applications.

In the sixth contribution, Lin et al. proposed a novel weed detection method for vegetable crops using image classification neural networks and image processing. Rather than applying deep learning directly for weed identification, they partitioned input images into grid cells. Image classification neural networks identified grid cells containing vegetables, excluding them from further analysis. The ResNet model demonstrated the highest computational efficiency, achieving a classification time of 12.76 ms per image and a corresponding frame rate of 80.31 fps, meeting real-time weed detection requirements. By accurately identifying vegetables and clearly differentiating weeds from soil, this approach significantly simplifies detection complexity while enhancing overall accuracy.

In the seventh contribution, Wang et al. developed a portable laser heterodyne radiometer for field measurement of atmospheric carbon dioxide (CO_2) column abundance in Taiyuan, Shanxi, China area. The system achieved an impressive spectral signal-to-noise ratio of 130 with 0.0083 cm^{-1} resolution. By employing a forward model based on line-by-line integration and an iterative fitting algorithm, the system obtained high-precision column abundance calculations. Successful outdoor field tests demonstrated the method's feasibility and practicality, establishing a foundation for wider applications. This work significantly advances atmospheric monitoring capabilities while supporting the development of targeted greenhouse gas reduction strategies.

In the eighth contribution, Dai et al. present a comprehensive review of optical gas sensing technologies for dissolved gas analysis in transformer oil. As a highly reliable diagnostic tool, dissolved gas analysis enables early fault detection in transformers, thereby preventing further equipment damage. The review systematically examines prevalent sensing technologies for analyzing dissolved gases in transformer oil, including Raman spectroscopy, Fourier transform infrared spectroscopy, tunable diode laser absorption spectroscopy and photoacoustic spectroscopy. Furthermore, this review establishes critical selection guidance for online gas sensing technologies, enabling precise assessment of transformer operating conditions to safeguard power grid stability.

In the ninth contribution, Sun et al. developed a quartz enhanced photoacoustic spectroscopy system using a T-shaped quartz tuning fork (QTF) for SF_6 gas matrix. The custom-designed T-shaped QTF demonstrated a resonant frequency of 12.46 kHz with a *Q*-factor of 4587, achieving a minimum detection limit of 1 ppm for C_2H_2 in SF_6 gas matrix. The experimental results conclusively demonstrate the T-shaped QTF's detection capability in SF_6 gas matrix, establishing a promising technical solution for real-time decomposition monitoring and predictive fault analysis in SF_6-insulated equipment.

In summary, with the improvement of human life quality, more and more researchers pay attention to air quality and develop gas sensors. In this Research Topic, 5 contributions are reported for the SO_2, NO_2, CO_2, and C_2H_2 detection with the optical spectroscopy technology and MoS_2 nanosheet. The high sensitive for these paper all reached ~ sub-ppm level, which has demonstrated its application potential in the fields of air quality detection and industrial safety production. Moreover, 2 novel point cloud simplification strategy models were reported, which shows superior performance for spacecraft assembly accuracy and efficiency. Finally, a research paper reported a novel weed detection method for vegetable crops using image classification neural networks and image processing. And a review on the significant advancements in organic solar cells with ternary additives was presented in this Research Topic. This compilation of cutting-edge studies offers a thorough investigation into the latest breakthroughs across multiple disciplines, highlighting transformative discoveries and technological leaps. By providing actionable knowledge and novel solutions, these works drive progress in artificial intelligence, sustainable energy, and global health. Their dissemination is poised to shape the future of both scholarly discourse and industrial practices, fostering new avenues for innovation.

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References

1. Sun J, Yu X, Li W, Jia B, Shi D, Song Y, et al. Real-time accurate detection and analysis of breath acetone using CRDS: toward metabolic dynamic monitoring and potential application. *Sensors Actuators B: Chem* (2025) 433:137422. doi:10.1016/j.snb.2025.137422

2. Yin X, Wu H, Dong L, Li B, Ma W, Zhang L, et al. Ppb-level SO_2 photoacoustic sensors with a suppressed Absorption–Desorption effect by using a 7.41 μm external-cavity quantum cascade laser. *Acs sensors* (2020) 5:549–56. doi:10.1021/acssensors.9b02448

3. Wu H, Dong L, Yin X, Sampaolo A, Patimisco P, Ma W, et al. Atmospheric CH_4 measurement near a landfill using an ICL-based QEPAS sensor with V-T relaxation self-calibration. *Sensors Actuators B: Chem* (2019) 297:126753. doi:10.1016/j.snb.2019.126753

4. Xu K, Xing M, Zhang R, Sha M, Nie W, Quan Y, et al. High-accuracy DOA estimation algorithm at low SNR through exploiting a supervised index. *IEEE Trans Aerospace Electron Syst* (2022) 58(4):3658–65. doi:10.1109/TAES.2022.3144121