Development Trend of Electronic Nose Technology in Closed Cabins Gas Detection

Tan, L., Feng, Z., Zheng, H., Yao, Z., Weng, X., Wang, F., & Chang, Z. (2022). Development trend of electronic nose technology in closed cabins gas detection: A review. Applied Sciences, 12(23), 9326. https://doi.org/10.3390/app12239326

The detection of hazardous gases in closed cabins, such as vehicles, aircraft, and space stations, is critical for ensuring the safety of occupants and the proper functioning of these environments. Traditional gas detection methods are often slow, expensive, and unable to provide real-time monitoring, which can lead to delays in identifying and addressing potential hazards. Electronic nose (e-nose) technology, which uses sensor arrays and pattern recognition algorithms to mimic the human sense of smell, offers a promising alternative. This study explores the development and application of e-nose technology for gas detection in closed cabins, highlighting its potential to improve safety and efficiency.

The study discusses the components of e-nose systems, including gas sensors, signal processing circuits, and pattern recognition algorithms. These systems are designed to detect a wide range of gases, such as volatile organic compounds (VOCs), and provide real-time monitoring of air quality in closed cabins. The study highlights the advantages of e-noses, such as their low cost, fast response times, and ability to operate in various environments. However, challenges remain, including improving sensor selectivity and stability, as well as ensuring accurate performance under fluctuating environmental conditions like temperature and humidity. The study also reviews the applications of e-nose technology in industries such as automotive, aerospace, and environmental monitoring, demonstrating its versatility and potential for widespread use.

The study concludes that e-nose technology is a promising tool for gas detection in closed cabins, offering a faster and more cost-effective solution compared to traditional methods. However, further research is needed to address challenges such as sensor selectivity and stability, as well as to optimize the performance of e-nose systems in real-world conditions. Future work should focus on developing advanced sensor materials, integrating machine learning algorithms for improved data analysis, and creating portable, durable systems for use in various closed cabin environments. By addressing these challenges, e-nose technology can become a critical tool for enhancing safety and efficiency in closed cabins.

Application of Gas Sensor Technology to Locate Victims in Mass Disasters

Karami, H., Thurn, B., de Boer, N. K., Ramos, J., Covington, J. A., Lozano, J., Liu, T., Zhang, W., Su, S., & Ueland, M. (2025). Application of gas sensor technology to locate victims in mass disasters – A review. Natural Hazards, 121(1), 31–60. https://doi.org/10.1007/s11069-024-06809-5

Mass disasters, such as earthquakes, terrorist attacks, and industrial accidents, often result in victims being trapped under rubble or scattered over large areas, making it difficult to locate them quickly. Traditional search methods, such as manual searches and search dogs, are effective but have limitations, including high costs, fatigue, and the inability to operate in hazardous environments. Gas sensor technology, particularly electronic noses (e-noses), offers a promising solution by detecting volatile organic compounds (VOCs) emitted by humans, which can help locate both living and deceased victims. This study examines the application of gas sensor technology for victim location in mass disasters, highlighting its potential to improve disaster response and save lives.

The study discusses various types of gas sensors, including metal oxide semiconductors (MOS), electrochemical sensors, and optical sensors, and their strengths and weaknesses. E-noses, which use sensor arrays and pattern recognition algorithms, are particularly effective for detecting VOCs associated with human presence. The study highlights the advantages of e-noses, such as their ability to operate in hazardous environments and provide real-time data. However, challenges remain, including low detection limits, complex gas analysis, and the need for accurate performance under harsh environmental conditions. The study also reviews current e-nose systems and their applications in disaster scenarios, demonstrating their potential for improving victim detection and response times.

The study concludes that gas sensor technology, particularly e-noses, has the potential to revolutionize victim location in mass disasters by providing a fast, accurate, and safe alternative to traditional methods. However, further research and development are needed to address challenges such as low detection limits, complex gas analysis, and performance in harsh environments. Future work should focus on improving sensor accuracy, integrating advanced machine learning algorithms, and developing portable, durable systems for use in disaster zones. By addressing these challenges, e-nose technology can become a critical tool for enhancing disaster response and saving lives.

Development of an Electronic Nose for Smell Categorization Using Artificial Neural Network

Macasaet, D., Bandala, A., Illahi, A. A., Dadios, E., Lauguico, S., & Alejandrino, J. (2021). Development of an electronic nose for smell categorization using artificial neural network. Journal of Advances in Information Technology, 12(1), 34–44. https://doi.org/10.12720/jait.12.1.34-44

The sense of smell, or olfaction, is one of the most complex and least understood human senses. It plays a critical role in detecting environmental hazards, identifying food quality, and even warning of potential dangers. However, replicating this sense artificially has been a significant challenge. Electronic noses (e-noses), which use gas sensor arrays and pattern recognition algorithms, have emerged as a promising technology to mimic the human olfactory system. This study focuses on developing an e-nose capable of categorizing smells into ten basic categories: fragrant, sweet, woody/resinous, pungent, peppermint, decaying, chemical, citrus, fruity, and popcorn. The e-nose employs ten MQ gas sensors and uses an artificial neural network (ANN) for pattern recognition. The goal is to create a portable device that can classify odors accurately, which has applications in various fields such as food quality assessment, environmental monitoring, and disaster response.

The study begins by discussing the importance of the olfactory system and the challenges in replicating it artificially. The e-nose prototype developed in this research integrates ten MQ gas sensors, each sensitive to different gases such as LPG, methane, alcohol, and carbon monoxide. These sensors are connected to a microcontroller, which transmits data to a computer for processing using MATLAB. The ANN is trained to recognize patterns in the sensor data and classify smells into the ten predefined categories. The study highlights the limitations of current sensor technology, as only four categories (pungent, chemical, peppermint, and decaying) could be reliably detected. The remaining six categories (fragrant, sweet, woody/resinous, fruity, citrus, and popcorn) showed minimal variation in sensor readings, leading to misclassification.

The methodology involves training the ANN using a dataset of 753 samples, with 70% used for training, 15% for validation, and 15% for testing. The results show that the e-nose achieved an overall accuracy of 59% when classifying smells into ten categories. However, when the system was adjusted to classify only the four detectable categories, the accuracy improved to 75.9%. The study also discusses the use of cross-entropy error and confusion matrices to evaluate the performance of the ANN. The findings suggest that the e-nose is most effective in detecting strong, distinct odors, such as those in the chemical and decaying categories.

The study concludes that the e-nose prototype is capable of classifying smells into four categories (pungent, chemical, peppermint, and decaying) with reasonable accuracy. However, the technology is limited by the current capabilities of gas sensors, which struggle to detect subtle variations in odor. The researchers recommend the use of more advanced sensors to improve the system's ability to classify a wider range of smells. Additionally, they suggest that future studies should focus on optimizing the ANN and improving the system's performance in different environmental conditions. The study also highlights the potential for e-nose technology to expand into new applications, such as food quality assessment and environmental monitoring, as sensor technology continues to advance.

Subandri, M. A., & Sarno, R. (2019). E-Nose Sensor Array Optimization Based on Volatile Compound Concentration Data.

Subandri and Sarno (2019) explore the optimization of electronic nose (e-nose) sensor arrays to enhance efficiency while maintaining accurate gas detection capabilities. The study specifically focuses on reducing the number of gas sensors used in an e-nose system by selecting those most relevant to volatile organic compound (VOC) concentration data, rather than relying on traditional electrical signal measurements. Initially, the researchers employed a prototype e-nose with ten different metal oxide semiconductor (MOS) sensors, but through optimization, they reduced this number to four without compromising classification accuracy. The study utilized a case study involving banana quality assessment, where the optimized sensor array, combined with a k-Nearest Neighbors (KNN) classification algorithm, achieved an 80% accuracy rate in predicting banana ripeness based on VOC emissions. Even after applying the optimized model to a final e-nose product, the system retained a high prediction accuracy of 78%.

This research highlights the benefits of minimizing sensor count in e-nose systems, particularly in applications requiring portability and energy efficiency. The authors emphasize that traditional e-nose devices often suffer from high computational loads, excessive data processing requirements, and increased energy consumption due to an unnecessarily large number of sensors. By focusing on essential VOC concentration data, the study presents a solution that aligns well with the growing integration of Internet of Things (IoT) technologies in remote sensing applications. The findings are particularly relevant to UAV-mounted e-nose systems, where optimizing sensor performance while reducing hardware weight and power consumption is critical for efficient airborne gas detection in hazardous environments.

Electronic Noses: From Gas-Sensitive Components and Practical Applications to Data Processing.
Zhai, Z., Liu, Y., Li, C., Wang, D., & Wu, H. (2024). Electronic noses: From gas-sensitive components and practical applications to data processing. Sensors, 24(4806). https://doi.org/10.3390/s24154806

Zhai et al. (2024) provide a comprehensive review of electronic nose (e-nose) technology, focusing on three key aspects: gas-sensitive materials, sensor applications, and advanced data processing techniques. The authors discuss the evolution of e-nose devices from early models using traditional metal oxide semiconductor (MOS) sensors to the latest advancements incorporating metal-organic frameworks (MOFs), which offer improved selectivity, stability, and sensitivity. The review highlights the limitations of conventional MOS sensors, such as poor selectivity and sensitivity drift over time, and explains how newer materials like MOFs and nanomaterial composites can enhance detection performance. Additionally, the study examines the role of gas sensor optimization in improving efficiency, reducing power consumption, and minimizing false positives, all of which are critical for applications in hazardous gas detection and environmental monitoring.

Beyond hardware improvements, the study delves into data processing techniques that enhance the accuracy and reliability of e-nose systems. The authors emphasize the importance of machine learning algorithms, such as Support Vector Machines (SVM), Artificial Neural Networks (ANN), and Principal Component Analysis (PCA), in classifying complex gas patterns. They also discuss methods for signal drift compensation, a major challenge in long-term e-nose deployment, particularly in fluctuating environmental conditions. The review concludes by emphasizing the need for real-time, adaptive machine learning models that can dynamically adjust to changing conditions in the field. These findings are particularly relevant for UAV-mounted e-nose applications, where real-time hazard detection and rapid response are crucial for disaster management and emergency response operations.

Performance of a Novel Electronic Nose for the Detection of Volatile Organic Compounds Relating to Starvation or Human Decomposition Post-Mass Disaster.

Sunnucks, E. J., Thurn, B., Brown, A. O., Zhang, W., Liu, T., Forbes, S. L., Su, S., & Ueland, M. (2024). Performance of a novel electronic nose for the detection of volatile organic compounds relating to starvation or human decomposition post-mass disaster. Sensors, 24(5918). https://doi.org/10.3390/s24185918

Sunnucks et al. (2024) investigate the effectiveness of an advanced electronic nose (e-nose) system, NOS.E, in detecting volatile organic compounds (VOCs) associated with human decomposition in mass disaster scenarios. The study addresses the limitations of traditional post-disaster victim identification methods, such as search-and-rescue dogs and manual searches, which can be expensive, time-consuming, and hazardous. To assess the capabilities of the NOS.E system, the researchers tested it in both controlled laboratory environments and a simulated mass disaster scenario involving human cadavers. The system was trained on analytical standards representing known human ante-mortem and decomposition VOCs, including sulfur-containing compounds like dimethyl disulfide (DMDS) and dimethyl trisulfide (DMTS), which are known biomarkers of human decomposition. Results showed that the NOS.E could effectively distinguish decomposition-related VOCs from environmental background gases, achieving an average detection limit of 7.9 ppm across different chemical classes.

The study highlights several key advantages of e-nose technology over conventional methods, including portability, continuous operation, and rapid sampling capabilities. Unlike search dogs, which have limited working hours and require extensive training, the NOS.E system can operate autonomously, reducing response time in disaster scenarios. Additionally, the e-nose system provides real-time chemical fingerprinting of VOC profiles, allowing for more precise hazard classification and targeted search efforts. However, the authors also acknowledge limitations, such as the inability to identify individual VOCs within complex gas mixtures and challenges related to sensor drift. They suggest further improvements in machine learning algorithms and sensor calibration techniques to enhance detection accuracy. These findings are particularly relevant to UAV-based e-nose applications, where autonomous gas detection in disaster zones could significantly improve search-and-rescue efficiency while minimizing risks to human responders.