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DEVELOPMENT OF AN "ELECTRONIC NOSE" BASED ON MQ GAS SENSORS

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Abstract
This paper presents the development of a prototype electronic nose based on an array of MQ gas sensors. The main characteristics of the employed sensors and their combined application for detecting various gas mixtures are described. The hardware architecture of the system is presented, along with a virtual instrument developed in the LabVIEW environment, which enables data acquisition, visualization, and storage in a suitable format for subsequent processing. Experimental tests were conducted to investigate the influence of temperature on the sensor readings. The obtained results demonstrate that the developed device represents a low-cost and accessible electronic nose platform, which may find applications in industry, medicine, ecology, and security.
Keywords:electronic nose; MQ sensors; gas mixtures; LabVIEW

INTRODUCTION

In recent years, electronic nose (e-nose) systems have been established as a promising technology for the analysis and classification of various odors and volatile organic compounds. These are multisensor devices that mimic the human sense of smell by employing an array of gas sensors in combination with data processing algorithms and machine learning methods. The application of electronic noses is particularly active in the food industry, where product quality and freshness are of critical importance.

Numerous studies have demonstrated the effectiveness of electronic noses in meat quality assessment. For instance, systems for identifying beef freshness using sensor arrays and neural networks [1], as well as for chicken meat classification with the aid of methods such as Support Vector Machine and machine learning [2,3], have shown high accuracy and reliability. Similar approaches have been applied to classify mixtures of meat products [4], predict microbial populations in seafood [5], and evaluate the quality of crabs [6].

The development of electronic noses for seafood has also been the subject of active research—for example, in shrimp [7]—where correlations between sensor data and physicochemical indicators have been established.

Applications in plant-based products are also widespread. Various authors have developed electronic noses for determining tomato ripeness using deep neural networks [8–10], as well as for monitoring tomato paste quality through neural networks and fuzzy logic [11,12]. Electronic noses have also been employed in assessing avocado quality [13], as well as for general monitoring of spoilage in fruits and vegetables [14].

Beyond food, the technology has been applied to spices [15], oils [16,17], coffee [18], rice wine [19], spirits [20], and olive oil [21,22]. In these studies, electronic noses are

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combined with a variety of algorithms—from classical approaches such as Principal Component Analysis (PCA) and Support Vector Machine (SVM), to modern deep learning methods, which significantly enhance the selectivity and accuracy of the systems.

These developments emphasize that electronic noses have the potential to complement or replace traditional laboratory methods, which are often expensive, time-consuming, and require complex sample preparation. In this context, the present work focuses on the development of a prototype electronic nose based on cost-effective MQ gas sensors, which can be utilized as a compact and low-budget platform for food and food product research.

MQ GAS SENSORS: MAIN CHARACTERISTICS

The MQ series of gas sensors are among the most widely used low-cost semiconductor sensors for detecting various gases. Each type is optimized for a specific gas or group of gases, operating on the principle of a change in the resistance of the sensitive layer (typically SnO_2) upon contact with certain gas molecules.

Table 1. Sensors used in the electronic nose

Sensor	Target gases
MQ-2	LPG, Propane, Methane, Hydrogen
MQ-3	Alcohol (Ethanol)
MQ-4	Methane (CH_4)
MQ-5	LPG, Natural Gas
MQ-6	LPG (Butane, Propane)
MQ-7	Carbon Monoxide (CO)
MQ-8	Hydrogen (H_2)
MQ-9	Carbon Monoxide (CO), Methane (CH_4)
MQ-135	Ammonia (NH_3), NO_x, Benzene, CO_2, Smoke

Most of these sensors are not selective to a single gas but respond to several, while being most sensitive to a specific type. Therefore, they are often used in combination or in so-called electronic noses, where different MQ sensors are integrated and the data are processed with algorithms for the recognition of gas mixtures.

Table 2. Sensors suitable for detecting specific gases

Gas	Suitable MQ sensors
Methane (CH_4)	MQ-2, MQ-4, MQ-5, MQ-9
Propane / Butane (LPG)	MQ-2, MQ-5, MQ-6, MQ-9
Hydrogen (H_2)	MQ-2, MQ-5, MQ-8
Carbon Monoxide (CO)	MQ-7, MQ-9, MQ-135
Carbon Dioxide (CO_2)	MQ-135 (partial sensitivity, not primary)
Alcohol (Ethanol, Methanol, etc.)	MQ-3
Gasoline vapors / Benzene (C_6H_6)	MQ-3, MQ-135
Ammonia (NH_3)	MQ-135
Nitrogen Oxides (NO_x)	MQ-135
Smoke / general combustible gases	MQ-2, MQ-135

ELECTRONIC NOSE DEVICE

The electronic nose device comprises a set of gas sensors (MQ-3, MQ-7, MQ-9, MQ-6, MQ-8, MQ-4, MQ-5, MQ-135, MQ-2), as illustrated in the block diagram in Fig. 1.

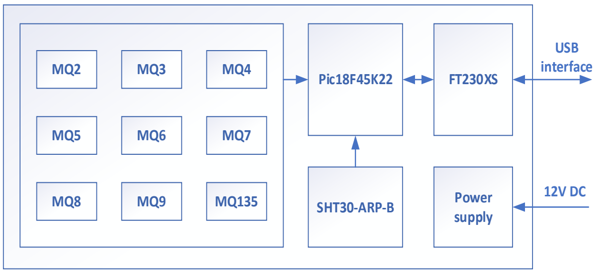

***Fig. 1**. Block diagram of the sensor array*

Additionally, the sensor array includes a temperature and relative humidity sensor SHT30-ARP-B, manufactured by Sensirion. The SHT30-ARP-B integrates temperature and humidity sensing elements within a single package, along with an analog-to-digital processing circuit and factory

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calibration. The device measures humidity in the range of 0–100 %RH with an accuracy of ±3 %RH, and temperature from –40 to +125 °C with an accuracy of ±0.3 °C. The measurements are output as analog voltages through two separate outputs for temperature and humidity. The sensor operates at a supply voltage of 2.4–5.5 V and features low power consumption for this type of device.

The data from the gas sensors and the temperature and humidity sensor are digitized using the built-in 10-bit analog-to-digital converter (ADC) of the PIC18F45K22 microcontroller. During the digitization of the analog signals, software-based smoothing filters are applied in the microcontroller.

The acquired data are transmitted via a USB interface implementing a virtual serial port to an external personal computer, which collects the sensor measurements for subsequent processing.

The developed electronic nose system is shown in Fig. 2.

Fig. 2. *Electronics of the electronic nose*

The electronic system is housed in a tightly sealed enclosure, ensuring that the volatile compounds and gas emissions from the tested substances remain within the enclosure volume. Fig. 3 shows the final version of the developed e-nose.

Fig. 3. *General view of the electronic nose*

LABVIEW-BASED DATA ACQUISITION SYSTEM

A LabVIEW virtual instrument, compiled into an application, was developed for data acquisition from the electronic nose. The main features of the virtual instrument include data collection from all gas sensors, as well as from the temperature and humidity sensor; data visualization; and recording of the measured values in an .xlsx file. Fig. 4 shows the developed virtual instrument.

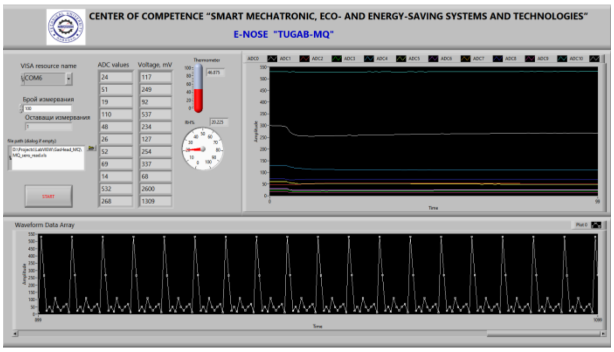

Fig. 4. *LabVIEW virtual instrument for data acquisition from the electronic nose*

TESTING OF THE ELECTRONIC NOSE

Tests were conducted with the developed electronic nose to demonstrate the changes in gas sensor readings due to variations in ambient temperature during measurements. The structure of the data recorded in the .xlsx file is shown in Fig. 5.

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	A	B	C	D	E	F	G	H	I	J	K	L
1	141	224	112	630	303	156	293	351	87	47	24	
2	141	224	112	635	298	156	293	351	87	47	24	
3	141	224	112	630	298	156	293	351	87	47	24	
4	141	224	112	630	298	156	293	351	87	47	24	
5	141	224	112	630	298	156	293	351	87	47	24	
6	141	224	112	630	298	156	293	342	78	47	24	
7	122	224	92	606	263	122	278	332	68	46	21	
8	107	229	87	586	259	122	263	332	68	46	20	
9	107	234	87	576	254	122	259	337	68	46	19	
10	112	244	87	571	249	122	254	337	68	46	19	
11	107	244	87	562	249	122	254	342	68	46	19	
12	107	249	87	557	244	122	249	342	68	46	19	
13	107	254	87	557	244	122	249	342	68	46	19	
14	107	254	87	552	244	122	244	342	68	46	19	
15	107	254	87	552	244	122	244	342	68	46	19	
16	107	259	87	547	244	122	244	342	68	46	19	

Fig. 5. *Measured data from the electronic nose*

The collected data can thus be easily imported into specialized environments for mathematical processing, such as MATLAB. In these environments, the data can be visualized.

An example from testing the developed electronic nose is the determination of the influence of ambient temperature on the sensor readings. Figure 6 shows a visualization of the changes in sensor responses as a function of temperature variation.

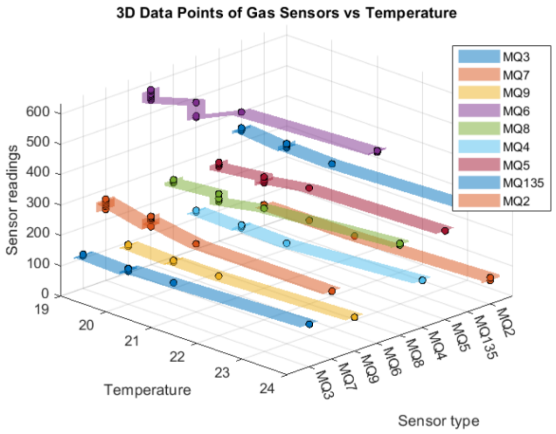

Fig. 6. *Changes in gas sensor readings with variations in ambient temperature*

CONCLUSION

In this work, a prototype electronic nose based on an array of widely available MQ gas sensors has been presented. The system comprises both hardware, enabling the collection and analysis of gas mixtures, and a software platform implemented in the LabVIEW environment, providing data visualization and recording for subsequent processing. Experimental tests demonstrate that the developed device responds clearly to changes in gas composition and ambient temperature, and that the collected data can be effectively used for mathematical modeling and classification in environments such as MATLAB.

The results confirm that a combination of different MQ sensors is suitable for building compact, low-cost, and accessible electronic nose systems, which can be applied across a wide range of fields including the food industry, medical diagnostics, environmental monitoring, and security. Future developments may include the implementation of various data processing algorithms and machine learning techniques to further enhance the selectivity and reliability of measurements performed with the electronic nose.

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REFERENCE

[1] Amalia, A.; Rivai, M.; Purwanto, D. Indoor Beef Quality Identification Using Gas Sensor Array and Probabilistic Neural Network Method. In Proceedings of the 2024 IEEE International Conference on Artificial Intelligence and Mechatronics Systems (AIMS), Virtual, 22–23 February 2024; pp. 1–5.

[2] Mada Sanjaya, W.S.; Roziqin, A.; Purnama Sari, N.A.M.; Sintia, P.; Alamsyah, F.; Putra, T.F.; Taqwim, A.; Mubasyir, F.H.; Temiesela, A.W.; Zaman, M.F.B.; et al. Chicken Meat Freshness Evaluation using Support Vector Machine Method and Raspberry Pi 4 based Electronic Nose. In Proceedings of the 2023 IEEE 9th Information Technology International Seminar (ITIS), Batu Malang, Indonesia, 18–20 October 2023; pp. 1–6.

[3] Anwar, H.; Anwar, T. Quality assessment of chicken using machine learning and

doi: www.doi.org/10.70456/.........................

electronic nose. Sens. Bio-Sens. Res. 2025, 47, 100739.
[4] Laga, S.A.; Sarno, R. Optimal Sample Temperature of Electronic Nose For Detecting Beef and Pork Mixture. In Proceedings of the 2019 International Conference on Information and Communications Technology (ICOIACT), Yogyakarta, Indonesia, 24–25 July 2019; pp. 398–402.
[5] Zakaria, E.; Wijaya, D.R.; Gunawan, T. Predicting Microbial Populations in Seafood using Support Vector Regression Algorithms and Electronic Nose. In Proceedings of the 2023 International Conference on Artificial Intelligence Robotics, Signal and Image Processing (AIRoSIP), Yogyakarta, Indonesia, 9–10 August 2023; pp. 280–284.
[6] Hermawan, L.M.; Novamizanti, L.; Wijaya, D.R. Crab Quality Detection with Gas Sensors Using a Machine Learning. In Proceedings of the 2024 IEEE International Conference on Internet of Things and Intelligence Systems (IoTaIS), Bali, Indonesia, 28–30 November 2024; pp. 270–275.
[7] Jiang, C.; Ning, J.; Mei, Z.; Chen, J.; Gao, Y.; Yi, X.; Wu, P. Development of food electronic nose for prawn (macrobrachium rosenbergii) quality rapid assessment and their relationship with the physicochemical index. Int. J. Food Prop. 2021, 24, 346–353.
[8] Padilla, D.A.; Krystine, D.; Anticuando, M.; Directo, C.K.R. An Electronic Nose Approach in Identifying Ripe Tomato Fruit Using LeNet-5 Structure. In Proceedings of the 2024 7th International Conference on Information and Computer Technologies (ICICT), Honolulu, HI, USA, 15–17 March 2024; pp. 223–227.
[9] Anticuando, M.K.D.; Directo, C.K.R.; Padilla, D.A. Electronic Nose and Deep Learning Approach in Identifying Ripe Lycopersicum esculentum L. Tomato Fruit. In Proceedings of the 2022 13th International Conference on Computing Communication and Networking Technologies (ICCCNT), Kharagpur, India, 3–5 October 2022; pp. 1–6.
[10] Affognon, L.; Diallo, A.; Diallo, C.; Ezin, E.C. Supervised Learning Models for Tomato Quality Prediction Using Electronic Nose Data. In Proceedings of the 2023 International Conference on Electrical, Computer and Energy Technologies (ICECET), Cape Town, South Africa, 16–17 November 2023; pp. 1–6.
[11] Concepcion, R.S.; Sybingco, E.; Lauguico, S.C.; Dadios, E.P. Implementation of Multilayer Perceptron Neural Network on Quality Assessment of Tomato Puree in Aerobic Storage using Electronic Nose. In Proceedings of the 2019 IEEE International Conference on Cybernetics and Intelligent Systems (CIS) and IEEE Conference on Robotics, Automation and Mechatronics (RAM), Bangkok, Thailand, 18–20 November 2019; pp. 65–70.
[12] Concepcion, R.S.; Bandala, A.A.; Bedruz, R.A.R.; Dadios, E.P. Fuzzy Classification Approach on Quality Deterioration Assessment of Tomato Puree in Aerobic Storage using Electronic Nose. In Proceedings of the 2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), Laoag, Philippines, 29 November–1 December 2019; pp. 1–6.
[13] Elbi, M.D.; Özgören Çapraz, E.; ¸Sahin, E.; Koyuncuo˘glu, M.U.; Tuncer, C. A classification based on support vector machines for monitoring avocado fruit quality. Pamukkale Üniversitesi Mühendislik Bilim. Derg. 2024, 30, 343–353.
[14] Caya, M.V.C.; Cruz, F.R.G.; Fernando, C.M.N.; Lafuente, R.M.M.; Malonzo, M.B.; Chung, W.Y. Monitoring and Detection of Fruits and Vegetables Spoilage in the Refrigerator using Electronic Nose Based on Principal Component Analysis. In Proceedings of the 2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), Laoag, Philippines, 29 November–1 December 2019; pp. 1–6.
[15] Yunxiang, L.; Tianwei, L. Study on electronic nose and algorithm for identification of spice. In Proceedings of the 2016 First IEEE International Conference on Computer Communication and the Internet (ICCCI), Wuhan, China, 13–15 October 2016; pp. 518–521.

doi: www.doi.org/10.70456/.........................

[16] Gonzalez Viejo, C.; Fuentes, S. Digital Detection of Olive Oil Rancidity Levels and Aroma Profiles Using Near-Infrared Spectroscopy, a Low-Cost Electronic Nose and Machine Learning Modelling. Chemosensors 2022, 10, 159.
[17] Oates, M.J.; Fox, P.; Sanchez-Rodriguez, L.; Ángel, A. Carbonell-Barrachina.; Ruiz-Canales, A. DFT based classification of olive oil type using a sinusoidally heated, low cost electronic nose. Comput. Electron. Agric. 2018, 155, 348–358.
[18] Rasekh, M.; Karami, H.; Wilson, A.D.; Gancarz, M. Classification and Identification of Essential Oils from Herbs and Fruits Based on a MOS Electronic-Nose Technology. Chemosensors 2021, 9, 142.
[19] Chen, I.T.; Chen, C.C.; Dai, H.J.; Rianto, B.; Huang, S.K.; Lee, C.H. An Incremental Learning Method for Preserving World Coffee Aromas by Using an Electronic Nose and Accumulated Specialty Coffee Datasets. IEEE Trans. Agrifood Electron. 2024, 2, 12–27.
[20] Zheng, W.; Wang, Y.; Liang, X.; Zhang, A. Origin identification for rice wines based on an electronic nose and convolution dot-product attention mechanism. Sens. Actuators A Phys. 2024, 375, 115521.
[21] Harnsoongnoen, S.; Babpan, N.; Srisai, S.; Kongkeaw, P.; Srisongkram, N. A Portable Electronic Nose Coupled with Deep Learning for Enhanced Detection and Differentiation of Local Thai Craft Spirits. Chemosensors 2024, 12, 221.
[22] Viejo, C.G.; Fuentes, S.; Godbole, A.; Widdicombe, B.; Unnithan, R.R. Development of a low-cost e-nose to assess aroma profiles: An artificial intelligence application to assess beer quality. Sens. Actuators B Chem. 2020, 308, 127688.

doi: www.doi.org/10.70456/.........................