Vol. XVI & Issue No. 06 June - 2023
INDUSTRIAL ENGINEERING JOURNAL

# A REVIEW ON ARTIFICIAL INTELLIGENCE BASED SENSOR ARRAY SYSTEM FOR DETECTION OF HARMFUL GASES OF THE ENVIRONMENT

**Ms. Pratiksha Rai**
**S. Hasan Saeed**

**Abstract**

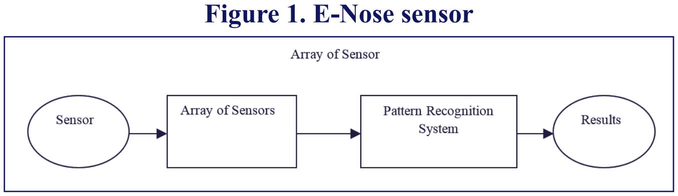
*In order to govern the environment, monitor industry, as well as ensure domestic safety, gas sensors are widely utilised. Due to its higher sensitivity, rapid reaction time, and brief recovery period for ethanol, acetone, methane, propane etc., metal oxide semiconductor gas sensors have emerged as a significant area of work in the domain of gas sensing. Pattern recognition techniques are used to describe the sensor network's performance. Detection principle is used to examine each gas sensing method as well as different factors including gas detection, sensitivity, reaction time, recovery time, sensor variables, sensor features, and benefits and drawbacks are discussed. Sensor array is remarkably responsive, accurate, low-effort, low-power consuming, and can differentiate most significant harmful gasses. This sensor array will distinguish the most notable polluting gases and is notably responsive, precise, low-effort, as well as low-power consuming. In this review all pattern recognition techniques are employed here with cross-validation. These methods demonstrate how to properly distinguish between gases.*

***Keywords: Electronic nose; Gas sensing system; Pattern Recognition; PARAFAC; ANN; PLS; PCA.***

## 1. INTRODUCTION

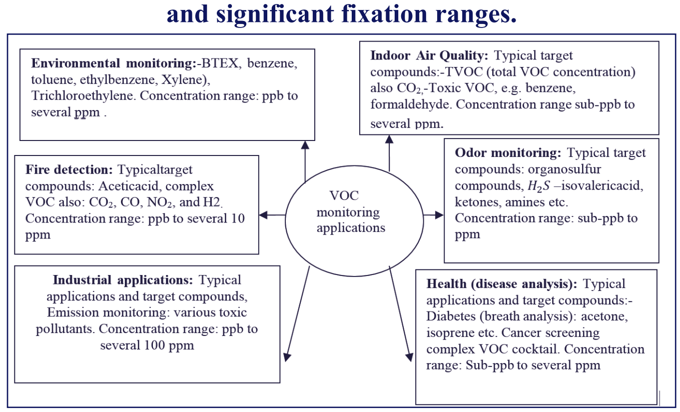
Pollution in the economy has steadily increased over the last few decades. As far as human health care is needed, detecting pollution problems is a critical duty. As a result, the research has been focused on developing an electronic system for detecting polluting gases. E-nose is a gadget that may be used to detect aromas and evaluate various gases. E-nose is bulky and costly. The usage of e-nose technology in several industries has rapidly increased in recent years. Scientists are currently working on producing gadgets that are smaller, cheaper and more sensitive. Pattern recognition and sensing are the two key components of e-nose systems. E-nose should be used in environmental modification to assess emissions from a contaminated river. It's also utilised to tell the difference between different bacterial forms of injuries. Implementing sensing equipment such as an e - nose to enhance environmental protection and control polluting gases is a demand in the current context. Using several sensor arrays, the E-nose system detects polluting gases like butane, LPG, acetone, ethanol, and methane.

**Figure 1. E-Nose sensor**




Detecting volatile organic compounds (VOCs) in solid waste has a variety of applications. VOCs are a class of extremely dangerous chemicals that are frequently found in the environment and can pose a major health risk to humans [1]. VOCs found in human breathing, on the other hand, may be used to determine a variety of illnesses. For example, the presence of a certain amount of acetone is thought to be a symptom of diabetes [2]. Abnormal ethanol concentrations can be treated in the same way [3]. MOS sensors are advantageous because they respond quickly and are inexpensive. This lack of selectivity can be perceived as a disadvantage when interacting with a single sensing material in the context of several gases that stimulate sensitivity. Nano-sensors are highly selective gas detecting systems made up of arrays of numerous sensors, each with a different reaction to the gases of interest. Figure 2 shows the application of VOCs (Volatile organic compounds).

**Figure 2. Outline of different applications requiring checking of VOCs in addition to commonplace target gases and significant fixation ranges.**




The propelled nose is a device that detects smells with greater precision than the human nose. An electronic nose combines a component for substance reporting. The automated nostrils are a perceptual distinguishing device that employs a range of gasoline sensors to cover an area near a prior revision section. Eventually, pushed noses have served as external focal places for a range of corporate enterprises, agriculture, biomedical, someone very, environmental, food, water, and many useful research fields. The aromas are made up of particles that have been selected based on their size and shape. Each of these particles has a receptor that has been evaluated and sized appropriately within the human nostril. When a molecule is detected by unique receptors, it sends a signal to the mind, and the forebrain recognises the smell of the unique particle. Electronic noses work in the same way as human nostrils. Sensors serve as the propelling nose's receptor. When a sensor detects particles, it sends a signal to a psyche-based preparation programme. Electronic nostrils have been used in agronomy, biochemical management, plant science, cell customisation, and plant cultivar selection, among other corporate green projects [5]. Pollution can be in the form of a chemical mixture, such as solid particles, liquid dots, or gasoline [6], as well as a symptom that mixes agitation, warmth, and brightness. Air pollution is caused by both natural and man-made assets. There is an increasing demand for increased space and monitoring of ozone-depleting compounds as a result of the increase in contaminated gases [7]. However, we would most likely deal with the signature gases that are delivered by means for household waste in this work, and we can regard air quality toxins because it is the most major natural threat to prosperity [8]. As a result, the proposed architecture meets the vast majority of defilement requirements. It gathers information and measures noxious gases such as CO, $CO_2$, and LPG. The most difficult problems were with zone programming, because the most often used sensors are sensitive to barometric conditions [9, 10]. The electronic sepal cause is too trustworthy after the surfaces overflow and confirmation of the link between propelled nasal reactions and notice strength. Quality controls of the aroma aspects of manufactured stock are crucial since consistency is critical for preserving consumer seal image and enjoyment.

**1.1 Need for Gas Sensor:** The environment we live in is made up of both biotic and abiotic elements. In truth, abiotic influences played a role in the evolution of life. A sufficient level of abiotic factor is required for the survival of life on the planet. Abiotic factors contain gases of various sorts, precipitation, humidity, temperature, and so on. The concentration of useful gases such as oxygen must be kept at a safe level, while the concentration of harmful gases should not exceed a critical threshold. Atmospheric pollution has the potential to cause significant personal health loss in a short period of time. In year 1984, the fatal effect of methyl isocyanides leaked from the Union Carbide Company was noticed in India. This incident is remembered as the Bhopal gas tragedy (M.P.), which claimed the lives of over 8000 individuals and affected approximately 500,000 more. Rise in environmental pollution, urbanisation, the use of automobiles, and industrial wastes are the primary causes of gas concentrations above the threshold level. Pollution is the cause of a number of ailments. [5-8] The WHO (world health organisation) is an international health organisation. According to one study, pollution causes seven millions of deaths per year. [9] 21% oxygen, 0.9 percent argon, 78 percent nitrogen as well as 0.035 percent carbon dioxide make up the air we breathe. The major cause of air pollution has been identified as 6 contaminants. Lead and gases such as carbon and nitrogen oxides make up the particulate particles. Oxides of nitrogen are produced when fuel is burned in power stations and transportation vehicles. It is harmful to both environment as well as human health. The health consequences could include diseases such as asthma, while the environmental consequences could include acid rain. As in realm of environmental monitoring, air pollutants control is an essential part. It is because polluted air is the primary cause of respiratory organ illnesses. Migraine, heart disease, acute respiratory infections, as well as lung cancer are among the major disorders caused by air pollution. Inflammable as well as hazardous gases are protected from plants and workers using gas detection devices. As mentioned below, gas can harm people and their possessions in three ways: [10-11]

(1) Some gases, such as butane, propane, methane, LPG and others, are flammable, meaning they can catch on fire at ◦ c (Room temperature) or slightly above it.

(2) Toxic: Certain gases are poisonous. Because of their poisonous nature, they can pose a threat to humans and their property. Carbon monoxide, hydrogen sulphide, chlorine, methyl isocyanide, and other gases are examples.

(3) Asphyxiant: For the physiological process of breathing, we all require oxygen. The oxygen content is of the air about 20.9 percent. It is termed oxygen insufficient when the oxygen level falls below 19.5 percent. Whenever oxygen concentration falls below 16 percent, respiration of humans and animals becomes impossible. Suffocation is a possibility with several gases. Excessive exposure to nitrogen causes a shortage in oxygen, resulting in asphyxia. As a result, there is a pressing need for such a development of accurate detecting devices to prevent against harmful impacts. Table 1 describes the effect of toxic gases on human beings as well as environment.

**Table 1. Effects of poisonous gases on both the environment and people [45].**

| Sr. No | Poisonous gases | Primary Origin | Environmental impact | Effects on people |
|---|---|---|---|---|
| 1 | Methane | Landfills, natural gas, petroleum pipelines as well as coal mining. | Hazardous air pollutants, Greenhouse gases as well as ground level ozone. | Issues with vision, headache, nausea, vomiting, skin redness etc. |
| 2 | CO | Energy production and transportation via combustion. | Contributes indirectly to climate change. | Commas are caused by headaches, heartbeat, and prolonged inhaling. |

| | | | | |
|---|---|---|---|---|
| 3 | $CO_2$ | Automobiles, cement building, as well as fossil fuels. | Global Warming | Increased heart rate, comma as well as elevated blood pressure. |
| 4 | Sulfur –dioxide | Electric utilities, petroleum refineries and combustion. | Rivers, ponds, or forests are affected by acid deposition as well as acid rain. | Children's breathing issues, vision issues, and respiratory issues. |
| 5 | Acetone | Vegetation, forest fires, automobile exhaust, cigarette smoke, and landfills. | Different agricultural as well as horticultural plants have experienced membrane damage, a reduction in size, and a drop in germination. | A quicker heartbeat, nausea, vomiting, discomfort, headaches, etc. |
| 6 | Ethanol | Corn grain, sugar cane or from cellulosic feedstocks (like wood chips). | Hazardous surface level ozone and fog formation. | Alcohol abuse over a long period of time is linked to liver, cardiovascular, cancer, as well as nervous system harm. |
| 7 | Propane | Liquid elements collected during the extraction of natural gas. | It has no negative impact on ozone when discharged into the air since it vaporises and evaporates. | It can be dangerous to inhale or consume. |
| 8 | Butane | Natural gas plants and from steam crackers. | When burnt, butane solely emits carbon dioxide as a by product. | Headache, dizziness, fatigue, and fainting from oxygen deprivation. |

Sensors' influence zone is too broad to be limited to technical sensing units alone. Sensors may be utilised in many different uses. "A sensor is just a device that accepts inputs and acts in an electrical signal," says Jacob Franden. It can also be described as "a device that reacts to physical stimuli including such temperature, light, noise, pressure, polarity, and other forms of energy as well as delivers an impulse as a response." A sensor's operation can be summarised as follows:

- The sensor must be in touch directly with the subject being analyzed.
- Sensors must be able to convert non-electrical data into electrical signals.
- External factors should elicit a rapid response from sensors.
- Sensors should be compact and inexpensive to produce.
- Sensors should be able to work indefinitely or at minimum in cycles.
- The sensors must be highly specific as well as precise.
- Sensors must be sensitive, meaning they should respond rapidly even when there is a minimal quantity of analyse present.

The poisonous fumes were recognised for the first time by humans. A damp blanket would be draped over the person's shoulders and head, and a long stick would be carried with its end ignited on fire. The person would next enter into mine and begin to move the wick's flame across the mine's wall. When the miner came across a tiny amount of methane, it might burn, but still the miner was secure beneath the damp blanket.

Coal has to be the most readily available fossil fuel. The usage of coal for heating dates back to the prehistoric era. The depths and blackness of a coal mine is a special & hazardous working environment. Toxic gases including methane, carbon dioxide, hydrogen sulphide, as well as carbon monoxide can kill mine employees. Carbon monoxide is a highly toxic gas. Carbon monoxide is highly combustible as well as lighter than air, making it more hazardous. As a result, in 18th century, hazardous vapours were identified using a variety of hit-or-miss procedures. Singing birds (Serinus canaria) were sometimes utilised to identify dangerous gases, particularly carbon monoxide. Whenever a male canary is alone, he sings constantly in the hopes of attracting a female. In reality, their constant singing is the major reason they are kept in captivity. In the advent of carbon monoxide, the heartbeat of canaries confined in mines harbouring hazardous gases rises. As a result, in the case of carbon monoxide, the bird ceases to sing or may perish. This was a sign that there was a toxic gas present, specifically carbon monoxide. H. Davy, a British physicist, invented the Davys lamp, a methane gas metre, in 1815. Johnson built the first industrial catalytic combustion gas sensor in 1926, as well as the firm they established with Williams in 1929 becomes first electronics manufacturer in Silicon Valley. During the 1970s, the term sensor gained prominent. Taniguchi built and copyrighted a first chemo resistive gas sensor for practical uses, which used tin oxide as both the gas sensitive material, in the early 1970s. Indeed, after studying a variety of metal oxides, he discovered that SnO2 had a number of advantages, including increased sensitivity, a low working temperature, and a thermally stable construction. Any alteration in a sensor causes a chemical change, which causes an electric impulse to be generated, which ultimately drives a circuit. It is, even as name implies, a gadget that feels or is designed to sense something. This is the characteristic for which it is built, such as temperature, pressure, movement, moisture, heat, sunlight, or any of a variety of other environmental events. The processing element in sensors reads the parameter and converts it to the required readable format. The operation of a sensor necessitates a small amount of power. The sensor's power source can be active or passive. Active refers to an AC power source, while passive refers to a battery with a limited lifespan. A sensor is a transducer in its most basic form. The sensor reads data in its own way, and we must convert to comprehend what it has received. It translates the material that is read into a different format. Like voltage, current, and so on, which may be interpreted by another device and so the readings can be found. The following are the components of a transducer. Sensors, transducers, signal conditioners, and readouts are all part of the process. Sensor characteristics can be split into two groups: static as well as dynamic. It is critical to comprehend these typical behaviours in order to appropriately map the output against input of the measurement. Actually, a sensor is a transducer whose job is to detect some aspect of its surroundings. It detects events or changes in quantity and generates an output, which is usually an electrical or visual signal, such as a thermocouple. Rapid advancements in microelectronics made technological intelligence readily available. Machines become more intelligent and self-sufficient. As a result, there was a need for the development of artificial sense organs that would allow robots to self-orient. Gas sensors are used to detect flammable, explosive, and hazardous gases, and when the measured gas concentration reaches a threshold value, they can sound an alarm. They can be mobile or permanent. Sensors, such as blood pressure sensors, blood sugar sensors, blood oxygen sensors, blood component sensors, light sensors, and taste sensors, commonly known as electronic tongues, are now widely used in daily life. Even large-scale laboratory analysis necessitates a variety of sensors. Gas detecting devices, on the other hand, are frequently employed across all sorts of sensors. It is, in fact, a component that detects changes in the gaseous state. There are several gas sensors depending on the components they detect; here are a few examples:

(1) Carbon dioxide sensors are used to monitor pollution caused by $CO_2$-emitting vehicles.

(2) Alcohol sensors: Alcohol is, in reality, a liquid. The sensor, on the other hand, can identify the odour of alcohol. This is a common tactic used by traffic cops.

(3) LPG Sensors: These are used to prevent the combustion of LPG cylinders that have leaked.

A sensor's primary characteristics may include the ability to work constantly or at least in a cycle, to respond fast, to convert non-electric information into electrical signals, to be in close contact with the work piece under investigation, and to be tiny in size. Stability, sensitivity, and repeatability are the most critical features of a good sensor. Sensor is often effective once all three parts are precisely stated. Selectivity plus linearity are two more characteristics that are desirable in a good sensor. A gas sensor is often based on the piezoelectric effect, with quartz or topaz crystals being investigated for electrical and vibration axis changes. The change in the mass axis will be evident in the other axes and will be linked accordingly. Armed forces are already using such sensors to detect gas. Gas sensors respond to gas stimuli, but resistance changes must be converted into a comprehensible format. Gas sensors are generally non-specific to stimulus and can detect changes in a wide range of gases. As a result, they're used in an array that mimics the biological olfactory system. Today, the development of gas sensors for applications is quite popular such as air quality monitoring, mine gas detectors, grading of agro-products like coffee and spices, personal protection, exhaust gas tracking, hand-held breadth analyzers, and so on. In fact, the gas molecule of concern interacts with or is added to the surface of a gas sensitive material, causing a change in the material's electrical signature, which is used to determine the gas concentration. Table 2 shows the different types of MOS sensor.

**Table 2. Different types of MOS sensors with their parameters [48].**

| Sensors | Detecting Material | Voltage/ RBase | Power |
|---|---|---|---|
| MICS 5135 | Ethanol, HC, CO as well as VOC. | 3.2V, 97Ω | 102mW |
| MICS 5521 | Carbon mono-oxide, Hydrocarbons, and Volatile organic compounds. | 5V DC,74Ω | 76mW |
| TGS 2602 | Ammonia, Ethanol, Hydrogen and Toluene. | 5V DC,59Ω | 15mW |
| TGS 2600 | Iso-butane, Ethanol, $CH_4$, CO and Hydrogen. | 5V DC,83Ω | 15mW |
| TGS 2611 | $CH_4$, Iso-butane, C2H5OH and H2. | 5DC,59Ω | 15mW |
| TGS 2620 | Methane, C2H5OH, Iso-butane, CO, H2. | 5DC/ AC,83Ω | 15mW |
| TGS 822 | Ethanol, Methane, CO | 5DC/ AC,38Ω | 660mW |
| TGS 825 | H2S,CO | 5DC/ AC,38Ω | 660mW |
| TGS 880 | Ethanol, hydrogen | 5DC, 30Ω | 15mW |
| TGS6810 | Methane, LPG | 3DC/ AC,32Ω | 525mW |

**1.2 Characteristics of a Sensor:** Detectors should have high sensitivity, discrimination, a fast reversal response, and long-term durability in general. Semiconductor materials oxide gas sensors are frequently utilised among the many sensors because of their numerous benefits over other gases [20-24], including:

**(1) Sensitivity:** The material should be highly sensitive to changes in impedance or capacitance when in contact with a very little amount of the vapour in question.

**(2) Selectivity:** Many gases are similarly sensitive to a certain materials (for example, Pt supported on TiO2). This isn't a good quality to have. Selectivity is a crucial criterion to consider.

**(3) Reproducibility:** The material should be able to detect gas through a high number of cycles and also for long periods of time, and the sensors should not degrade rapidly owing to humidity, heat, and other environmental conditions; repeatability.

**(4) Cost effective:** So because sensors have to become a consumer item, it will use as few expensive components as feasible, such as noble metals.

**(5) Low operating temperature:** The device's working temperature must be as low as feasible, and it should not require any additional power. This will assist in keeping costs down.

**(6) Low response time:** Both the response and recovery rates must be as fast as possible..

**(7)** The final detector should be as compact as feasible to allow for easy integration into the circuitry.

**(8)** It must be sturdy and tough because it is a consumer item.

**(9)** The error of the sensors is the discrepancy between both the actual worth of the detecting and the value of the detected by the sensor.

**(10)** The lowest abrupt approach in the measure that may be detected in an output signal is referred to as resolution.

**(11)** The noise of the sensor is what happens when we don't change the measure but there are some oscillations in the output. Numerous causes can contribute to noise, including temperature, electromagnetic radiation, and vibrations.

**(12)** The sensor's stability is essential. A sensor's reliability is defined as its capacity to generate the same correct output for the same inputs over a period of time.

**(13)** The Response Time: It is the amount of time, takes for a sensor to reach a steady value. In reaction to a stepped increase in the input, it is usually stated as the time when the output reaches a particular percentage (for example, 95%) of its final value. In a similar approach, the recovery time is defined, but in the opposite direction.

**(14)** Hysteresis it's the variation output values for the same measure, where one is approached while rising from the lower limit and the other is addressed with lowering from the maximum value. In table 3 different types of parameters show for MOS sensors.

**Table 3. MOS Sensor performance for different parameters [46].**

| Sr. no | Parameters | MOS |
|---|---|---|
| 1 | Sensitivity | Excellent |
| 2 | Selectivity | Moderate |
| 3 | Stability | Good |
| 4 | Recovery Time | Fast |
| 5 | Accuracy | Good |
| 6 | Maintenance | Excellent |
| 7 | Cost | Low |
| 8 | Response Time | Fast |
| 9 | Suitability to portable instruments | Excellent |

## 2. SENSORS AND THEIR ADVANTAGE AND DISADVANTAGE

There are many types of sensors which are used to define the type of sensing and their application, advantage and limitations are given in table 4.

**Table 4. Type of sensors with their advantage, limitations and applications**

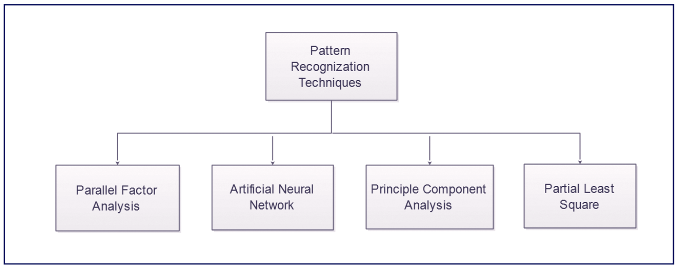
| Material | Advantages | Limiting Factors | Applications |
|---|---|---|---|
| | (1) Low in cost. | (1) Poor discrimination & accuracy | |
| | (2) Size is small. | (2) Operating temperature is high | |
| Oxide Semiconductor | (3) Short response time. | (3) Humidity and toxicity have an impact. | Almost all areas |
| [25–27] | (4) Life is long-lasting. | (4) Non- linearity in a hot environment. | |
| | (5) Is not complex in circuit. | (5) Energy consumption is high | |
| | (1) Sensitivity is strong. | (1) High response as well as recovery time. | (1) Biological sensor |
| Conductive Polymer | (2) General operating temperature | (2) Low selectivity | (2) Detection of illness |

| | | | |
|---|---|---|---|
| Composites | (3) Bio-molecular collaborations that are strong | (3) High in cost | (3) Used in batteries |
| [28–29] | (4) Various preparation processes | (4) Easy affected by humidity | (4) In fuel cells |
| | (1) High sensitivity | (1) Most expensive | (1) In biomedical imaging |
| | (2) Adsorption capability is high. | (2) Manufacturing is Complex | (2) Cancer therapy |
| C (carbon) Nano-materials | (3) Sturdiness and lightness | (3) Non-uniform standard | (3) Used in field of military |
| [30–33] | (4) Stable as well as suited for blending with other substances | (4) Difficult in structure | |
| | | | |
| | (5) Rapid absorption capability | | |
| Acoustic Wave Sensor | (1) Heightened sensitivity as well as speedy reaction | (1) Effected by temperature and moisture | (1) E-nose |
| [34–37] | (2) Little power usage | (2) Complex coating process | (2) Environmental surveillance |
| | (3) Almost all gases are acceptable | (3) S/N performance is poor | (3) Testing for food safety |
| | (4) Enduring stability | | |
| | (1) Sensitivity of humidity is low | (1) Poisoning by catalyst | (1) Identification of combustible gases |
| Catalytic Sensor | (2) Price is low | (2) Lower sensitivity | (2) Discovery of drunken driving |
| [38–39] | (3) Trustworthy reproduction | (3) Selectivity is low | |

## 3. PATTERN RECOGNITION USING GAS SENSING ELEMENT

Pattern recognition is a basic artificial intelligence technique that has been extensively employed in a variety of research & tech sectors, including information identification, feature analysis, data processing, and automatic control, among others. In order to infer unidentifiable gas based on its qualities, data sampling verification, analytical processing, extraction of features, as well as categorization decision are employed [40]. Smart gas sensing uses gas sensor arrays to create multidimensional data that improves recognition accuracy. There are a variety of pattern recognition approaches for detecting gases, some of which are listed below.

**Figure 3. Pattern Recognition Techniques**




### 3. 1 Parallel Factor Analysis (PARAFAC)

Using PARAFAC, you can obtain the previous component of odour. There might be no turn problem in parallel factor analysis, and pure spectra can be managed to recover from multi-way ghostly records. Parallel Factor Analysis is a principal component analysis theory for more rapidly organising shows, but some of system's features are really quite distinct from traditional containing. Parallel Factor Analysis is a framework for separating multi-dimensional groups with the goal of focusing on the characteristics of recreational activity and providing a detailed summary of the results. We used PARAFAC to investigate spatio-transient models of intentional connectivity across neurons based on spike trains recorded in the cat's primary visual cortex. Throughout those accounts, we reversibly deactivated information relationships from upper visual regions within the PMS (back centre suprasylvian) cortex to examine the influence of those best down pointers. For every feasible match of the 16 terminals inside the cathode display, cross relationship was enlisted. The Delayed Consequences of Time, Lift, And Deactivation Situation On Relationship Structures were then shown using PARAFAC. PARAFAC can continuously expel variations in relationship essentialness for distinct preliminary situations and exhibit the suitable limitations, according to our findings. As a result, PARAFAC proves to be quite useful in the context of electrophysiological (improvement potential) accounts [41].

#### 3.1.1 Advantage of Parallel Factor Analysis

The purpose of identifying groupings of interconnected variables is to determine their relationship to one another. Factor analysis may be utilised to find hidden components or dimensions which aren't apparent from a simple study. It is possible to employ both objective and subjective qualities. Combining two or more variables into a single component reduces the number of variables. When it comes to naming with dimensions, you have a lot of options. It's not difficult to accomplish, it's inexpensive, and it's precise.

#### 3.1.2 Disadvantage of Parallel Factor Analysis

It can be difficult to name the causes because numerous traits can be highly connected for no obvious reason. The researcher uses factor analysis to investigate the co-variation among a group of observed variables in order to learn more about their underlying latent structures.

### 3.2 Artificial Neural Network (ANN)

ANN is a fantastic classifier that provides great results in a wide range of applications, including design recognition, discourse recognition, and character recognition. In sensing the gases in the surrounding environment, ANN utilised to resemble a mammalian nose. To increase the nonlinear features and for precise gas acknowledgment under raucous conditions is a range of sensors, including as temperature and gas sensors based on SnO2 film are used. The use of ANN in conjunction with a range of sensors for gas separation is a promising method that yields precise results. The sensor's yield is presented to ANN as an example of information. Fake neuron is a type of ANN that is made up of extremely coupled handling components. The MAC unit can be used to create a fake neuron. It is structured to perform MAC unit radix-4 corner multiplier and convey spare viper. A key parameter termed enactment work is necessary to burn the neuron. Stage work, personality work, unipolar sigmoid capacity, bipolar sigmoid capacity, hyperbolic digression work, symmetrical hard breaking point enactment work, immersed direct actuation work, calculated capacity, and so on are all examples of initiation capacity. When compared to other capacities, hyperbolic digression work produces exact results. This approach is used to the creation of fake neurons [42].

#### 3.2.1 Advantages of ANN

1. ANN issues are defined using attribute-value sets.
2. The goal value could be discrete-valued, real-valued, or a vector of several real or discrete-valued attributes, whereas output of artificial neural networks can be discrete as well as real-valued.
3. ANN learning algorithms do not have an issue with training sample distortions. Even if training samples include errors, the outcome will not be affected.
4. When a rapid evaluation of taught target value is required, it is used.
5. Long training times for artificial neural networks may be caused by the amount of weights in network, the amount of training examples taken into account, as well as configuration of various learning algorithm variables.

#### 3.2.2 Disadvantages of ANN

1. Hardware Dependence:
- Parallel computing power is required for the creation of ANN.
- Equipment's manifestation is therefore dependent on this.

2. Unexplained functioning of the network:
- This is most significant issue of artificial neural networks.
- When ANN offers a probing outcome, it does not disclose why or how.
- This damages the network's credibility.

3. Guarantee of appropriate network architecture:
- Artificial Neural Networks design isn't governed by any certain rules.
- The perfect network design is developed by experience and trial as well as error.

4. Challenge of getting the network's attention on issues:
- ANNs can handle handling numerical data.
- It is necessary to convert an issue into numerical values before applying artificial neural networks to it.
- Effectiveness of the network will directly depend on projection strategy adopted.
- The capacity of user will determine this.

5. Unknown is how long the network will last:
- The training is complete when network's sample error is decreased to a certain level.
- We don't actually get finest outcomes from the value.

### 3.3 Principal Component Analysis

In order to decrease the dimensionality of huge data sets, a technique known as Principal Component analysis (PCA) is frequently utilised. PCA works by condensing a large collection of data into smaller group that still retains majority of the data in larger set. Reliability inevitably suffers as an information set's variables are reduced, but the answer to dimensionality reduction is to compromise a small accuracy for easiness. Since machine learning algorithms can analyse data much more quickly as well as easily with smaller data sets since there are less unnecessary factors to evaluate. In conclusion, the PCA method decreases number of variables in a data collection while maintaining as much information as possible. A set of p unit vectors, i-th of which is direction of a line that best matches data and still being orthogonal to the first i-1 vectors, make up the main elements of a gathering of dots in a realistic coordinate system. A line that reduces average squared distance between points and line is said to be best fit. Such directions make up an orthonormal basis, wherein there is no linear correlation between the various component dimensions of data. The method of computing principle components and utilising them to conduct a change of basis on the data is known as principal component analysis (PCA). Occasionally, the top few principal components are used while remainder are ignored [43]. Principal Component Analysis is used to create prediction models as well as for exploratory data analysis. It is frequently utilized to acquire lower-dimensional data yet retaining most of the data's variance by projected every data point onto only the first few main components. P ath that maximises variance of projected data may also be used to identify the first main component. The path orthogonal to the first i-1 principal components, which maximise variance of projected data, is i-th principle component.

### 3.3.1 Advantages of Principal Component Analysis

**1. Removes Correlated Features:** In real world, having a dataset with thousands of characteristics is rather common. Your method can't be performed on every feature since doing so would slow it down as well as make it challenging to observe all features in a given graph. As a result, number of features in your dataset MUST be decreased. You must establish the connection between traits (correlated variables). The process of manually identifying associations among thousands of characteristics is essentially time-consuming, annoying, and difficult. PCA does this for you. After doing principal component analysis on your dataset, each Principal Components are unrelated to one another. They are unrelated to one another.

**2. Improves Algorithm Performance:** Your method's functionality will suffer substantially with so many features. By eliminating linked variables which don't aid in decision-making, Principal Component analysis is a common technique for accelerating your machine learning algorithm. The learning time of methodologies is significantly shortened with limited functionality. As a result, using Principal Component Analysis to speed up approach is an alternative if the input dimensions are quite big.

**3. Reduces Overfitting:** A dataset overfits when there are too many variables in it. On a result, with reducing the number of features, PCA helps to address overfitting problem.

**4. Enhances Visualization:** High-dimensional data is challenging to visualise as well as understand. PCA transforms a higher-dimensional dataset into a lower-dimensional dataset with only two dimensions, allowing for simple visualisation.

### 3.3.2 Disadvantages of Principal Component Analysis

**1. Independent variables become less interpretable:** After applying PCA to database, your basic features will change into Principal Components. PCs (Principal components) are your unique qualities combined in a linear fashion. Principal Components are less readable as well as easy to interpret than unique features.

**2. Data quality is necessary before implementing Principal Component Analysis:** Principal Component analysis (PCA) will not be able to identify best Principal Components without data standardisation.

For instance, training set's variance scale is quite large if a feature set comprises data that is measured in kilogrammes, light years, or millions. Loadings on features with considerable variation will also be large if PCA is applied to this feature set. Significant components will therefore be biassed toward traits with significant instability, leading to incorrect conclusions.

Additionally, all category data must be converted into nominal attributes for standardisation before Principal Component analysis can be applied.

**3. Information Loss:** Principal Components (PCs) make an effort to account for as most variation among features in a data as feasible, but if quantity of PCs is not properly selected, this could miss certain data whenever compared to original collection of features.

### 3.4 Partial Least Square Method

Relating to principal component regression, Partial Least Square (PLS regression) sees a regression model by attempting to design predicted elements but also visible factors to a new space rather than searching for hyperplanes of maximum variance between response as well as independent variables. Due to fact that both X and Y variables are projections to new regions, the PLS family of methodologies is sometimes referred to as bilinear modelling. PLS-DA or partial least - square discriminator assessment, is used when Y is categorical [44]. Discovering the underlying connections between two matrices is done using partial least square, a latent variable method for modelling covariance patterns in two spaces (X and Y). The multi-dimensional directions in X space which best describes multidimensional variance in Y space will be sought after by a PLS models. Partial least square regression is an excellent option if there is multi-colinearity among X values as well as the predictor's matrix contains significantly more variables than data. Standard regression, however, will not work under these circumstances (unless it is regularized).

### 3.4.1 Advantage of Partial Least Square Method

Partial Least Squares (PLS) has many pluses over regression when it comes to structure-activity similarity, such as the ability to handle more descriptor variables than compounds, non-orthogonal descriptors, and numerous biological results whereas providing more prediction performance and a lower risk of chance connection.

### 3.4.2 Disadvantage of Partial Least Square Method

The main drawbacks include an increased chance of missing 'real' correlations and sensitivity to descriptor variable relative scaling.

### 3.5 Cross Validation

Any of numerous similar model validation techniques, including cross-validation, can be used to test the generalizability of a statistical study's findings to a different set of data. Out-of-sample testing or rotations estimation are other names for it. Cross-validation is a resampling method that uses multiple data subsets to assess as well as train a model along a number of cycles. It is frequently used in cases when goal is predicting and one wants to determine how successfully a predictive algorithm would perform in actual circumstances. In a prediction problem, a model is often provided a dataset of known data for training (training dataset) and a dataset of unknown data (or first seen data) for testing (called validation dataset or testing set). Cross-validation checks model's tendency to estimate new data which was not utilized in its estimate in order to give insight into how algorithm will generalization to an isolated dataset and to uncover problems like overfitting or selection bias (that is an unknown dataset, for instance from a real problem) [47]. Table 5 includes summary of Pattern recognition techniques.

**Table 5. Summary of Pattern recognition techniques**

| Author | Detection principles | Pattern recognition techniques | Gas detection/ Material used | Remark |
|---|---|---|---|---|
| Shri om et al, 2018. [48] | Parafac and PCA | PFA | Acetone, LPG, Ethane as well as Propane and other natural gases. | To provide a sensor display system that can differentiate the most severe contaminant gases and is highly responsive, precise, and power-efficient. |
| Farel Ahadyatulakbar Aditama et al., 2018.[49] | Back propation technique | ANN | Gyrinops versteegii agarwood | Gyrinops versteegi ararwood may be distinguished by an e-nose based on reliability. |
| Md. Ashfaqul Hossain Khan et al. 2020.[50] | Machine Learning Technique (SVM, Kernel etc.) | PCA | $NO_2$, Ethanol, $SO_2$, $H_2$ | Superior SUM as well as NB On the test sample, classified systems displayed 100% classification efficiency. |
| Yunlong Sun et al. 2018.[51] | Selective Local Linear embedding(SLLE) | PCA,LDA, PCA +LDA | $CO_2$, $CH_4$, $NH_3$ & VOCs | High-dimensional commercial gas data may be responded to more effectively and accurately using SLLE. |
| Hans Sundgren et al, 1990.[52] | Linear & non-Linear PLS models | PLS | $H_2$, $NH_3$, $C_2H_4$, $C_2H_5OH$ | Presence of 3 different interfering gases, hydrogen concentrations may be estimated rather well. |

## 4. CONCLUSION

The summary of the research work is given here in which electronics nose is defined. A device called an electronics nose is made up of several sensors. Small, affordable, sturdy, as well as semiselective sensors must be employed in e-noses. For some applications, the right choice of sensors for e-noses may be beneficial. Due to their inexpensive price and compact size, MOS-based sensors are most popular since they meet these specifications. Numerous applications in quality inspection, process monitoring, ageing, contamination and spoiling, adulteration, and other areas were studied for the possible use of such sensors in different types of electronic noses. The sensor materials, advantages and limitations of currently available MOS sensors with their independence and selectivity are being reported in table 2 and table 4. The preservation of environment as well as human health, as indicated in table 1, requires the detection of numerous harmful gases. For the detection of various toxic gases many pattern recognition techniques are required like artificial neural network, parallel factor analysis that is defined in section 3. So the section 3 discusses many types of pattern recognition algorithms, which are critical for identifying harmful gases in the environment. As a result, we may conclude that an optimised electronic nose with fewer sensors can efficiently identify harmful gases.

## ACKNOWLEDGEMENT

We are thankful to the integral university for this work.

## REFERENCES

*[1] Zheng, Ziqiao, and Huali Wang. "Different elements doped graphene sensor for CO2 greenhouse gases detection: The DFT study." Chemical Physics Letters 721 33-37 (2019).*

*[2] Cho, Junghwan, Zachary Howard, and Pradeep Kurup. "Electronic nose system combined with membrane interface probe for detection of VOCs in water." In AIP Conference Proceedings, vol. 1362, no. 1, pp. 211-212. American Institute of Physics (2011).*

*[3] Bell, Ryan J., Nicholas G. Davey, Morten Martinsen, Christian Collin-Hansen, Erik T. Krogh, and Christopher G. Gill. "A field-portable membrane introduction mass spectrometer for real-time quantitation and spatial mapping of atmospheric and aqueous contaminants." Journal of the American Society for Mass Spectrometry 26, no.212-223 (2014).*

*[4] Krivetskiy, Valeriy V., Matvei D. Andreev, Aleksandr O. Efitorov, and Alexander M. Gaskov. "Statistical shape analysis pre-processing of temperature modulated metal oxide gas sensor response for machine learning improved selectivity of gases detection in real atmospheric conditions." Sensors and Actuators B: Chemical 329, 129187 (2021).*

*[5] Wilson, Alphus D. "Diverse applications of electronic-nose technologies in agriculture and forestry." Sensors 13, no. 2, 2295-2348 (2013).*

*[6] Kumar, Anuj, Hiesik Kim, and Gerhard P. Hancke. "Environmental monitoring systems: A review." IEEE Sensors Journal 13, no. 4,1329-1339 (2012).*

*[7] Firtat, Bogdan, Carmen Moldovan, Costin Brasoveanu, George Muscalu, Mariuca Gartner, Maria Zaharescu, Paul Chesler et al. "Miniaturised MOX based sensors for pollutant and explosive gases detection." Sensors and Actuators B: Chemical 249, 647-655 (2017).*

*[8] Sbci, U. N. E. P. "Buildings and climate change: Summary for decision-makers." United Nations Environmental Programme, Sustainable Buildings and Climate Initiative, Paris ,1-62 (2009).*

*[9] Acevedo, Cristhian Manuel Durán, Pablo Andrés Goméz Monsalve, and Rafael Andrés Acosta Rozo. "Wireless Smell System for Hazardous Gases Detection." ( 2018).*

*[10] Ievlev, V. M., S. V. Ryabtsev, A. M. Samoylov, A. V. Shaposhnik, S. B. Kuschev, and A. A. Sinelnikov. "Thin and ultrathin films of palladium oxide for oxidizing gases detection." Sensors and Actuators B: Chemical 255, 1335-1342 (2018).*

*[11] Di Rosa, Ambra Rita, Francesco Leone, Federica Cheli, and Vincenzo Chiofalo. "Fusion of electronic nose, electronic tongue and computer vision for animal source food authentication and quality assessment–A review." Journal of Food Engineering 210, 62-75 (2017).*

*[12] Buratti, S., D. Ballabio, G. Giovanelli, CM Zuluanga Dominguez, A. Moles, S. Benedetti, and N. Sinelli. "Monitoring of alcoholic fermentation using near infrared and mid infrared spectroscopies combined with electronic nose and electronic tongue." Analytica chimica acta 697, no. 1-2, 67-74 (2011).*

*[13] Muntner, Paul, Daichi Shimbo, Robert M. Carey, Jeanne B. Charleston, Trudy Gaillard, Sanjay Misra, Martin G. Myers et al. "Measurement of blood pressure in humans: a scientific statement from the American Heart Association." Hypertension 73, no. 5,e35-e66 (2019).*

*[14] Kwon, Oh Seok, Hyun Seok Song, Seon Joo Park, Seung Hwan Lee, Ji Hyun An, Jin Wook Park, Heehong Yang et al. "An ultrasensitive, selective, multiplexed superbioelectronic nose that mimics the human sense of smell." Nano letters 15, no. 10 , 6559-6567 (2015).*

*[15] Schindler, Konrad, Wolfgang Förstner, and Nicolas Paparoditis. "2011 IEEE International Conference on Computer Vision workshops (ICCV workshops 2011): Barcelona, Spain, 6-13 November 2011." In CVRS 2011: IEEE/ISPRS workshop on Computer Vision for Remote Sensing of the Environment. IEEE (2011).*

*[16] Padvi, M. N., A. V. Moholkar, S. R. Prasad, and N. R. Prasad. "A critical review on design and development of gas sensing materials." Engineered Science 15, 20-37 (2021).*

*[17] Kovacs, Zoltan, Dániel Szöllősi, John-Lewis Zinia Zaukuu, Zsanett Bodor, Flóra Vitális, Balkis Aouadi, Viktória Zsom-Muha, and Zoltan Gillay. "Factors influencing the long-term stability of electronic tongue and application of improved drift correction methods." Biosensors 10, no. 7,74 (2020).*

*[18] Iwasaki, Akiko, and Padmini S. Pillai. "Innate immunity to influenza virus infection." Nature Reviews Immunology 14, no. 5, 315-328, 2014.*

*[19] Broughton, Edward. "The Bhopal disaster and its aftermath: a review." Environmental Health 4, no. 1,1-6 (2005).*

*[20] Torsi, L., A. Dodabalapur, L. Sabbatini, and P. G. Zambonin. "Multi-parameter gas sensors based on organic thin-film-transistors." Sensors and Actuators B: Chemical 67, no. 3, 312-316 (2000).*

*[21] Chen, Wenhua, Pengju Liu, Yuan Liu, Qi Wang, and Wenfeng Duan. "A temperature-induced conductive coating via layer-by-layer assembly of functionalized graphene oxide and carbon nanotubes for a flexible, adjustable response time flame sensor." Chemical Engineering Journal 353, 115-125 (2018).*

*[22] Li, Jin, Hao Yan, Hongtao Dang, and Fanli Meng. "Structure design and application of hollow core microstructured optical fiber gas sensor: A review." Optics & Laser Technology 135,106658 (2021).*

*[23] Sabri, Naseer, S. A. Aljunid, M. S. Salim, R. Badlishah Ahmad, and Rosliha Kamaruddin. "Toward optical sensors: Review and applications." In Journal of Physics: Conference Series, vol. 423, no. 1, p. 012064. IOP Publishing (2013).*

*[24] Munyemana, Jean Claude, Jia Chen, Yangxia Han, Shusheng Zhang, and Hongdeng Qiu. "A review on optical sensors based on layered double hydroxides nanoplatforms." Microchimica Acta 188, no.3,1-19 (2021).*

*[25] Lu, Shaohe, Xuefeng Hu, Hua Zheng, Junwen Qiu, Renbing Tian, Wenjing Quan, Xinjie Min et al. "Highly selective, ppb-level xylene gas detection by Sn2+-doped NiO flower-like microspheres prepared by a one-step hydrothermal method." Sensors 19, no. 13, 2958 (2019).*

*[26] Li, Zhijie, Hao Li, Zhonglin Wu, Mingkui Wang, Jingting Luo, Hamdi Torun, PingAn Hu et al. "Advances in designs and mechanisms of semiconducting metal oxide nanostructures for high-precision gas sensors operated at room temperature." Materials Horizons 6, no. 3, 470-506 (2019).*

*[27] Mandal, Biswajit, Ritesh Bhardwaj, Sayan Maiti, Daya Shankar Sharma, Apurba K. Das, and Shaibal Mukherjee. "Functionalized Oligo ($ p $-Phenylenevinylene) and ZnO-Based Nanohybrid for Selective Ammonia Sensing at Room Temperature." IEEE Sensors Journal 19, no. 8, 2847-2854 (2018).*

*[28] Liu, Hu, Yilong Li, Kun Dai, Guoqiang Zheng, Chuntai Liu, Changyu Shen, Xingru Yan, Jiang Guo, and Zhanhu*

*Guo. "Electrically conductive thermoplastic elastomer nanocomposites at ultralow graphene loading levels for strain sensor applications." Journal of Materials Chemistry C 4, no. 1,157-166 (2016).*

*[29] Abel, Silvestre Bongiovanni, Robert Olejnik, Claudia R. Rivarola, Petr Slobodian, Petr Saha, Diego F. Acevedo, and Cesar A. Barbero. "Resistive sensors for organic vapors based on nanostructured and chemically modified polyanilines." IEEE Sensors Journal 18, no. 16, 6510-6516 (2018).*

*[30] Selvakumar, D., H. Sivaram, A. Alsalme, A. Alghamdi, and R. Jayavel. "Freestanding flexible, pure and composite form of reduced graphene oxide paper for ammonia vapor sensing." Scientific reports 9, no. 1,1-8 (2019).*

*[31] Sakthivel, Bhuvaneshwari, and Gopalakrishnan Nammalvar. "Selective ammonia sensor based on copper oxide/reduced graphene oxide nanocomposite." Journal of Alloys and Compounds 788, 422-428 (2019).*

*[32] Luo, Rubai, Qiqi Li, Bin Du, Shisheng Zhou, and Yuheng Chen. "Preparation and characterization of solid electrolyte doped with carbon nanotubes and its preliminary application in NO2 gas sensors." Frontiers in Materials 6, 113 (2019).*

*[33] Casanova-Cháfer, Juan, Èric Navarrete, and Eduard Llobet. "Gas sensing properties of carbon nanotubes decorated with iridium oxide nanoparticles." Multidisciplinary Digital Publishing Institute Proceedings 2, no. 13 ,874 (2018).*

*[34] Chen, Wei, Fanfei Deng, Min Xu, Jun Wang, Zhenbo Wei, and Yongwei Wang. "GO/Cu2O nanocomposite based QCM gas sensor for trimethylamine detection under low concentrations." Sensors and Actuators B: Chemical 273, 498-504 (2018).*

*[35] Lin, Shu, Tao Jiang, Yudong Xia, Xuemin Wang, Dawei Yan, and Weidong Wu. "The Investigation of a SAW Oxygen Gas Sensor Operated at Room Temperature, Based on Nanostructured Zn x Fe y O Films." Sensors 19, no. 13 (2019).*

*[36] Poli, Jean-Philippe, Christine Mer-Calfati, Emmanuel Scorsone, and Samuel Saada. "SAW sensor's frequency shift characterization for odor recognition and concentration estimation." IEEE Sensors Journal 17, no. 21, 7011-7018 (2017).*

*[37] Zhang, Dongzhi, Haonan Chen, Peng Li, Dongyue Wang, and Zhimin Yang. "Humidity sensing properties of metal organic framework-derived hollow ball-like TiO 2 coated QCM sensor." IEEE Sensors Journal 19, no. 8, 2909-2915 (2019).*

*[38] Rossi, Maurizio, and Davide Brunelli. "Ultra low power MOX sensor reading for natural gas wireless monitoring." IEEE Sensors Journal 14, no. 10, 3433-3441 (2014).*

*[39] Karelin, Alexey, Alexander M. Baranov, Saba Akbari, Sergey Mironov, and Elena Karpova. "Measurement algorithm for determining unknown flammable gas concentration based on temperature sensitivity of catalytic sensor." IEEE Sensors Journal 19, no. 11, 4173-4180 (2019).*

*[40] Cardellicchio, Angelo, Angela Lombardi, and Cataldo Guaragnella. "Iterative complex network approach for chemical gas sensor array characterisation." The Journal of Engineering 2019, no. 6, 4612-4616 (2019).*

*[41] Mangalgiri, Kiranmayi, Zhiwen Cheng, Sheila Cervantes, Samantha Spencer, and Haizhou Liu. "UV-based advanced oxidation of dissolved organic matter in reverse osmosis concentrate from a potable water reuse facility: A Parallel-Factor (PARAFAC) analysis approach." Water Research 204, 117585 (2021).*

*[42] Otchere, Daniel Asante, Tarek Omar Arbi Ganat, Raoof Gholami, and Syahrir Ridha. "Application of supervised machine learning paradigms in the prediction of petroleum reservoir properties: Comparative analysis of ANN and SVM models." Journal of Petroleum Science and Engineering 200, 108182 (2021).*

*[43] Feldman, Dan, Melanie Schmidt, and Christian Sohler. "Turning big data into tiny data: Constant-size coresets for k-means, PCA, and projective clustering." SIAM Journal on Computing 49, no. 3, 601-657 ( 2020).*

*[44] Richter, Nicole Franziska, Sandra Schubring, Sven Hauff, Christian M. Ringle, and Marko Sarstedt. "When predictors of outcomes are necessary: Guidelines for the combined use of PLS-SEM and NCA." Industrial management & data systems (2020).*

*[45] Dhall, Shivani, B. R. Mehta, A. K. Tyagi, and Kapil Sood. "A review on environmental gas sensors: Materials and technologies." Sensors International 2, 100116 (2021).*

*[46] Dey, Ananya. "Semiconductor metal oxide gas sensors: A review." Materials Science and Engineering: B 229, 206-217 (2018).*

*[47] Hawkins, Douglas M., Subhash C. Basak, and Denise Mills. "Assessing model fit by cross-validation." Journal of chemical information and computer sciences 43, no. 2, 579-586 (2003).*

*[48] Mishra, Shri Om, and S. Hasan Saeed. "Optimization of electronic sensors for detecting pollution due to organic gases using PARAFAC." International Journal of Electrical and Computer Engineering 9, no. 5, 3441 (2019).*

*[49] Aditama, Farel Ahadyatulakbar, Lalu Zulfikri, Laili Mardiana, Tri Mulyaningsih, Nurul Qomariyah, and Rahadi Wirawan. "Electronic nose sensor development using ANN backpropagation for Lombok Agarwood classification." Research in Agricultural Engineering 66, no. 3, 97-103 (2020).*

*[50] Khan, Md Ashfaque Hossain, Brian Thomson, Ratan Debnath, Abhishek Motayed, and Mulpuri V. Rao. "Nanowire-based sensor array for detection of cross-sensitive gases using PCA and machine learning algorithms." IEEE Sensors Journal 20, no. 11, 6020-6028 (2020).*

*[51] Sun, Yunlong, Dehan Luo, Hui Li, Chuchu Zhu, Ou Xu, and Hamid Gholam Hosseini. "Detecting and identifying industrial gases by a method based on olfactory machine at different concentrations." Journal of Electrical and Computer Engineering (2018).*

*[52] Sundgren, Hans, Ingemar Lundström, Fredrik Winquist, Ingrid Lukkari, Rolf Carlsson, and Svante Wold. "Evaluation of a multiple gas mixture with a simple MOSFET gas sensor array and pattern recognition." Sensors and Actuators B: Chemical 2, no. 2 ,115-123 (1990).*

**AUTHORS**

**Ms. Pratiksha Rai**, Department of Electronics & Communication Engineering, Integral University, Lucknow – 226 016, India
Email: pratiksha20r@gmail.com

**S. Hasan Saeed**, Department of Electronics & Communication Engineering, Integral University, Lucknow – 226 016, India
*Email:* hasansaeedcontrol@gmail.com