



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 10, October 2023

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

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[www.ijirset.com](http://www.ijirset.com)

# A Mining Industry Using Smart Helmet for Air Quality

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**ABSTRACT:** An intelligent helmet is designed to detect the harmful CO and CO<sub>2</sub> gases that elaborate in the mines. By using this helmet the miner can easily get alert about the harmful gas. This system can also alert the miner when helmet is removed while mining in the mining industry, we propose a Helmet novel artificial-intelligent-based multiple hazard gas detector (MHGD) system that is mounted on a motor vehicle-based robot which can be remotely controlled. First, we optimized the sensor array for the classification of three hazardous gases, including cigarette smoke, inflammable ethanol, and off-flavor from spoiled food, using an e-nose with a mixing chamber. The mixing chamber can prevent the impact of environmental changes. We compared the classification results of all combinations of sensors, and selected the one with the highest accuracy (98.88%) as the optimal sensor array for the MHGD. The optimal sensor array was then mounted on the MHGD to detect and classify the target gases without a mixing chamber but in a controlled environment. Finally, we tested the MHGD under these conditions, and achieved an acceptable accuracy (70.00%).

**KEYWORDS:** Helmet, electronic nose, environmental monitoring, remote sensing and control

## I. INTRODUCTION

Urban air quality nowadays is heavily aggravated by gas emissions from different sources, such as industrial manufacture, traffic activities, and household heating. The growing concern that these activities of citizens exert noticeable impacts on deteriorating the urban air quality, with often negative effects on the life and health of all city residents [1] leads to the development of systematic air quality monitoring. For example, a number of monitoring stations are built to understand the emission sources, context, and dispersion of various kinds of air pollutants. Such monitoring and source estimation activities can improve air quality, for instance by assisting the decision-maker with appropriate air pollution information and identifying proper pollution abatement solutions.

The indoor environment plays an important role in an individuals overall health. The occurrence of a new class of diseases, identified as building-related illnesses (BRI) and sick building syndromes (SBS), arising from the long-term occupancy in confined living spaces, such as office buildings or homes, and being caused by chemical contaminants, in particular volatile organic compounds (VOCs), has motivated recent interest in indoor air quality (IAQ) monitoring [1]. Studies have linked IAQ to mental health and other illnesses that are not easily noticeable in the short-term but can be major concerns in the long-term [2]. Typically, we can find thousands of indoor chemical contaminants, including by-products of combustion (Nitrogen dioxide (NO<sub>2</sub>), Sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO), etc.), cigarette smoke, particulate matter, rotten meat, mineral fibers, and a number of volatile organic compounds. In spite of the very low concentrations, some of these compounds are extremely toxic, like NO<sub>2</sub> or CO; some others, like benzene and

formaldehyde, were proved to be carcinogenic. Therefore, the monitoring of air quality is of paramount importance to ensure safe living conditions.

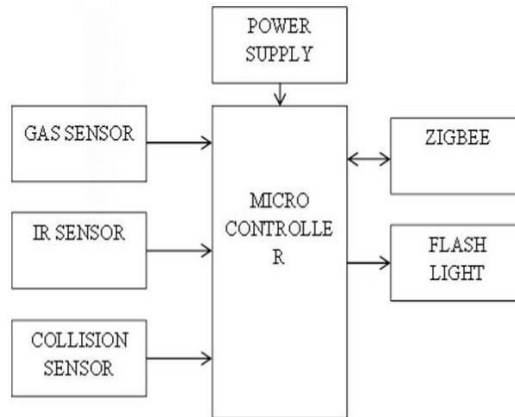


Fig 1: Block Diagram

In the last few years, the electronic nose (popularly known as the e-nose) has been widely applied to gas detection/identification in many real-world applications as a general gas detector. For example, the e-nose has been utilized in combustion processes, e.g., rocket combustion and forest fire smoke [3,4]. In environmental monitoring processes, the e-nose has been applied to analyze the principal atmospheric pollutants emitted from combustion processes, which contain carbon monoxide and dust [5]. Furthermore, the e-nose can be used for food quality assessment [6,7] by determining the amount of off-odor food in packaging materials, for medical diagnostics [8,9], as well as for monitoring the harmful gas species related to health and safety issues in the home.

The objective of this project is to develop a robot (a multiple hazard gas detector (MHGD)) using e-nose technology to help vulnerable people by detecting harmful gases more quickly and precisely.

For example, the detection of off-odor rotten meats prevents the misuse of spoiled meat which may lead to severe diarrhea, amoebiasis, and life-threatening intestinal infections in aging people. The detection of inflammable gases, such as ethanol, aims to provide an early warning system for the safety of elderly people. The MHGD notices the hazardous gas after taking samples, and then gives an early warning. This is especially important for those who suffer olfactory impairment or movement disorders and so cannot smell or find the potential fire.

Furthermore, homes with little kids, pregnant women, and patients with breathing problems also need such safety precautions. Exposure to secondhand smoke causes numerous health problems in infants and children, including more frequent and severe asthma attacks, respiratory infections, ear infections, and sudden infant death syndrome (SIDS) [10]. It has been shown that smoking during pregnancy results in more than 1000 infant deaths in the USA annually [11]. Thus, it is essential to produce a real-time detector to protect the infant and the pregnant woman from hazardous materials and gases. A hazardous gas detector can act to reassure these people, lessening their potential exposure to risks, and thus improving their quality of life.

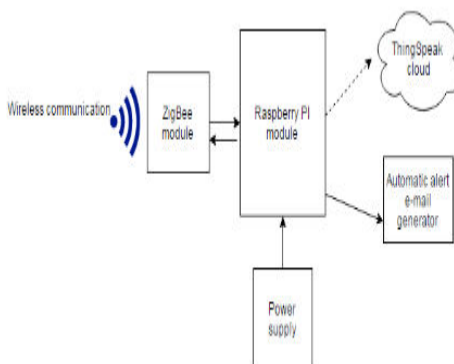


Fig 2: Work Flow

Traditionally, ceiling-fixed sensors can have a delay when the origin of the smoke is far away, even failing to detect the hazardous smoke altogether because of the low concentration of the gas. The designed MHGD can be setup to be much more sensitive and responsive in detecting the “smell” of the smoke than traditional fixed sensors. Additionally, the MHGD can provide powerful self-designed models, such as defining an alarm grading system, to only alert customers themselves without disturbing the neighbors.

However, the generated data from the e-nose may contain irrelevant information, and moreover, the principles of the new field of research can be very complex, some of them never having been studied before. Thus, machine learning as a powerful tool for advanced data processing has become a core technique for e-nose development. A complete machine-learning process consists of data preprocessing, feature extraction and dimension reduction, and system modeling [12]. The sensor signals are composed of a large number of variables, after the data pre-processing, feature extracting methods are used to transfer signals from original high-dimensional space to a low-dimensional feature space or to select “representative” (pertinent) variables to characterize the whole system. Furthermore, machine learning is utilized to establish models for classification.

In the sensor optimization, we compared three machine learning methods: support vector machine algorithms (SVMs), k-nearest neighbors algorithm (kNN), multinomial logistic regression (also known as Softmax regression). The experimental results show that the proposed MHGD system can detect the different gases quickly and classify the odors accurately. Furthermore, considering different applications, we provide three strategies for customers to choose from.

Early studies focused on using either officially fixed monitoring stations [6] or dedicated mobile sensing equipment [7] to sense air quality. But the monitoring stations are usually located at a few important sites due to the prohibitive deployment and maintenance costs. Accurate samples can be obtained in this sensing paradigm, however, limited to specific areas. As shown in Fig. 1, only one monitoring station is installed at the downside of the wind direction, and thus scarce measurements in key regions can be obtained. With advances in sensing and robotics, low-cost sensors equipped on a mobile platform, such as mobile robots or unmanned aerial vehicles (UAVs), are adopted to collect data on pre-planned routes. More importantly, mobile sensors are also able to complete source searching task [8] and aid in the emergency response, with the attempt of driving the mobile sensor to reach the emitting source. However, the wireless sensor networks (WSNs) sensing paradigm is still not enough to support the need for urban air quality monitoring and source estimation since there is an increasing interest observed in citizens for caring about the fine-grained air quality conditions around them.

## II. BACKGROUND WORK

The AI-based methods typically leverage a learning model to estimate the whole distribution of gaseous pollutants in real-time and they can forecast future distribution in the target region as well. These approaches can be generally divided into three categories: basic machine learning approaches, deep learning network, and a deep hybrid framework combining deep neural network and basic machine learning approaches. In basic machines learning approaches, artificial neural network (ANN) [6], back propagation neural network (BPNN) [7], support vector machine (SVM) [1], and random forest approach [2] are commonly used ones for inferring and forecasting air quality values. While deep recurrent neural network (RNN) [5], and deep convolutional neural network (CNN) [8] are the most frequently used models in a deep learning network. Other studies proposed the hybrid deep framework combining the aforementioned models [9] with the attempt to exploit the spatial-temporal correlations and tackle various datasets from different sources, such as meteorological data, POI data, traffic flow data and so on.

Introduced by Candès and Ta compressive sensing has been mathematically proven to be an efficient technique for reconstructing a signal. Matrix completion is the CS theory treating signals in a matrix form [17]. A premise of applying CS or MC on a signal is that sparsity or low-rank feature should exist in the signal or data matrix. Proved by [9], most of the urban sensing maps, especially the air quality map, usually observe such a low-rank feature. Therefore, scholars leverage CS techniques [9] to acquire only few observations from some subareas, and then to infer the unsensed data in other subareas. Following this way, this study [10] proposed a fresh framework (namely Sparse MCS) consisting of cell selection, quality assessment and data inference to reduce sensing costs. Then, researchers [10] extended the framework to tackle with multi-task scenarios by dynamically sensing a small set of subareas. Inspired by the concept of linear systems, Xie et al. [15] determined the sensing subareas in each upcoming cycle by following a bipartite-graph based sensing scheduling scheme and proposed a matrix completion algorithm instead of vector-based compressive sensing algorithm to recover the unsensed data accurately.

In terms of numerical simulation based methods, they need to first estimate the source terms based on the measured data, and then import the source term parameters along with related datasets (e.g. meteorological data) into the ATD models. The accuracy of the inferred data in unsampled locations mainly related to the estimation of source terms and the complexity of ATD models. Generally, over the past 50 years, the ATD model has undergone three generations of development, and they are box model based on mass conservation law [3], Gaussian dispersion model [2], and the Lagrange trajectory model [2]. Based on these theoretical models, several commercial software for simulating the dispersion process was developed, such as CALPUFF [4], AERMOD [5], CMAQ [6], ADMS [7], and so on. Similar to artificial intelligence based methods, numerical simulation based methods are not only able to infer the values in unsensed locations in that time step, but also predict the concentration distribution in future time steps.

### Methods

Arduino Uno is a micro controller board based on the ATmega328P micro controller. Arduino has 14 digital input/output pins, 6 can be used as PWM outputs, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the micro controller simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.6.5 The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform for an extensive list of current, past or outdated boards see the Arduino index of boards.



Fig 3: Iot Based Safety

Air pollution is primarily caused by the discharge of particulate matter (atmospheric pollutant) and a gas consists of methane (CH<sub>4</sub>), sulphur dioxide (SO<sub>2</sub>), and nitrogen oxides (NO<sub>2</sub>), in addition to carbon monoxide (CO). When humans are exposed to these toxic gases, it could cause negative response on their well-being. These uneven proportions of air deterioration gases and suspended particulate matter; surges respiratory disorder like asthma, cardiovascular problems, and chronic bronchitis. In this project we are using MQ7 sensor. This gas sensor composed of micro Al<sub>2</sub>O<sub>3</sub> ceramic tube and Tin Dioxide (SnO<sub>2</sub>). Electrode and heater are fixed into a crust. The heater provides required work conditions for the work of sensitive components. The conductivity of sensor is higher along with the gas concentration rising.

A GSM modem is a wireless modem that works with a GSM wireless network. It is a specialized type of modem which accepts a SIM card and operates over a subscription to a mobile operator Here we are using SIM800L GPRS chip works on frequencies 900/ 1800 MHZ. The baud rate is configurable from 9600- 115200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS, Voice as well as DATA transfer application in M2M interface. The onboard Regulated Power supply allows you to connect wide range unregulated power supply. Using this modem, you can make audio calls, SMS, Read SMS, attend the incoming calls and internet etc. through simple AT commands. it has 3G PCB antenna. To intimate to responsible authorities who are at long distance. Meanwhile GSM based wireless sensor network are investigated due to their remote environmental monitoring capabilities. By using GSM based technology we can make the system based on IOT

The Internet of Things (IOT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IOT has evolved from the convergence of wireless technologies, micro-electro mechanical systems (MEMS), micro services and the internet. The convergence has helped tear down the silo walls between operational technology (OT) and information technology (IT), allowing unstructured machine - generated data to be analyzed for insights that will drive improvements

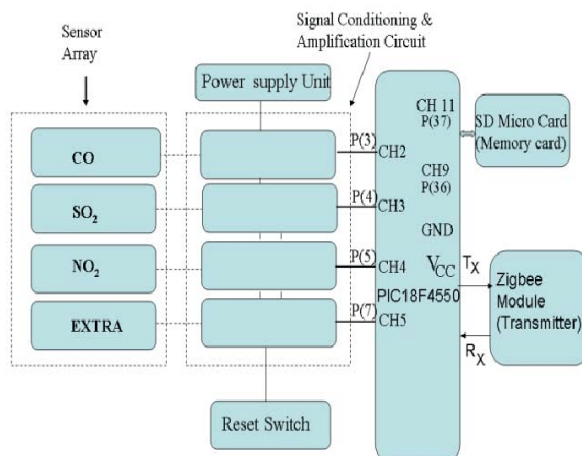


Fig 4: Quality Monitoring

Buzzer will be turned on when the sensor output crosses the threshold level detected by sensor. Here piezoelectric sensor is used. Piezo buzzer is the handy sound generator used in electronic circuits to give audio indication. It is widely used as alarm generator in electronic devices. A Piezo buzzer has a Piezo disc and an oscillator inside. When the buzzer is powered, the oscillator generates a frequency around 2-4 kHz and the Piezo element vibrates accordingly to produce the sound.

THING SPEAK is an open source Internet of Things (IOT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. Thing Speak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates. Thing speak is a cross platform application written in Ruby language. Thing Speak has integrated support from the numerical computing software MATLAB from Math Works, allowing Thing Speak users to analyze and visualize uploaded data using Mat lab without requiring the purchase of a Mat lab license from Math works. Thing Speak has a close relationship with Math works, Inc. In fact, all of the Thing Speak documentation is incorporated into the Math works' Mat lab documentation site and even enabling registered Math works user accounts as valid login credentials on the Thing Speak website. The terms of service and privacy policy of Thing Speak com are between the agreeing user and Math works

### III. RESULT AND DISCUSSION

Safety helmet removal test is done by using infrared sensor. When helmet is removing then helmet removal event is detected and displayed in LCD as “HELMET REMOVED” and it has been indicated through alerting unit [buzzer]. This test given satisfactory and 100% result is obtained as shown in Air quality sensor test is done by using MQ6 and MQ7 measures a wide range of gases like LPG, CO and CO2. This sensors detect critical levels of dangerous poisonous gases which are hazardous for human health in the mining industry and it has been indicated through alerting unit and the data is displayed in LCD as shown in the fig.5 and fig 6. The data is transmitted to monitoring section by using gprs with IOT technology.

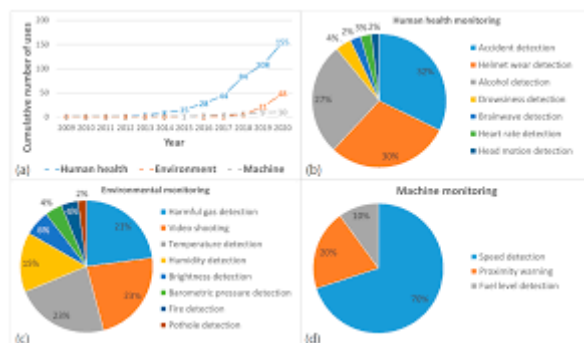


Fig 5: Result Analysis

#### IV. CONCLUSION

Effectively monitoring urban air quality, and analyzing the source terms of the main atmospheric pollutants is important for public authorities to take air quality management actions. Previous works, such as long-term observations by monitoring stations, cannot provide customized data services and in-time emergency response under urgent situations (gas leakage incidents). Therefore, we first review the up-to-date approaches (often machine learning and optimization methods) with respect to urban air quality monitoring and hazardous gas source analysis. To bridge the gap between present solutions and practical requirements, we design a conceptual framework, namely MAsmed (Multi-Agents for sensing, monitoring, estimating and determining), to provide fine-grained concentration maps, customized data services, and on-demand emergency management. In this framework, we leverage the hybrid design of wireless sensor networks (WSNs) and mobile crowdsensing (MCS) to sense urban air quality and relevant data (e.g. traffic data, meteorological data, etc.); Using the sensed data, we can create a fine-grained air quality map for the authorities and relevant stakeholders, and provide on-demand source term estimation and source searching methods to estimate, seek, and determine the sources, thereby aiding decision-makers in emergency response (e.g. for evacuation). In this paper, we also identify several potential opportunities for future research.

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