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# HOLES PROBLEM IN WIRELESS UNDERGROUND SENSOR NETWORKS

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Abstract
With wireless underground sensor networks (wusns) designed to identify gases, the "hole problem" is still a significant obstacle. owing to anomalies in sensor placement or signal transmission below ground, these networks, intended to recognise identify and evaluate gases in underground settings, are inherently limited in their coverage. One major challenge impeding the efficiency and dependability of gas identification in these networks is locating and filling in these "holes," or absences of coverage. Effective management of the creation of data collection tools is also necessary for these networks' adaptive data aggregation systems, cloud processing and employing hole-mending optimisation algorithms to mitigate coverage gaps. Even in the face of coverage gaps, these processes seek to combine and integrate sensor data intelligently, leading to more precise and prompt gas identification and how to solve the "holes problem" in wireless underground sensor networks.

Keywords: Holes problem, coverage, wireless underground sensor networks, hole-mending Optimisation algorithm.

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## I. Introduction

Uneven sensor node distribution, which results in coverage gaps or places with inadequate monitoring, is the primary concern linked to the hole problem. Uneven ground, barriers, scarce energy supplies, and communication limitations in the subterranean setting are some of the causes of this issue.
One cannot emphasise how critical it is to solve the hole issue because it has an immediate influence on the sensor network's efficacy and reliability. Applications such as precision agriculture and disaster response may suffer greatly from lost data, erroneous measurements, and impaired network performance due to inadequate coverage. The identification and tracking of subsurface gases aim to achieve these networks, which have a wide range of applications, including environmental monitoring, mining safety, and integrity assessment. The hole problem can be solved by strategically placing sensor nodes to provide consistent coverage while taking energy-related limits, impediments, and topographical fluctuations into account. Advanced methods and approaches are needed for this optimisation process because it can be resource-intensive and complex. The deployment of sensor nodes uneven can result in uneven energy consumption since nodes in areas with extensive coverage may use up their energy more quickly than those in places with poor coverage. Extending the lifetime of individual nodes and the network as a whole depends on balancing energy consumption throughout the network. Over time, coverage gaps can be reduced with the use of adaptive deployment techniques like mobile or dynamic node placement. According to shifting network requirements or environmental conditions, these solutions entail moving or reallocating sensor nodes. Sensitivity to coverage gaps and node failures can be improved by incorporating redundancy into the sensor network design. In the event of errors or disruptions, redundant communication routes or nodes can guarantee ongoing monitoring and backup coverage.

## II. Literature Review

The state of technology is evolving daily in this digital and contemporary world. Owing to the tremendous growth of technology, Industry 4.0 relies heavily on IoT and WSN to create autonomous smart industries, networked data centres, and smart applications. With the aid of modern, intelligent equipment, data networks are being improved and upgraded. This comprehensive evaluation of the literature included an analysis of the threats to WSN and IoT networks in addition to a descriptive comparison study. Attackers can primarily exploit these networks as attack surfaces to mine system and user data for valuable patterns [1].

Solving problems such as exploiting hyperspectral pictures' temporal properties, accurately classifying ensembles, and evaluating changes in vegetation stress caused by gas micro- leakage are necessary to find subsurface gas leaks. To detect natural gas micro-leakage stress in vegetation, this work suggest a model that uses multi-temporal hyperspectral imaging and ensemble classification techniques to incorporate spectral, spatial, and temporal features [2].

To remedy the situation of 3D indoor deployment in WSN, the authors of this study suggested AcNSGA- III, a hybrid algorithm based on NSGA-III and ACO [3].

To demonstrate the new algorithm's efficacy, five goals are taken into account, and the hypervolume measure is applied to evaluate the performance of the previously described algorithms through simulations and experimental testing. The recommended algorithm performs superiorly to the conventional NSGA-III and ACO. The Wireless Underground Sensor Network (WUSN) concept is introduced in this paper. In agricultural applications, WUSNs are able to be employed to monitor soil qualities and, in environmental monitoring, they are able to monitor harmful substances [4].
The sophisticated channel models presented in this review were created to describe the subterranean wireless while considering the channel properties of electromagnetic wave propagation in soil and their relationship to wave frequency, soil composition, and soil moisture [5].

The authors have demonstrated their competitiveness across a range of domains and are replacing conventional algorithms. We have presented in this study an intelligent optimisation technique for patching network holes and selecting optimal patching spots to minimise the total number of holes in the network, based on the TSA (Tree Seed technique) [6].

This study examines how autonomous cars are used in industrial settings and how the SC ecosystem and IoT environment are affected by them [7].
This paper proposes a distributed protocol for knowledge range adjustment (PRADA) based on probes is presented, enabling each node to effectively choose its topological knowledge range online. It is demonstrated that PRADA converges quickly to a close ideal solution [8].

In this paper an emphasis on rangelands and pastures, this review provides an overview of the latest remote sensing technologies available for vegetation monitoring at CCS sites and regions. These technologies include medium-to- high-resolution satellite, aerial (both manned and unmanned aircraft) and in situ sensors and methodologies [9].

A field study on the stress caused by natural gas leaks on vegetation was conducted. After the acquisition of hyperspectral pictures of grasslands, cornfields and bean crops, a novel spectral-spatial-based methodology for identifying areas of vegetation stress and natural gas leaks was proposed [10].

In this paper the agent uses three factors to determine how two traffic filters should operate: the amount of normal traffic, the nature of traffic attacks, and the IP address history log. Using CIDDS as a standard dataset, we test and assess the APFA model through a simulation system. The model finds 303,024 request conditions for the tested 135,583 IP addresses and adjusts to the changes in the simulated attack scenarios with success [11].
This paper proposes the success of traditional WUSN connectivity is greatly influenced by subsurface

soils. With its benefits in long-range capability and ultra-low power consumption, Long Range (LoRa), a pioneering low-power wide-area networks (LPWANs) technology, offers a novel approach for subterranean industrial monitoring [12].
This paper proposes in contrast to the previous accumulation, the newly optimised accumulation can improve the flexibility of its ability to uncover time-series development patterns. The newly designed model introduces a combined fractional accumulated generation operator by incorporating both traditional and conformable fractional accumulation [13].

## III. Methodology
By ensuring that sensor data from all regions is captured, the hole problem can be solved, and data collection and transmission reliability can be improved. This is important for a variety of applications, including agriculture and environmental monitoring. More precise detection and reaction are possible when there is extensive sensor coverage, since it reduces the possibility of overlooking important occurrences or anomalies in the subterranean environment. For the purpose of capturing the coverage distance of malfunctioning sensor nodes, the gas sensors are maintained at a distance of Rc/2. Rc-Radius of a node of coverage.

### 3.1 Underground Harmful Gases
Various natural or human activities might cause harmful gases to be discharged from underground. Several typical varieties consist of:

1. Methane ($CH_4$)

Additionally, known as a natural gas, methane can cause asphyxiation in small areas due to its flammability and ability to displace oxygen.

2. Carbon Monoxide (CO)

The incomplete combustion of fuels containing carbon may lead to the emission of carbon monoxide (CO), an odourless and colourless gas that is extremely hazardous.

3. Hydrogen Sulphide ($H_2S$)

The gas hydrogen sulphide ($H_2S$) has a rotten egg- like smell that can irritate respiratory systems.

4. Volatile Organic Compound (VOC)

Volatile organic compounds, or VOCs, are a class of gases produced by particular industrial operations, the burning of specific organic materials, and the creation of formaldehyde and toluene. These compounds can cause air contamination as well as health issues.

5. Sulphur Dioxide ($SO_2$)

It is a contributing factor to air contamination as well as respiratory problems and is released during volcanic eruptions or industrial activities involving the burning of fuels containing sulphur.

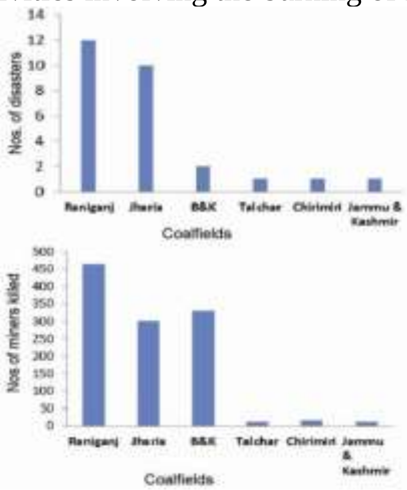

Figure. 1 Number of death rates in coal fields of mines

IV. Block Diagram

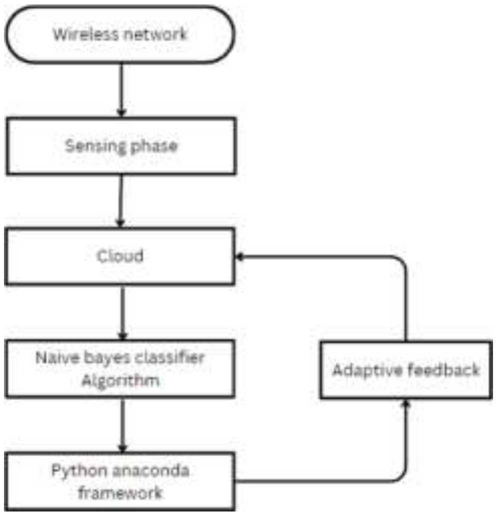


Figure. 2 Flow chart


Figure. 3 Block diagram

V. Hardware Required

5.1. Sensors

1.MQ2 Sensor

This kind of gas sensor, which is capable of identifying a range of gases like methane, butane, propane, alcohol, smoke, etc., as displayed in the block diagram (Fig. 3), extensively used in air quality monitoring systems, gas leak detectors, and industrial safety.

2. MQ4 Sensor

Made specifically to identify methane and natural gas, the MQ-4 sensor is a type of gas sensor. Due to its sensitivity to methane, propane, and other gases in this class, it is commonly employed in gas leak detection systems. Similar to other MQ series sensors, the MQ- 4 detects changes in conductivity to determine the concentration of gas in the surrounding air and outputs an analogue signal.

3. MQ6 Sensor

The MQ-6 sensor is mostly used for the detection of propane, isobutane, and LPG (liquefied petroleum gas) extensively used in industrial and residential gas leak detection systems that employ these gases.

4. MQ9 Sensor

This gas sensor measures carbon monoxide (CO) and combustible gases like LPG and methane ($CH_4$). In applications like industrial and home safety systems, they are utilised to monitor and detect these gases.

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5. MQ135 Sensor

The MQ135 gas sensor has the capacity for identifying a wide range of gases, including smoke, benzene, ammonia, nitrogen oxides, and other hazardous gases. Air quality monitoring systems, indoor air quality detectors, and environmental monitors frequently employ this.

5.2. Microcontroller

1. Overview

The 40 nm ultra-low-power TSMC technology was employed in the design of the ESP32 single-chip 2.4 GHz Wi-Fi module. The product is engineered to achieve optimal power efficiency, radiofrequency performance, durability, adaptability, use, and dependability across various power profiles and applications.

2. Featured Solutions

The Internet of Things (IoT) and mobile applications are the focus of the ESP32's design. It contains some of the most sophisticated low-power semiconductor capabilities, such as dynamic power scaling, performance modes, and high-precision clock gating.

5.3. LCD

One kind of flat-panel display called an LCD (Liquid Crystal Display) primarily makes use of liquid crystals. Starting with the word itself, LCD has a definition. It is a blend of the liquid and solid phases of matter. A viewable image is produced by the LCD using liquid crystals.

VI. Software Required

6.1 IOT (Blynk platform)

Blynk provides an intuitive platform that makes creating Internet of Things initiatives, like using several sensors to monitor gas levels, simpler.

Gas sensors are usually configured in relation to the selected microcontroller during the procedure. The microcontroller receives the information gathered by these sensors, which measure the gas concentrations in the surrounding air. Blynk's user- friendly interface enables users to establish a special project within the application, customising a dashboard according to their needs. A smooth connection between the gas meters as well as the Blynk app is created by creating and integrating Blynk capabilities into the microcontroller's code. This coding allows real-time monitoring and visualisation by enabling the continuous transmission of gas level sensor data that is sent to the platform.

VII. Experimental Result

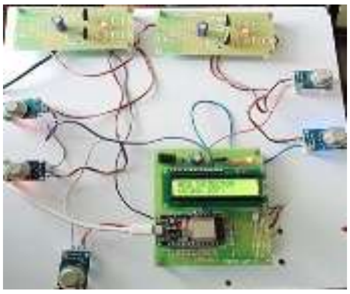

Figure. 4 Hardware output

In the early detection stage, sensors are essential for identifying dangerous gases such as sulphur dioxide, carbon monoxide, and methane. The presence of potentially hazardous materials is indicated by an LED that blinks when these gases are identified by the system (Fig. 4). At the same time, the microcontroller starts gathering sensor data. As the central processing unit, this microcontroller arranges for the data to be collected, analysed, and coordinated.

VIII. Conclusion

To increase the concentrations of dangerous gases by sensing and to continually monitor the gas concentrations in the underground setting in the present. Between the sensor nodes and the cloud, the microcontroller facilitates communication and data transfer. If any of the closest sensor nodes fail, the coverage of the compromised node will be taken over by them and updated to the cloud.

## IX. Future Work

The article is split into two sections in the remaining portion (Fig. 2) section 2 uses the Anaconda Jupyter Python machine learning structure for locating anomalies in the sensors, and Section 3 uses the Naïve Bayes algorithm to determine the defective node and take up its coverage.

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