AI - Driven Safety Surveillance and Health Monitoring System with Magnetic Induction Based Wireless Data Transfer for Underground Mining and Tunneling Applications

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Abstract: For long-distance communication in the air, Electromagnetic (EM) waves are often used as well. However, when used for communication through soil, their performance becomes compromised due to the varying composition of the soil such as red soil or black cotton soil. Soil with these properties absorbs and diffraction is very high, which results in data loss. Due to the underground environment, path loss and signal attenuation increase as transmission distance increases.

In modern times, communication systems are primarily used underground to transmit data in fields such as agriculture, tunnel monitoring, and underground infrastructure. These communications are supported by Wireless Underground Sensor Networks (WUSN) that have been developed. Due to the challenges faced with underground applications of EM waves, Magnetic Induction (MI) has become more effective. The use of magnetic coils as transceivers provides a more stable and efficient way to transmit data through soil.

Keywords: *Electromagnetic Waves, Wireless Underground Sensor Networks, Magnetic Induction.*

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I. INTRODUCTION

Wireless Underground Sensor Networks (WUSNs) play a crucial role in various underground communication applications, particularly in environments like soil. Traditional methods relied on electromagnetic (EM) waves for data transmission. However, EM waves are not effective in underground conditions due to their poor penetration ability and high attenuation caused by materials such as sand, rocks, and different soil types.

Magnetic Induction (MI) was developed as a means of communication to overcome these limitations. The WUSN transmitter is equipped with several magnetic coils as part of the MI-based method. These coils are linked to a UART module that sends serial data. This is referred to as serial-data communication. The difference in attenuation between MI and EM waves is much less, leading to more reliable and efficient underground data transmission. Additionally, there have been studies that compare different methods of MI communication, such as using MI waveguides and direct MI transmission. The optimization of system parameters through various techniques has been suggested to enhance weak link strength. The application of these optimized parameters can lead to an increase in data rate and a much longer transmission distance for MI waveguides. [1]

Magnetic Induction (MI) is the primary method for computing data using WUSNs that are grounded. The greater the number of detectors, it is superior both in terms of delicacy and ability to collect real-time data. A significant amount of detector bumps is encouraged to be deployed within the network. Not only does enforcing multiple detector types improve dimension trustability, but it also helps to reduce data loss and enhance channel application by improving overall channel usage [2].

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The transmission medium consists of many materials, rocks, water, stone and different type of soils. Due to this the magnetic permeability of the soil is varied. This variation can be measured and it used for future process. Even electrical permittivity and electrical conductivity will be varied based on the mixture of the soil. The impact of electrical conductivity and permittance will be adjusted based on the amount of water mixed with the soil. The impact of Electromagnetic parcels on MI dispatched units and localization based on attenuation can be maintained. The determination of skin depth in jewels and minerals is based on the combination of soil layers [3].

Techniques for modeling electromagnetic waves propagating through soil, such as the two-path Rayleigh fading channel model, and methods for signal propagation specific to underground networks are available. Ground surface reflections, inadequate penetration and multipath fading effects are common ground challenges that arise when using soil-based communication methods. These techniques can pose obstacles as well. [4].

To address radio frequency (RF)-related challenges, it is not viable to increase channel capacity by confining all induction coils with the same resonant frequency. Rather than other methods, the technique of spread resonance is employed, where each coil is set to a specific resonant frequency. By optimizing the overall resonant frequency, the system's performance can be enhanced through this approach. Thus, the magnetic induction MI-based waveguide's transmission range can be greatly extended. [5].

II. LITERATURE REVIEW

Yuntao Liang, Yingjie Liu, Changjia Lu, Dawei Cui, Jinghu Yang, Rui Zhou (2024) proposed a paper on “INTELLIGENT MONITORING AND PROTECTION EQUIPMENT OF VITAL SIGNS OF UNDERGROUND PERSONNEL IN COAL MINES REVIEW”. This paper addresses on the challenges and advancements in covering the vital signs of underground coal mine workers. Traditional styles bear professional medical labor force and warrant real-time capabilities. This paper highlights the development of intelligent safety technologies, including wearable bias equipped with detectors for temperature, heart rate, and respiratory rate monitoring. These bias, frequently in the form of smart helmets or smart watches, enable nonstop data collection and transmission to face monitoring centers via wireless communication. The integration of big data analysis and AI algorithms allows for timely discovery of anomalies and allocation of warnings. The proposed system focuses on the design considerations for wearable devices in harsh underground environments, such as corrosion resistance, explosion-proof batteries, and communication protocol adaptability. Additionally, it explores the use of smart clothing and accessories, like smart jackets and backpacks, for comprehensive health and environmental monitoring. This system implements IOT assisted decision-making systems further enhances safety by enabling real-time data analysis and risk assessment [6]

Pratap S. Malik, Abouhawwash, Abdulwahab Almutairi, Rishi Pal Singh, and Yudhvir Singh (2022) proposed paper titled "COMPARATIVE ANALYSIS OF MAGNETIC INDUCTION BASED COMMUNICATION TECHNIQUE FOR WIRELESS UNDERGROUND SENSOR NETWORKS". A detailed analysis of magnetic induction (MI) communication techniques for wireless underground sensor networks (WUSNs) is presented in the proposed system. Underground communication is complicated by the presence of soil and rocks that interfere with the transmission of conventional electromagnetic (EM) waves. The use of coupled coils in MI communication is a viable option. Three MI methods are examined in the proposed system: direct MI transmission, MI waveguide transmission and 3D coil MI communication. Each technique's working principles, advantages, and limitations are discussed in detail. The analysis of the system reveals that MI-based systems can achieve transmission ranges up to 250 meters with reduced path loss (<100 dB) and bandwidths between 1–2 kHz. The paper emphasizes the potential of MI communication in enhancing the reliability and efficiency of WUSNs, especially in challenging underground environments. The system highlights the importance of selecting appropriate MI techniques based on specific application requirements. The finding of the system serves as a valuable guide for researchers and engineers in designing effective underground communication systems [7]

Yufeng Jiang, Wei Chen, Xue Zhang, Xuejun Zhang, Guowei Yang (2024) proposed a paper on “REAL-TIME MONITORING OF UNDERGROUND MINER’S Status Based on Mine IoT System”. The suggested system showcases an IOT-driven mechanism for monitoring underground miners' health and safety in real time. Using light electronic bracelets and smart miner lamps with sensors to collect vital signs such as respiration, body temperature pulse rate, heart rate and blood pressure, the system works. Through Bluetooth, the miner lamps are able to read data from their bracelets and send it back directly to the surface monitoring center using 4G, 5G or Wi-Fi. The miner lamps have the ability to detect gas leaks and provide positioning assistance. The system's integration guarantees secure data transmission in intricate underground environments. The collected data undergo processing for health and safety assessment and fatigue estimation, which are then displayed on a unified monitoring platform. The proposed system has been deployed in a coal mine in Northwest China, demonstrating its effectiveness in enhancing miner safety and operational efficiency.[8]

Daria Trubicina, Kirill Varnavskiy, Alexander Ermakov, Fedor Nepsha, Roman Kozlov, Naser Golsanami, Sergey Zhironkin (2024) proposed a paper on “APPLICATION OF METHODS OF ARTIFICIAL INTELLIGENCE IN SYSTEMS FOR CONTINUOUS AUTOMATIC MONITORING OF DUST CONCENTRATION AND DEPOSITS IN MINE ATMOSPHERE”. The proposed system is designed to address the mounting concern of dust attention in mining operations and its potential harm to workers. A study presents an AI-based system that utilizes advanced digital

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technologies to monitor dust situations in mine environments without interruption, as part of the Assiduity 4.0 concept. The system measures parameters such as dust attention, air moisture, and tailwind haste. This data is processed by AI algorithms in real time to enable the detection of dangerous conditions. With the ability to cover and examine environmental factors in real-time, the system provides an innovative approach to safeguarding icing from corrosion in mines [9]

Vivekananda Reddy Uppaluri (2025) proposed a paper on "REAL-TIME AI-DRIVEN HAZARD DETECTION: INTEGRATING COMPUTER VISION AND SENSOR NETWORKS FOR ENHANCED MINING SAFETY". The proposed system presents a comprehensive analysis of real-time hazard discovery systems in mining operations through the integration of computer vision and detector networks. The system explores how artificial intelligence and advanced monitoring technologies are transubstantiating traditional mining safety protocols, introducing innovative results for early hazard discovery and exigency response. The perpetration of sophisticated model infrastructures for videotape analytics, multilayered detector networks, and data integration fabrics enables precise shadowing of worker gester, outfit propinquity, and environmental conditions. The proposed system examines system performance metrics, implementation challenges, and validation processes, demonstrating the significant impact of AI-driven safety systems on reducing workplace incidents and improving operational efficiency. It also addresses critical challenges in underground mining environments, including environmental factors, technical constraints, and data quality management, while providing insights into future developments and best practices for industry adoption [10]

Kaiqiang Lin, Yijie Mao (2025) proposed a paper on "RIS-AIDED WIRELESS-POWERED BACKSCATTER COMMUNICATIONS FOR SUSTAINABLE INTERNET OF UNDERGROUND THINGS". This paper explores the integration of Reconfigurable Intelligent Surfaces (RIS) with Wireless-Powered Backscatter Communications (WPBC) to enhance the Internet of Underground Things (IoUT). The authors propose a general architecture of RIS-aided WPBC systems tailored for underground scenarios, addressing challenges such as severe channel impairments caused by soil and blockage of direct links. The system demonstrates that the proposed framework outperforms traditional systems in terms of sum throughput, highlighting its potential for sustainable and efficient underground communication. The paper also discusses the advantages, implementation challenges, and future research directions for practical IoUT applications, emphasizing the role of RIS in overcoming underground communication barriers.[11]

Luca Scalambrin, Andrea Zanella, Xavier Vilajosana (2023) proposed a paper on "LoRA MULTI-HOP NETWORKS FOR MONITORING UNDERGROUND MINING ENVIRONMENTS". The paper examines the creation, execution, and assessment of a LoRa -based multi-hop network that is specially designed to span underground mining conditions. Despite the challenges of wireless dispatch in subsurface environments, the study suggests a synchronization frame that permits bumps to sleep for most of the time and only wake up when they need to change their business. Subsurface operations are mostly feasible due to the network's ability to achieve sub 40 second synchronization delicacy between parent and child dyads with minimal outflow. The authors model the interplay between network throughput, frame size, and sampling periods, providing insights into optimizing network performance to meet the specific demands of underground mining use cases. The proposed models aim to ensure robustness, low power operation, and compliance with radio-frequency regulations.[12]

M. Thirunavukkarasu, E. B. Priyanka, S. Thangavel, S. Vinothkannan, K. Vengadesh Prasath, N. Abdul Aathif, R. Dhanush Narayanan (2023) proposed a book on "SHELLCOM-IOT-BASED HEALTH MONITORING MODULE FOR MINING INDUSTRY". The suggested system is based on a smart helmet system that is IoT-based and was created to improve the safety of mining activities. The system keeps track of the diverse risks faced by miners, including those related to the environment and the health of workers. With sensors installed, the helmet can detect changes in temperature, moisture, oxygen usage and heart rate. The system also identifies whether the helmet has been taken off or the worker is incapacitated. A central monitoring system receives data from the LoRa WAN module. If the readings go beyond a predetermined threshold, warning signals are sent to the control room, which permits prompt responses. The system aims to prevent accidents by providing real-time data on potential hazards. By integrating IoT technology, SHELLCOM offers a proactive approach to mining safety, ensuring continuous surveillance and timely interventions. The system underscores the importance of wearable technology in hazardous work environment and its role in safeguarding worker health.[13]

Xiaoyu Ai, Chengpei Xu, Binghao Li, Feng Xia (2024) proposed a paper on "ROBOT-AS-A-SENSOR: FORMING A SENSING NETWORK WITH ROBOTS FOR UNDERGROUND MINING MISSIONS". This paper focuses on the conception of" Robot- As-A-Sensor"(RAAS), which treats robots as mobile detectors within structures analogous to Wireless Sensor Networks (WSNs). In the mining assiduity, robots are stationed as mobile platforms equipped with seeing, communication, and calculating capabilities, especially in dangerous and repetitious surroundings. The study identifies specific challenges in integrating RAAS technology and proposes technological advancements to address these challenges. The RAAS frame aims to beget a shift towards safer, more intelligent, and sustainable assiduity practices by using the cooperative capabilities of multiple robots. The paper discusses the potential of RAAS in transforming industries requiring advanced technological integration, emphasizing its applicability in underground mining missions. [14]

Shahriar Hasan, Katrin Sjoberg, Peter Wallin (2025) proposed a paper on "WIRELESS COMMUNICATION IN UNDERGROUND MINING TELEOPERATION: A

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SYSTEMATIC REVIEW". This paper focuses on Wireless communication in underground mining teleoperation. Effective teleoperation in hazardous areas necessitates low quiescence and high data rates for safe, effective operations. However, there is no standard protocol for communication across different modes like remote driving, backing, and monitoring. The authors divide exploration into six thematic domains related to robotization scenarios and examine performance benchmarks such as quiescence, trustability, and data rate. The majority of present research centers on technologies such as Wi- Fi, LTE, and 5G. Significant gaps include managing communication interruptions, improving QoS, generating scripted and accurate outcomes (such as machine learning), and further exploration is necessary to support fully autonomous mining systems. Additional resources are also needed [15]

Inderjeet Singh, Shree Gaayathri V, Vipin Kumar, T Arthy, Vishnu Sharma (2024) proposed a paper on "REAL-TIME MONITORING AND SURVEILLANCE IN HAZARDOUS ENVIRONMENTS USING IOT-ENABLED ROBOTICS". The paper describes an innovative surveillance system that utilizes advanced Internet of Things (IoT) technologies integrated into a robotic platform, intended for use in hazardous and domestic settings. It has a variety of sensors, high-resolution cameras and is powered by an Arduino Nano microcontroller, which are connected to Wi–Fi/Bluetooth modules that allow the robot to be operated from smartphones or computers. The configuration empowers users to carry out surveillance activities in remote or hazardous areas without risk of injury. Real-time video can be transmitted from the robot to users' homes, and a wireless camera installed by the unit allows for continuous monitoring during both day and night. It offers a strong, reliable and effective surveillance solution suitable for domestic/industrial and military applications [16]

Shiyan Li, Xiaojuan Zhang, Kang Xing, Kang Xing (2022) proposed a paper on "FAST INVERSION OF SUBSURFACE TARGET ELECTROMAGNETIC INDUCTION RESPONSE WITH DEEP LEARNING". This paper focuses on electromagnetic detection capabilities for estimating position, shape and orientation of subsurface targets with 3D orthogonal dipole-based EMI inversion. Traditional approaches suffer from dependence on starting values, local optima convergence, and high computation cost. These issues are solved with a DNN deep learning inversion using Adam optimizer with learning rate decay. Through forward modeling datasets are created within certain controlled ranges to minimize non-uniqueness. Testing both in the field and through simulations demonstrated better robustness and accuracy. Inversion speed is accelerated by up to three to four orders of magnitude compared to traditional methods [17]

K.Thivyabrabha, Dhivya Priya E L, K.R. Priyadharshini, J.S. Sujin (2022) proposed a paper on "IOT BASED AUTOMATED COAL MINE DETECTION AND IMMEDIATE RESCUE ROBOT". Risks to miners' lives include fires, explosions, roof collapses, and toxic gas emissions, with thousands of workers employed in dangerous conditions, coal mining is essential to the global economy. These dangerous gases, which are frequently odorless, cause serious health problems and even death. Such risks are not adequately predicted by conventional techniques. The proposed system incorporates a robot with numerous sensors that can identify the presence of coal and harmful gases like carbon monoxide and methane in order to increase safety. Through a web interface, it facilitates gesture tracking, emergency rescue operations, and real-time monitoring.[18]

G Sharmila, C Ramasamy Sankar Ram (2024) proposed a paper on "PERFORMANCE EVALUATION OF DEEP LEARNING BASED INDUSTRIAL SAFETY ENHANCEMENT IN MULTIPLE SAFETY EQUIPMENT DETECTION". The goal of the proposed system is to improve safety standards for workers and employees in construction and industrial sites through monitoring. Video streams with CNN, R-CNN and YOLO safety equipment e.g. helmet, vest, gloves, boots and mask are analyzed using deep learning techniques. The proper operation of the system indicates that workers comply with requirements by wearing gear correctly. Alerts are sent when violations occur. If people lacking equipment enter identified danger zones, they trigger alarms. It guarantees uninterrupted compliance by solving multiple object problems in real-time. Fast accurate single shot detection is enabled via YOLO architecture integration. Enhanced automation of protective measures improves systems reliability while reducing accident risks during supervision. Aimed at improving human safety in dangerous workplaces, the system enhances overall safety requirements [19]

Huaijin Zhang, Guanghua Liu, You Xu, Tao Jiang (2023) proposed a paper on "LORAAID: UNDERGROUND JOINT COMMUNICATION AND LOCALIZATION SYSTEM BASED ON LORA TECHNOLOGY". This proposed system, "LoRaAid," is specifically built for dual communication and localization needs for underground emergencies. Most existing WUSNs ignore the ever so important positioning element that is crucial in emergencies like earthquakes or mine collapses. LoRaAid uses the highly sensitive yet simple LoRa technology to counteract the issue of signal attenuation underground. A portable LoRa device communicates with nearby buried nodes to receive data, thereby enabling both localization and target signal reception. To accomplish this, two demodulation schemes are applied, and the derived BER expression ensures signaling accuracy. For trilateration-based localization, noise-reduced RSSI values are mapped by LoRaAid systems. The long-range communication is robust provided by other experiments conducted confirming decimeter-level accuracy even in harsh underground environment globally [20]

Kiran More, Kaivalya Mane, Mansi Mane, Rushabh Mane, Siddharth Mane, Manish Bhojane (2024) proposed a paper on "VITAL VEST: SMART WEARABLE FOR MONITORING CONSTRUCTION WORKER HEALTH IN HARSH ENVIRONMENTS". This paper presents SGS has developed a new system called Vital Vest, which is a smart wearable that increases safety measures for construction workers in dangerous places using WBAN and IoT

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technologies. There is also real-time detection of vital signs such as body temperature, heartbeat rate monitoring, SpO2 levels and even movements. Responding to detected issues provides responsive alert systems to enable timely medical attention. The device uses low-power processing sensors and algorithms with minimal calculation overhead while still providing precise results dynamically. Real-time responsiveness is guaranteed with slight robotic overhead for fall recognition and health tracking. Lightweight IoT communications protocols guarantee reliable data transmission. Critical performance indicators also features smart adjustments on measurement precision and battery usage balancing the two competing requirements of accuracy and sustainability Vital Vest empowers most industries with a practical means of improving workplace safety standards [21]

III. EXSISTING SYSTEM

The signals in the being system can be converted from analog to digital at both ends. These transmitter signals are transmitted through electromagnetic swelling. The MEMS detector transforms the voice into a digital signal, which is transmitted through bottoms and bones using electromagnetic waves. This data is then used for mobile communication. Soil communication through EM swells is hindered by the presence of colorful soil types like red and black cotton. High diffraction in soil causes data loss when these swells are utilized for transmitting data. The explanation is quite simple. A rise in transmission distance results in greater path loss and increased attenuation

IV. PROPOSED SYSTEM

An integrated framework is provided by the proposed system to enhance safety and real-time monitoring in underground mining and tunneling operations. Its approach involves utilizing artificial intelligence-based surveillance, physiological health monitoring, and magnetic induction (MI)-backed wireless communication to tackle unique subterranean environments. The use of YOLOv8 as its central model involves applying deep learning to determine whether basic personal protective equipment (PPE), such as helmets and safety vests, are present or absent. Using an edge device that is connected to a camera module installed at strategic checkpoints, the model is trained on bespoke dataset of underground laborers. Meanwhile, a wearable health monitoring module continuously tracks vital signs including body temperature, heart rate and breathing levels using biomedical sensors. The data is preprocessed and ready for wireless transmission by connecting these sensors to a microcontroller unit (Arduino UNO). Magnetic induction-based wireless data transfer is utilized to address soil attenuation and metal interference in underground environments. Vibration sensors are incorporated into the system to enhance awareness of potential landslide indicators or tunnel collapses. The analysis of sensor data enables the identification of abnormal seismic patterns, leading to early warning. Data on safety compliance, essential indicators, and environmental data are transmitted to a server at the surface level, where they are presented in real-time via graphical means. Real-time alert notifications and tracking are available through this dashboard. In general, the proposed system is a safe, low-power, and scalable solution for improving safety and visibility in underground mining operations.

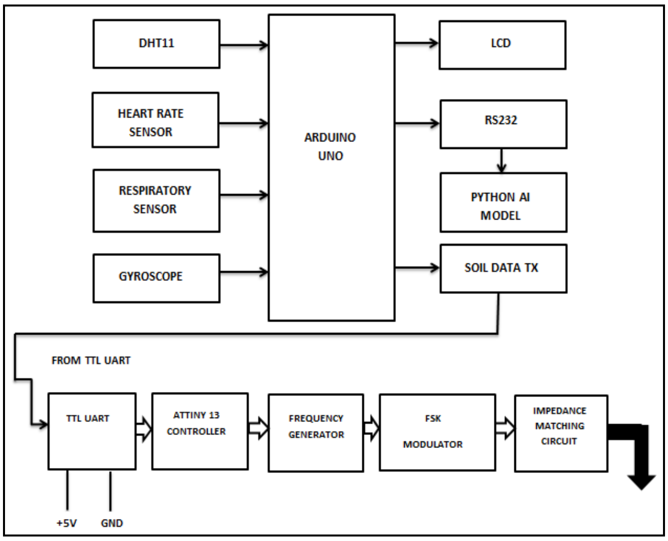

Fig 1 Transmitter Block

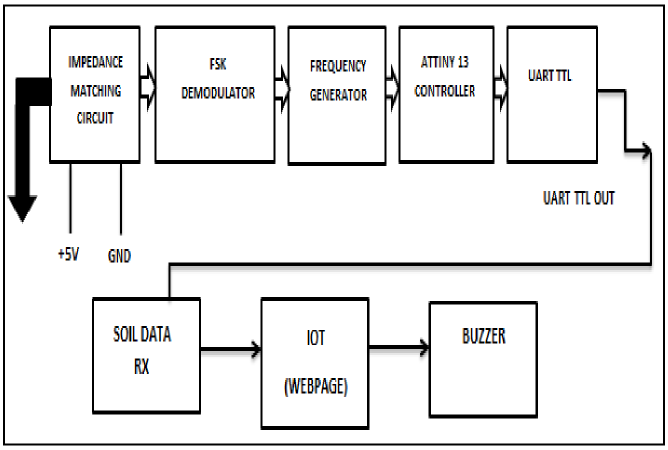

Fig 2 Receiver Block

V. SYSTEM DESIGN

The data gathered from the detectors is transmitted to TTL UART, which is then connected to 5v and GND. The TTL UART issue is categorized based on the fact that 0 bit equals 0v and 1 bit corresponds to a voltage of 5v. ATTINY 13 is correlated with this. The maximum MHz value of the controller is 16,8. This is the reason why the timekeeping machines are created. This term has a connection to frequency creator, which is employed to generate non-repeating or repeating electronic signals in either the analog or digital realm. Analog signal is produced by it during the transmission of signals. FSK modulation is linked to (important frequency shifts). The connection is made to an Impedance Matching circuit to optimize power transfer from the cargo. Furthermore, Induction swells are utilized to facilitate data transfer. The data is transmitted through soil, with the other side receiving a receiver. In contrast, the receiver and transmitter are identical. The required signal source's electrical load must be designed to minimize

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reflection of the signal. It is associated with FSK demodulation, which converts data into binary signals. This is connected to the Frequency Generator and produces repeated electronic signals in either the digital or non-digital domains. It is then connected via ATTINY 13 controller and UART TTL, from where its output is displayed on an LCD screen. The data is transmitted to an IOT-enabled webpage that offers real-time information, aiding in emergency response. An alert is given to take necessary actions when an emergency buzzer is activated.

➢ *Safety Gear Detection of Workers using Yolo*

YOLO (You Only Look Once) is one of the most well-known and accurate deep learning algorithms for object detection, with real-time performance. Traditional object detection techniques, including R-CNN and its variations, follow a multifaceted approach by performing detection in multiple stages, beginning with the identification of relevant regions and ending with classification. In contrast, YOLO approaches the problem as a single regression problem, which involves anticipating bounding boxes and class probabilities from an input image in one pass through the network. YOLO's unified architecture facilitates its rapid development, making it ideal for real-time detection applications like video surveillance, autonomous vehicles, and industrial safety monitoring. The proposed system utilizes YOLOv8. The new architecture features a new C2f module, an anchor-free detection head, and simplified loss function with Complete IoU for more accurate predictions of bounding boxes. Additionally, the interface adds support for multiple fault tolerance scenarios on the network. YOLOv8 is modular and flexible, providing classification capabilities as well as object detection, instance segmentation, and pose estimation with minimal configuration.

YOLO's operations are based on the fact that the image is divided into a square grid of SS dimensions. Objects are typically represented by the same cell that is responsible for detecting their center. Every cell will forecast B bounding boxes and assign a confidence score to each box. This armature is devoid of function, which means that the model cannot forecast two bounding boxes.' The bracket score will be 0.0 to 1.0, with 0 being the lowest and 1.1 being that of the highest; otherwise, the confidence scores for this cell should be 0.01. These confidence situations capture the model's certainty of having an object in a cell and that the bounding box is accurate. The x, y, range, height, and confidence are the 5-digit numbers that make up each bounding box. Values such as x and y are the position of the center of prognosticated bounding box, while range and height are pieces relative to the total image size. An IOU between a prognosticated bounding box and 'true' one is represented by the confidence, known as the ground verity box. The IOU is the area where the prognosticated boxes and the base ones intersect, and it represents the intersection of these boxes.

This proposed system uses YOLOv8 to automatically detect PPE worn by employees working underground or in tunnels. The objective is to enforce safety protocols by ensuring that employees wear the necessary safety gear and receive notifications when they are found to be breaking them. Additionally, The model learns to identify classes such as helmet, safety vest, gloves, shoes, and machineries. Roboflow, a public platform that offers labeled datasets for computer vision tasks, was the source of the dataset used for training purposes. The dataset comprises of tagged images of various PPE items and industrial objects under different lighting, angles, occlusions, and backgrounds. Class labels and bounding boxes are included in the YOLO format, along with annotations.

The Ultralytics Python API was utilized to train YOLOv8, using the dataset obtained. In the training, the model learned to recognize visual patterns and spatial features that correspond to each safety point. Parameters such as batch size, ages, image resolution, and confidence thresholds were trained. After training, the model was tested for good conception and high discovery delicacy. During deployment, the trained YOLOv8 model processes real-time video frames captured by surveillance cameras. The bounding boxes and assigning labels with confidence scores, it can determine if workers are adequately equipped with PPE. Failure to provide safety gear, such as a helmet or sleeveless vest for example, is flagged by the system. Real-time detection system helps workers in hazardous underground environments where manual monitoring is delayed or limited, thereby improving their safety

VI. RESULT

The proposed system is designed to address health indicators such as heart rate, oxygen force position, and environmental factors like temperature, moisture, or earth surface vibration. A webpage that is IOT enabled covers all parameters at the same time, but if it exceeds the threshold limit, alerts are sent to users on their face. The dashboard displays information in the images below.

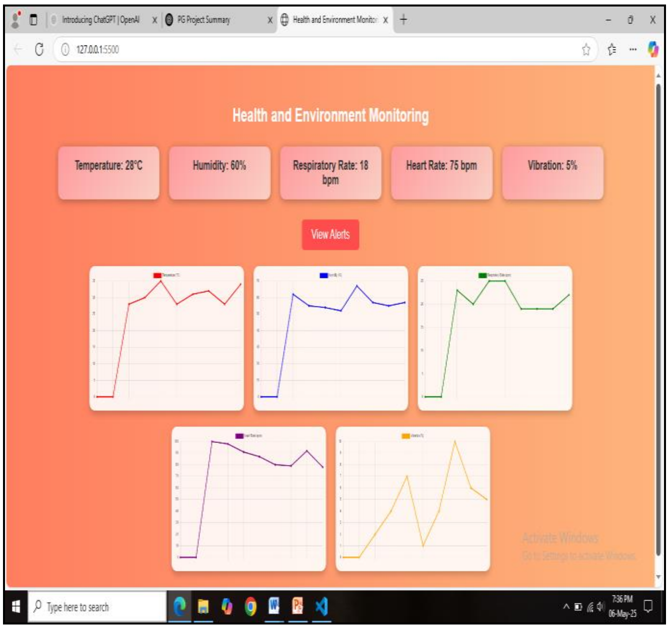

Fig 3 Overall Dashboard

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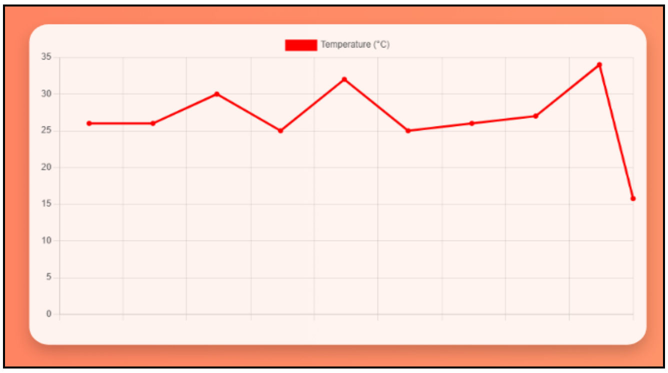

Fig 4 Temperature Graph

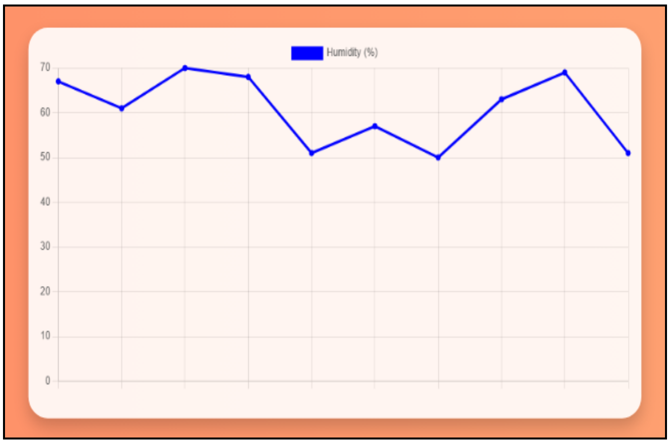

Fig 5 Humidity Graph

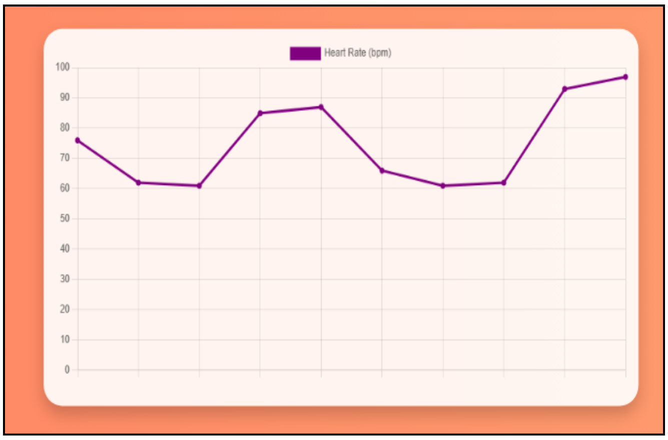

Fig 6 Heart Rate Graph

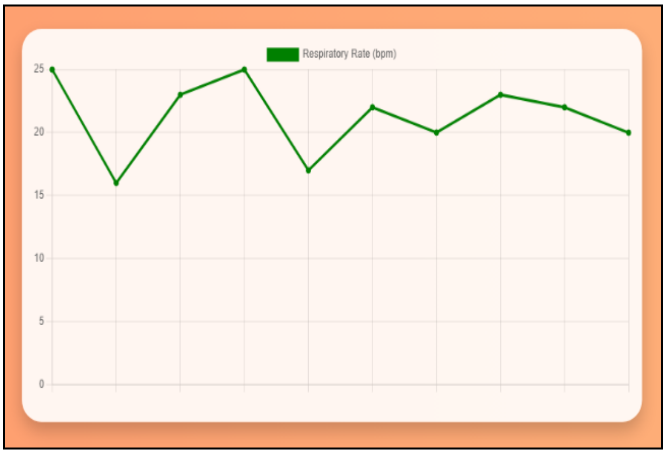

Fig 7 Respiratory Rate Graph

Fig 8 Vibration Graph

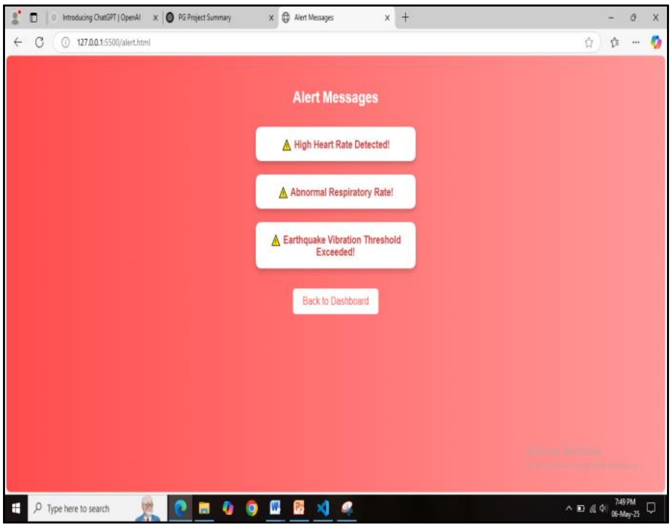

Fig 9 Alert Page

The safety gear detection of the workers is by employing Deep Learning – YOLO (You only look once). The parameters considered are helmet, hand gloves, vest shoes and machineries. The images below give safety gear of workers.

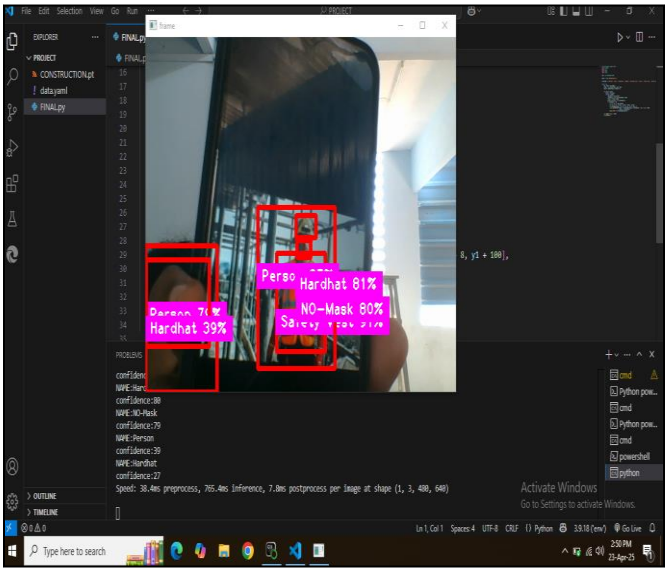

Fig 10 Safety Gear Detection of Helmet, Gloves, Vest, Shoes

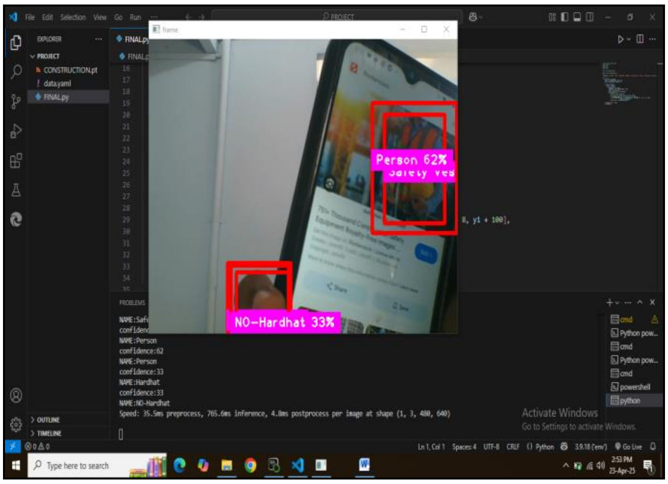

Fig 11 Missing Parameters in Safety Gear Detection

VII. CONCLUSION

By combining various technologies, the implemented system exhibits an effective safety monitoring solution for underground tunneling applications, as illustrated in the block diagram. The AI component employs YOLOv8 and is trained on a Roboflow-sourced dataset that includes helmets, safety vests, gloves, shoes, and machinery, with the aim of achieving high accuracy real-time detection of PPE from surveillance video streams. An embedded microcontroller is used to continuously measure physiological parameters like oxygen saturation, heart rate, and body temperature through the use of wearable sensors. The soil medium is used to transmit sensor data wirelessly to an above-ground receiver, enabling reliable data transfer in subterranean environments. This technology uses magnetic induction communication. A centralized monitoring dashboard is used to process and display the integrated data, making it easy to quickly assess safety or employee health status. The system's modular design, as illustrated in the block diagram, demonstrates its flexibility and practicality for deployment, providing evidence that by combining deep learning with wireless embedded sensing, safety management in hazardous underground operations can be improved.

FUTURE SCOPE

The system can be enhanced by an underground digital twin framework that simulates real time health and safety conditions.'". An AI-powered behavior analysis is utilized to detect signs of tiredness or unsafe posture. Integration with block chain can ensure that safety records and accountability are not falsified. In the event of communication failure or deep-sea surface conditions, draconian surface relays may be utilized to extend coverage. The system's shared data intelligence can be extended to enable autonomous tunnel inspection and worker-assistive robotics over time.

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