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Smart PPE Compliance Monitoring for Continuous Coal Miners Monitoring and Delayed Response.

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ABSTRACT

Coal mining is one of the most hazardous industrial activities due to the presence of toxic gases, high recent advancements in IoT and temperature, low oxygen levels, and embedded systems enable the confined underground environments. Development of intelligent safety Although Personal Protective Equipment solutions. Smart PPE systems integrate (PPE) is mandatory, conventional PPE sensors, processing units, and wireless does not provide real-time monitoring or communication to monitor safety early warning of dangerous conditions. Conditions in real time. This paper presents a Smart PPE focuses on the application of Smart PPE Monitoring System based on Internet of Monitoring systems to improve coal Things (IoT) technology to enhance coal miner safety and reduce occupational miner safety. Wearable sensors risks. Integrated into PPE continuously monitor environmental parameters and miner

Keywords - Coal Mine Safety, Internet of RFID and wireless sensor networksare Things (IoT), Wearable Sensors, Industrial Safety

INTRODUCTION

Applied for miner identification and location tracking. Although these systems improve safety, most of them monitor limited Coal mining plays a vital role in parameters. Integrated Smart PPE power generation and industrial systems that combine environmental development. However, underground coal monitoring, PPE Compliance, and real- mines expose workers to serious hazards time alert mechanisms are still under such as methane gas explosions, carbon development. This paper presents a monoxide poisoning, oxygen deficiency, unified Smart PPE Monitoring approach high temperatures, and physical injuries. Using IoT technology. Despite safety regulations and mandatory PPE usage, mining accidents

LITERATURE REVIEW

Activity. Sensor data is transmitted several studies have addressed wirelessly to a central monitoring system, mine safety using technology. IoT-based where alerts are generated during unsafe gas monitoring systems have been conditions. The proposed approach developed to detect methane and carbon improves safety compliance, reduces monoxide levels in underground mines. Accident risk, and supports intelligent mining operations. Smart helmets with accelerometers are used to identify falls and head impacts.

METHODOLOGY

Continue to occur due to a lack of The Smart PPE Monitoring System Carbon Monoxide (CO) Sensor: Identifies is based on wearable sensing, embedded toxic carbon monoxide levels. Processing, and wireless communication. These sensors continuously Sensors embedded in PPE continuously monitor gas concentration and generate monitor parameters such as gas signals when values exceed safe limits. Concentration, temperature, and miner B. Temperature and Humidity Sensor movement. The collected data is A temperature and humidity sensor processed by a microcontroller and is used to monitor underground transmitted to a central monitoring environmental conditions. Excessive system through IoT communication temperature and humidity can cause heat protocols.

Stress and discomfort to miners. The Predefined safety thresholds are sensor helps in detecting abnormal used to evaluate sensor data. When environmental conditions and ensures unsafe conditions are detected, alert timely warnings. mechanisms are activated to warn C. Microcontroller Unit miners and supervisors. This The microcontroller acts as the methodology ensures continuous safety central processing unit of the system. It monitoring and rapid emergency

Performs the following functions: response. Collects data from all sensors Processes sensor values Compares data with safety

RESULT AND DISCUSSION

Thresholds The Smart PPE Monitoring Controls alert and communication approach significantly improves safety modules performance compared to traditional PPE Commonly used micro controllers include systems. Continuous monitoring allows Aurduino or ESP32, due to low power early detection of hazardous gas levels consumption and IoT compatibility. and abnormal environmental conditions. D. Wireless Communication Module Real-time alerts reduce reaction time
A wireless communicationmodule
during emergencies and help prevent
enables data transmission be
Serious accidents. Wearable PPE and the central monitoring the system also improves system. Technologies such as Wi-Fi, compliance with safety regulations by Bluetooth, or LORA are used depending ensuring proper PPE usage. Centralized on range and environmental requirements. monitoring enables supervisors to track This module ensures real-time data multiple miners simultaneously, transfer. Improving safety management and E. Power Supply Unit decision-making a rechargeable battery is used to power the wearable PPE system. Low- V. Hardware Components Used power components are selected to The Smart PPE Monitoring system increase battery life and ensure for coal miners is composed of wearable continuous operation during mining shifts. Sensing units, embedded processing
Hardware, communication modules, and

VI. ADVANTAGES
Alert devices. The major hardware Continuous real-time safety components used in the system are Monitoring described below. A. Gas Sensors Early detection of hazardous conditions Gas sensors are used to detect Improved PPE compliance hazardous gases commonly present in coal mines. Faster emergency response Reduced accident probability Methane (CH_4) Sensor: Detects explosive methane gas concentration. Scalable and cost-effective solution detection and rapid alert mechanisms Reduced Manual Inspection Time reduce accident risks and enhance

VII. Block Diagram
Panic Button Li-ion occupational safety. The integration of wearable sensors and IoT communication supports the development of safer and smarter mining Batter dc-dc NRF/ environments. LORA

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LIMITATIONS

Engineering (22628), MaharashtraStateBoard of Technical Education. Dependence on the reliability of wireless communication reliability Initial deployment costs Battery life management of wearable devices Requirement for regular sensor maintenance Limited Network Coverage High Infrastructure Cost

CONCLUSION

Smart PPE Monitoring using IoT technology provides an effective solution for improving coal miner safety. Real-time monitoring, early hazard