COAL MINE SAFETY ROBOT WITH HAZARD DETECTION AND FIRST AID ASSISTANCE

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ABSTRACT: Coal mining, a critical industry, poses significant risks such as fires, gas leaks, and health hazards. The "Coal Mine Safety Robot with Hazard Detection and First Aid Assistance" project addresses these challenges by integrating IoT and automation technologies to enhance miner safety and emergency response capabilities. This system utilizes a Node MCU controller and features fire sensors, gas sensors, DHT sensors, cameras, and a web server to provide comprehensive safety monitoring. The robot continuously detects hazardous conditions like fires, gas leaks, and temperature fluctuations. Real-time environmental data is transmitted to a web interface, allowing operators to remotely monitor conditions and respond promptly. In emergency scenarios, the robot provides critical support by detecting casualties and delivering a first aid kit, offering immediate assistance until further help arrives. The onboard camera facilitates live video streaming, enabling operators to assess the situation and guide the robot as needed. It uses fire and gas sensors to detect hazardous conditions, while DHT sensors track temperature and humidity levels. When dangers like fire outbreaks or gas leaks are detected, the robot responds swiftly to reduce risks and maintain safe environment. Additionally, it is equipped with a camera that provides a real-time video feed, allowing remote operators to assess situations effectively. In case of a casualty, the robot can deploy a first aid kit and, under operator guidance, lift and transport the injured miner to a safer location.

KEYWORDS: COAL MINE, ROBOT, DHT, MCU, WEB SERVER.

I.INTRODUCTION: Coal mining is a vital industry, but it involves numerous risks, including fires, gas leaks, and adverse environmental conditions that threaten miners' safety and health. The "Coal Mine Safety Robot with Hazard Detection and First Aid Assistance" project is designed to tackle these challenges by combining IoT and automation technologies into a robust and effective safety system. This project employs a Node MCU microcontroller to coordinate various sensors and modules. Key components include fire sensors for detecting potential fire outbreaks, gas sensors to identify hazardous gas leaks, and DHT sensors for monitoring temperature and humidity levels within the mine. These sensors provide continuous real-time data, which is transmitted to a web interface for remote monitoring by operators. The robot is equipped with a camera that streams live video, enabling operators to visually assess conditions and guide the robot remotely in emergency scenarios. In critical situations, such as detecting casualties, the robot offers immediate assistance by deploying a first aid kit or carrying the injured individual to safety based on operator commands.

II.LITARATURE SURVEY: [1]M.Prashant,"WIRELESS ROBOT FOR COAL MINES BASEDONMIXEDSIGNALPROCESSOR", (IJAICT) Volume 1, Issue 12, pp 950-954, April 2015. The project titled "Wireless Robot for Coal Mines Based on Mixed Signal Processor(MSP430)"focuses on designing an autonomous robot to navigate hazardous coal mine tunnels during disasters. It detects toxic gases like CO, CO_2, and methane, monitors temperature, and transmits real-time data to the control room using the MSP430microcontroller and CC1120 wireless module. With its compact design, ultra-low power consumption, and obstacle avoidance system, the robot ensures safe and efficient operations, minimizing risks for human rescuers.

[2]Sachin M. Ledange, S. S. Mathurkar "Robot based Wireless Monitoring and Safety System for Underground Coal Mines using ZigBee" (SSRG – IJECE), Volume 3, Issue10 ,pp 23-26,October 2016. The project titled "Robot-Based Wireless Monitoring and Safety System for Underground Coal Mines Using ZigBee" enhances miner safety by employing a remote-controlled robot with sensors to monitor parameters like temperature, humidity, and toxic gases. Using ZigBee for real-time data transmission, the system ensures efficient communication and reduces human exposure to hazardous environments, providing a cost-effective solution for underground coal mine safety.

[3]Dr.Anbumalar,Akshaya.S,Hemalatha.V,"Coalmine Monitoring Robot"(IJSRSET),Volume10, Issue 2,PP 346-352,April 2023. The project titled *"Coal Mine Monitoring Robot"* focuses on designing an autonomous robot equipped with various sensors to monitor hazardous conditions in coal mines. The robot detects dangerous gases, temperature variations, and other environmental parameters, ensuring timely alerts and responses to protect workers. With the ability to operate in confined, hazardous areas, it enhances safety by reducing human exposure to risks like gas leaks, fires, and structural failures.

[4]M. Ndoh, G. Y. Delisle, "Geo-location in Underground Mines Using Wireless Sensor Networks", Antennas and Prop. Society Int. Symposium, 2005, 3B, pp. 229-32. The project titled "Geo-Location in Underground Mines Using Wireless Sensor Networks"aims to enhance safety and monitoring in coal mines. A wireless robot equipped with sensors detects temperature, humidity, and toxic gases like methane and CO. Using ZigBee technology, the system transmits real-time data to the control room, enabling quick response during emergencies. This cost-effective and efficient solution reduces human risk and improves underground communication.

III.OBJECTIVE: The objective of the project is to design an IoT-based "Coal Mine Safety Robot" aimed at ensuring the safety of miners working in hazardous environments such as coal mines. The robot leverages advanced sensors and automation technology to monitor environmental conditions, detect hazards like fires, gas leaks, and unsafe temperature or humidity levels, and provide real-time alerts. It is equipped with emergency response features, including alive video feed for situational awareness, and can deliver first aid or assist in rescue operations, ensuring prompt action in critical situations.

IV.PROPOSED SYSTEM:

The main components in block diagram are explained below:

Power Supply: Provides necessary voltage (5V-12V) to power the robot and sensors. ESP32: Central microcontroller to control robot operations and handle communication.

ESP32-CAM: Provides live video feed for real-time monitoring and manual control. Motor Driver: Controls the speed and direction of DC motors using external power (e.g., L298N).

DC Motors: Used for robot movement, enabling forward, backward, and directional control. **Servo Motor:** Controls the fork-lifting stretcher for precise lifting and positioning of injured workers.

DC Fan: Exhausts toxic gases from the surrounding area.

PIR Sensor: Detects casualties by sensing human motion. DS18B20 Temperature Sensor: Measures body temperature of injured workers.

Pulse Sensor: Monitors heart rate of injured individuals.

Relay: Controls high-power components like the water sprayer and DC fan using low-power signals from the microcontroller.

Water Sprayer: Extinguishes fires in case of an emergency. Communication and Connectivity:

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ESP-NOW Protocol: Facilitates wireless communication between multiple Node MCUs and the robot.

Web Server: Accessible via the ESP32, providing live video feed and environmental data for remote monitoring

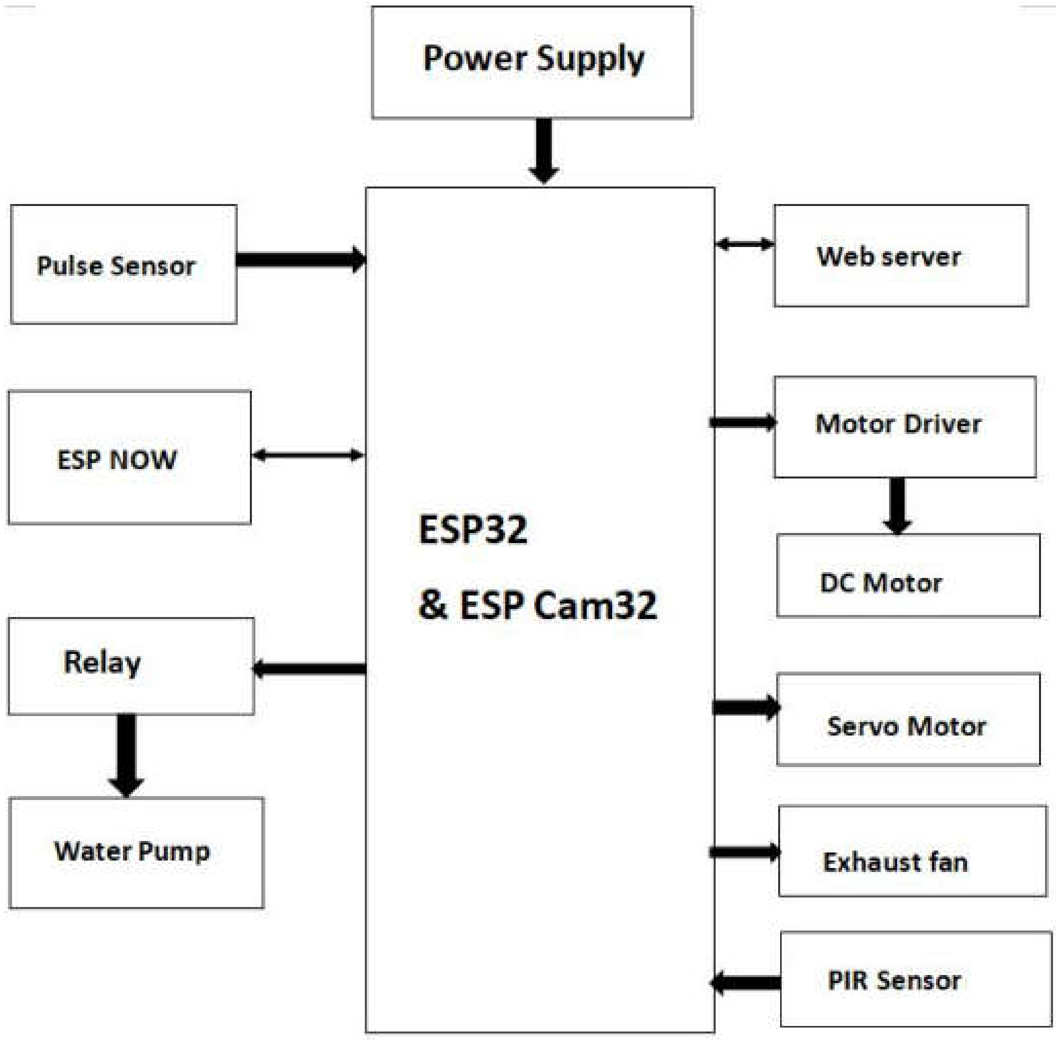

FIG 1 Block Diagram

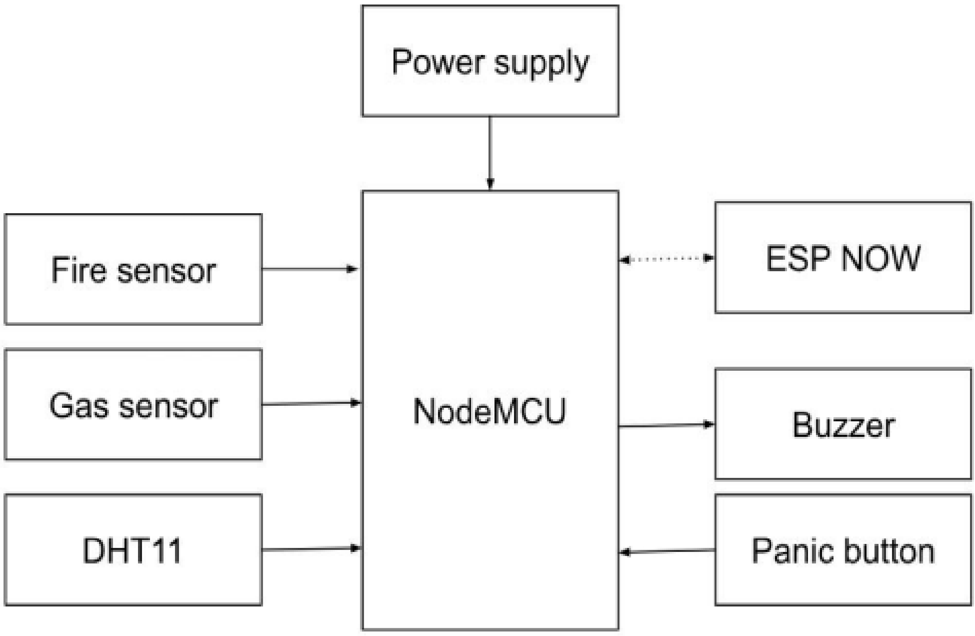

FIG 2 Block Diagram of SOS System

The main components in SOS System are explained below:

Node MCU: Placed at different locations within the coal mine for communication.

Fire Sensor: Detects flame or fire hazards in the mine and triggers an alert.

Gas Sensor: Identifies the presence of toxic gases to ensure worker safety.

DHT11: Measures temperature and humidity levels in the mine environment.

Buzzer: Provides audio alerts during emergencies or when hazards are detected.

Panic Button: Manual SOS trigger allowing workers to send emergency alerts to the robot.

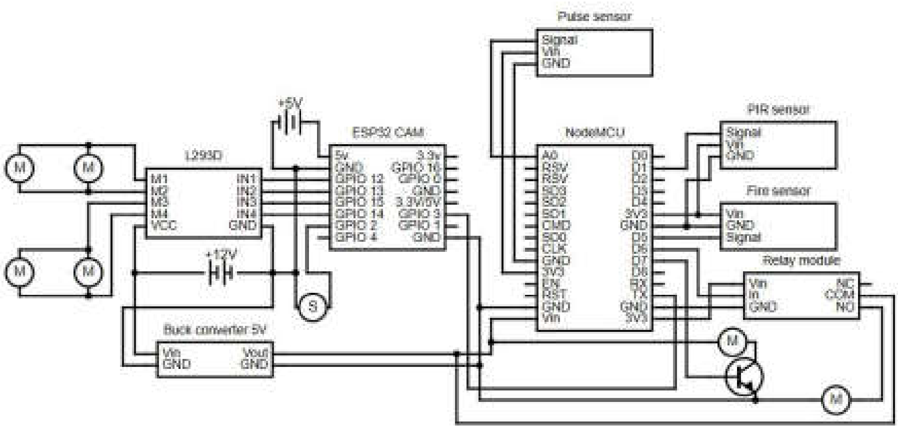

FIG 3 Circuit Diagram Of Robot

The above circuit diagram showcases an integrated IoT-based system involving multiple components such as the Node MCU, ESP32-CAM, L293D motor driver, sensors, and a relay module. At the core of the system, the Node MCU acts as the primary controller, handling sensor inputs and output control. It is connected to a pulse sensor on GPIO0 (D3), a PIR sensor on GPIO16 (D0), and a fire sensor on GPIO5 (D1). These sensors are powered through the Node MCU's 3.3V and GND pins. GPIO4 (D2) of the Node MCU is used to control a relay module, which is responsible for switching external devices like a fan or buzzer. The ESP32-CAM, responsible for capturing and streaming live video, is powered bya5Vline coming from a buck converter, which steps down 12V from the battery to 5V. Some of the ESP32-CAM's GPIO pins (GPIO12 to GPIO16, GPIO0, GPIO1, GPIO3, and GPIO4) are used for interfacing with the L293D motor driver, enabling it to control four DC motors connected to its output pins (M1 to M4). The motor driver itself receives logic-level power from the 5V line and motor-driving power from the 12V battery. The L293D uses four input pins (IN1 to IN4) connected to the ESP32-CAM's GPIOs to drive the motors in either direction. It has two power pins: VCC1 (5V) for internal logic and VCC2(12V) for motor power. The relay module is powered by 5V and controlled by a digital signal from the Node MCU to toggle connected external loads. All components share a common ground to ensure stable operation.

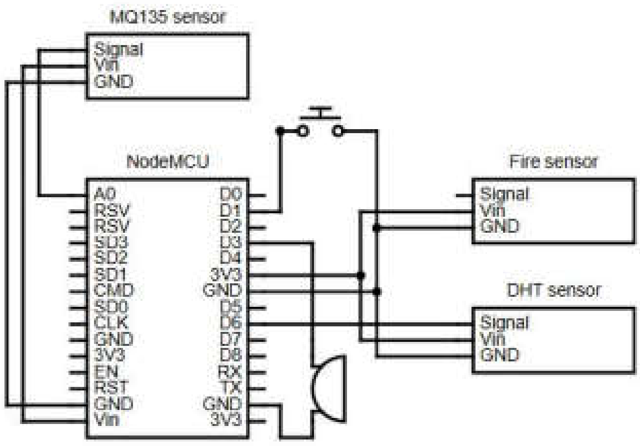

FIG 4 Circuit Diagram of SOS System

The above circuit diagram illustrates an environmental monitoring system using the Node MCU (ESP8266) as the main controller, interfaced with multiple sensors—MQ135gassensor, fire sensor, and DHT sensor—to detect air quality, fire presence, temperature, and humidity. The MQ135 sensor, which is used to detect harmful gases (such as CO_2, NH_3, and smoke), is

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connected to the Node MCU. Its signal pin is connected to the Node MCU analog input pinA0, while Vin and GND are connected to the 3.3V and GND pins of the Node MCU, respectively. This allows the NodeMCU to read analog values representing gas concentration. The fire sensor and DHT sensor (commonly a DHT11 or DHT22) are also connected to the NodeMCU. Their signal pins are routed to digital GPIO pins (for instance, D1 and D2), and they share the same power (Vin) and ground (GND) lines, also sourced from the NodeMCU3.3V and GND pins. Additionally, the circuit includes a push-button switch connected to a logic gate, which appears to control the activation or selection of the sensors, likely allowing the system to prioritize or enable certain functions based on user input. The logic gate (possibly an OR gate or AND gate, depending on application) is involved in decision-making based on the button press and sensor signals.

V.HARDWARE RESULTS:

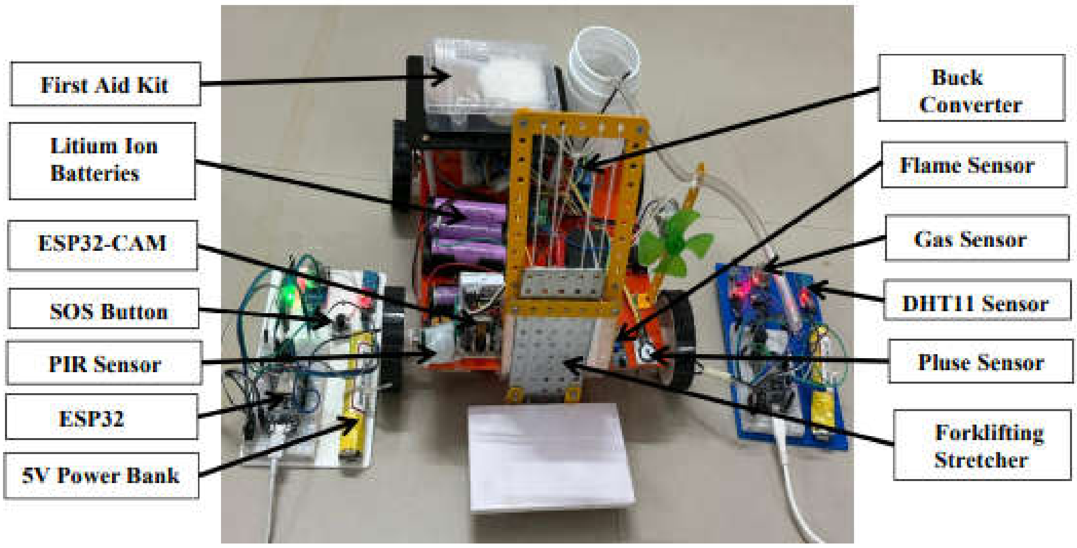

FIG 5 Hardware Setup

The Coal Mine Safety Robot with Hazard Detection and First Aid Assistance is a cutting-edge solution designed to enhance safety in coal mines. It integrates several advanced components to monitor and respond to hazardous situations effectively.

- Fire Detection and Extinguishing: A fire sensor detects flames, and a water pump extinguishes fires promptly.
- Gas Monitoring and Ventilation: A gas sensor identifies hazardous gases, while an exhaust fan clears the area.

- Environmental Monitoring: Humidity and temperature sensors provide real-time data on atmospheric conditions.
- SOS System: Equipped with two SOS mechanisms for emergency alerts.
- Live Video Streaming: An ESP32-CAM module streams live video, offering real-time visuals of the surroundings for better situational awareness.
- Data Transmission: Powered by a Node MCU, the robot transmits all sensor readings to a mobile-accessible web server, ensuring remote monitoring and control.

CASE –1: FIRE AND GAS DETECTION: When a flame is brought near the IR sensor, it detects the fire and activates the buzzer as an alert. The fire detection status is also displayed on the web page, allowing users to monitor it in real-time through their mobile device. A flame sensor is a specialized device designed to detect the presence of fire or flames by identifying specific light wavelengths emitted by flames, typically in the infrared(IR)spectrum. It is highly sensitive and can quickly detect even small flames, making it a critical component in fire detection systems.

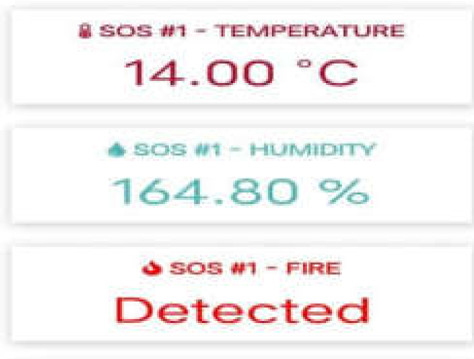

FIG 6 SOS 1 Indicates fire detection

The sensor operates by measuring the intensity of IR radiation and triggering an alert when the detected levels exceed a predefined threshold. Flame sensors are commonly used in safety systems for industrial, residential, and robotic applications due to their accuracy and 50 reliability. In robotics, such as the Coal Mine Safety Robot, the flame sensor plays a vital role in identifying fire hazards, triggering alarms, and initiating fire suppression mechanisms, ensuring quick response to prevent potential disasters.

CASE-2: HUMIDITY AND TEMPERATURE DETECTION: The DHT11 sensor is a widely used digital sensor for monitoring both temperature and humidity. It is compact, cost-effective, and easy to interface with microcontrollers, making it ideal for real-time environmental monitoring applications.

FIG 7 High Temperature and Low Humidity Levels

The sensor measures temperature in the range of 0°C to 50°C with an accuracy of ±2°Candhumidity levels between 20% and 90% with an accuracy of ±5%.The DHT11 operates by using a capacitive humidity sensor and a thermistor to measure the surrounding air, and it provides calibrated digital output.

CASE-3: HEART BEAT AND HUMAN DETECTION:

FIG 8 Heart Beat

This indicates a human heartbeat is detected at 71 beats per minute, which is a normal rest ingrate. Sensor Used: Pulse Sensor. It uses infrared light to detect blood flow and determine pulse rate.

FIG 9 Man Detected

If the system displays "Human Detected", it means the PIR (Passive Infrared) sensor has sensed motion from a human or warm body in its range. The PIR sensor detected infrared radiation (heat) changes caused by human movement. This triggers the system to update the display to Human Detected. The system works by using a PIR (Passive Infrared) sensor to detect motion caused by the heat emitted from a human body. When a person moves within the sensor's range, the PIR sensor senses the change in infrared radiation and sends a signal to the NodeMCU or ESP32 microcontroller. The microcontroller processes this signal and interprets it as human presence. Once detected, it updates the display or web-based user interface (UI) to show the message "Human Detected", informing the user that a person is nearby. This setup is especially useful in coal mine robots for identifying the presence of trapped or moving miners. When motion is detected: PIR sensor's signal pin goes HIGH. The microcontroller (NodeMCU/ESP32) reads this and updates the status.

CASE-4: FIRST AID KID ASSISTANCE:

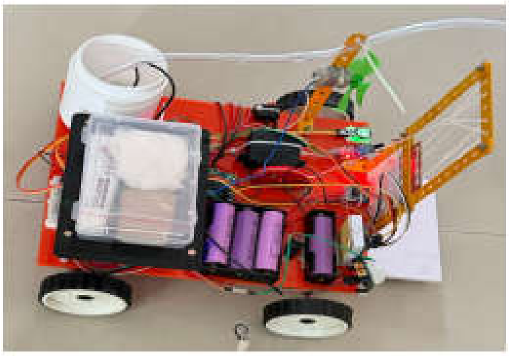

FIG 10 First Aid Kit Assistance

The First Aid Kit Assistance in coal mine safety robots provides immediate medical support to injured miners during emergencies like gas leaks or cave-ins. Equipped with essential supplies such as bandages, antiseptics, and painkillers, the robot uses sensors and cameras to locate victims and navigate to them. It offers voice-guided or remote-controlled access to the kit, ensuring quick care in hazardous areas, reducing reliance on human rescuers, and improving survival chances. is a feature integrated into coal mine safety robots to provide immediate medical support to injured miners during emergencies such as gas leaks, cave-ins, or explosions.

CASE-5: LIFTING INJURED PERSONS:

FIG 11 Lifting injured persons

The Casualty Lifting and Transport feature enables the safety robot to rescue injured miners by detecting them using sensors and cameras, then lifting them with robotic armsor platforms. It safely carries or drags the person from hazardous zones to safer areas using shock-absorbing supports, straps, and smooth movement control. This reduces evacuation time, limits risks to human rescuers, and allows access to areas where humans cannot easily each. the safety robot to lift, carry injured miners from dangerous areas to a safer location for further treatment or evacuation.

VI.CONCLUSION: In this work "Coal Mine Safety Robot with Hazard Detection and First Aid Assistance "using IoT, sensors, and NodeMCU has been successfully designed and developed. A prototype module has been constructed for demonstration, and the results have been satisfactory. The critical aspect of the project lies in designing robust software to ensure the reliable performance of the robot based on sensor inputs. The effectiveness of the system depends significantly on the embedded code programmed into the microcontroller. While the current prototype serves as a proof of concept, further enhancements are required to develop it into a fully functional system suitable for real-world applications. Additionally, the integration of live video streaming and real-time data monitoring has proven to be invaluable in ensuring miner safety. Comprehensive testing of the prototype confirms its ability to detect hazards, provide first aid assistance, and respond effectively in emergencies. This innovative solution aims to minimize risks, safeguard miners' lives, and contribute to the advancement of safety standards in the mining industry.

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