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Harvey Dent: SmartGuard(An IoT-Enabled Surveillance Robot for Mining Safety)

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Abstract: Mining involves extracting materials, such as coal, from underground. Common mine workers encounter dangerous risks such as hazardous accidents and extreme underground environments. To facilitate communication between miners inside the mine and outside rescue teams, we are creating a robotic interface that will leverage the Internet of Things (IoT) to send warning messages or alerts. Our various sensors, along with the components Raspberry Pi, PI camera, MQ sensor, PIR sensor, DHT 11, and ultrasonic sensor, will assist us in providing accurate data regarding the conditions within the coal mine via the Internet of Things. As a result, based on the obtained monitoring data and notifications, the rescue team will be sent out.
Keywords: Communication Link, Robotic Interface, Internet of Things

Fig. Physical Prototype of 'Harvey Dent' — The Custom-Built Interactive Bot

The figure displays the physical design of 'Harvey Dent', an interactive bot developed for IoT-based surveillance robot for hazardous environments which is a smartphone-controlled interface for remote operations. The prototype features a dual-tone exterior, integrated sensors, and movable components for enhanced functionality.

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I. INTRODUCTION

According to the Oxford Dictionary, the act of removing coal or other minerals from a mine is referred to as mining. The procedures involved in extracting these minerals carry inherent risks. The extreme conditions encountered underground can sometimes lead to injuries or fatalities for miners. While human error contributes to some accidents, many incidents are attributable to the hazardous nature of the underground environment. It is challenging to monitor these conditions without endangering someone's life. Traditional methods for monitoring mines typically involve sending a person underground to report back. However, this approach is perilous, as the individual tasked with observing specific hazards may themselves be harmed. Such direct observation is intrusive. Worker protection in these dangerous areas is ensured through various systems or schemes. Occupational Health and Safety encompass these systems/schemes. Besides supporting employees, these guidelines also help to minimize the economic burden of occupational diseases and accidents. Early dismissals and mining insurance bonuses can result in financiallosses brought on by these kinds of situations. Most of South Africa's largest mining firms have received certification, highlighting the importance of this standard's collaboration. To achieve the best results, this criterion can be improved by combining new and existing technology.

II. LITERATURE SURVEY

Coal, as a widely used fossil fuel, is essential for producing cement, steel, and generating electricity. However, due to hazardous fumes, fire risks, and a high incidence of accidents, coal mining—especially underground—poses significant dangers. Traditional mining techniques are greatly susceptible to inefficiencies and issues because they heavily rely on humans in perilous conditions. While rescue robots have been introduced for situations that occur post-disaster, there hasn't been much advancement inimplementing real-time monitoring systems during the mining process.

The "Harvey Dent: SmartGuard" project addresses this gap by introducing an Internet of Things-based robot with several sensors for hazard detection in real-time. Gas sensors from the MQ series detect methane and carbon monoxide; measurements of temperature and humidity are taken from the DHT11; human presence is identified using PIR sensors; and ultrasonic sensors aid in obstacle detection. Data processing and wireless communication are managed through a Raspberry Pi module, while a Raspberry Pi camera provides visual input. This setup enables remote supervision and prompt alert generation in case of dangers.

Wi-Fi is utilized for remote access via shared devices, while Bluetooth and BLE are being evaluated for short-range communication purposes. By integrating wireless technology with intelligent sensors, this system aims to improve both the effectiveness and safety of coal mining operations. With its capability for early alerts and rescue assistance, the robot having the capacity to greatly decrease the fatalities associated with mining.

III. PROPOSED APPROACH

1) *Modular Design Approach:*
- The project is segmented into different phases, including software development, sensor integration, controller choice, communication, and locomotion setup.

2) *Locomotion Mechanism:*
- A robot body designed for improved mobility across uneven mining terrain has been developed, incorporating a wheeled format with track mechanisms similar to those of a caterpillar.
- To obtain maximum torque and traction, DC geared motors are utilized.

3) *Central Control Unit:*
- Raspberry Pi 3 Bserves as the main microcontroller because of its compact design, integrated Wi-Fi/Bluetooth capabilities, and GPIO functionalities.
- Functions using Python for programming and allows remote access through VNC or terminal applications.

4) *Sensor Integration:*
- MQ Gas Sensor methane, CO, and other dangerous gases..
- DHT11 Sensor to measure temperature and humidity.
- Ultrasonic Sensor to sense obstacles and navigate independently.
- PIR Sensorto sense human presence.
- Pi Camera to monitor live video.

5) *Wireless Communication:*
- Sensor data is sent to the control room using Wi-Fi.
- The robot is operated and observed via the Telegram Bot API and a VNC Server interface.

6) *Assembly Strategy:*
- GPIO pins connect the sensors and motors, all of which are powered by a shared battery.
- Breadboards are utilized for preliminary circuit testing and for maintaining modularity.

7) *Software & Data Processing:*
- Python is utilized for collecting sensor data and managing control logic.
- Users receive immediate notifications and sensor data via a Telegram bot.

8) *Control & Monitoring:*
- Remote control of the robot through a smartphone or computer.
- A large number of users can access live streams and sensor information.

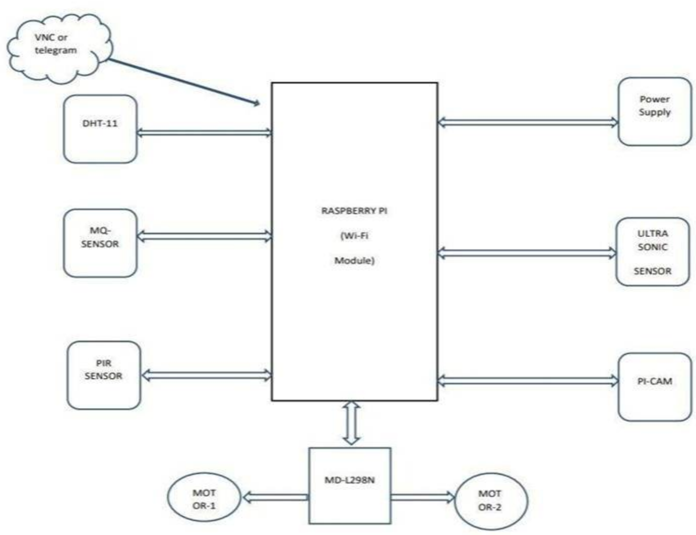

FIGURE 1. Flowchart of Model

IV. APPLICATIONS OF MASK-INCLUSIVE FACE RECOGNITION

1) *Real-time Hazard Detection*
- Identifies the existence of dangerous gases (like methane, carbon monoxide, etc.).
- Identifies elevated temperatures or abnormal vibrations indicating potential equipment failure or breakdowns.

2) *Remote Surveillance*
- Broadcasting video live and offering 360° visual monitoring in underground mining areas.
- Allows supervisors to monitor hazardous zones without needing to enter them.

3) *Worker Safety Monitoring*
- Monitors the real-time location of employees using RFID or GPS technology.
- Alerts if an employee is in a high-risk zone or does not move for a long duration (potential accident).

4) *Disaster Response and Rescue*
- Capable of being used in situations involving mine collapses, fires, or gas leaks.
- Assists in locating trapped miners using sensors and infrared technology.

5) Predictive Maintenance
- Monitors the vibration, temperature, and functionality of machinery.
- Issues preliminary alerts regarding mechanical issues before they result in breakdowns.

6) Data Logging and Analytics
- Gathers information from sensors for extended safety analysis.
- Helps mine managers identify trends and improve safety protocols.

7) Autonomous Patrolling
- Conducted both scheduled and independent surveillance within mining tunnels.
- Monitors hazardous or infrequently visited locations while ensuring personnel remain safe from risk.

8) Voice and Audio Communication
- Communication in both directions via voice between the miners and the control room during emergency situations.

V. ADVANTAGES OF FACE RECOGNITION SYSTEM

The primary objective of this project is to develop and utilize an intelligent, IoT-integrated robotic system capable of operating in hazardous environments to enhance security, monitoring, and emergency response.

1) Enhance Safety in High-Risk Zones

Use a robot to remotely report conditions to lessen human exposure to hazardous regions such as tunnels, chemical plants, mines, and disaster-affected areas.

2) Enable Real-Time Monitoring and Hazard Detection

To provide real-time environmental data — such as presence of gases, temperature, humidity, and motion—via sensors attached to a Raspberry Pi platform.

3) Facilitate Remote Surveillance via Live Video Feed

To include a Pi camera that uses programs like VNC Server and Telegram Bot API to transmit live photos to a distant command center.

4) Establish Seamless Communication Between Robot and Rescue Team

To transmit sensor data and emergency alerts (like Mayday signals) from within the risk area to a mobile phone interface or distant dashboard so that data-driven decisions can be made.

VI. CHALLENGES AND CONSIDERATION

1) Harsh Environmental Conditions
- Dust, humidity, heat, and low light levels found in mines can damage sensors and electronics.
- It is essential to make the robot sturdy, dustproof (IP rated), and waterproof.

2) Communication and Connectivity
- Wireless transmissions are frequently weak or nonexistent in subterranean settings.
- Sophisticated networking, including mesh networks, LoRa, or specific subterranean wireless systems, are necessary for robust IoT connection.

3) Navigation and Mobility
- Mines have barriers, uneven ground, and little passageways.

- The robot should have powerful mobility features like legs or wheels that can be tracked, as well as advanced sensors that can identify obstacles.

4) Power Supply and Battery Life
- Because underground power access is limited, the robot needs long-lasting batteries or effective power management.
- The possibility of incorporating energy harvesting or wireless charging stations.

5) Data Security and Privacy
- IoT devices are susceptible to cyber-attacks.
- Ensuring encrypted communication and secure storage of data is vital.

6) Cost and Maintenance
- Creating and sustaining a high-tech surveillance robot can be costly.
- The elements that are crucial to consider are inexpensive, easy to maintain, and resistant to harsh environments.

7) Real-Time Processing and Alerts
- Processing vast amounts of sensor data in real time is computationally difficult.
- There must be quick connectivity with a distant server or effective onboard data processing.

VII. KEY CONTRIBUTION

1) Enhanced Mining Safety Through Automation

Provides continuous, real-time monitoring in hazardous mining environments without posing a threat to human life.

2) IoT-Enabled Remote Monitoring

Boosts response times by integrating many sensors with IoT connectivity to provide remote data collection and real-time notifications.

3) Multi-Sensor Hazard Detection

Contains temperature, vibration, gas detection, and video monitoring to fully identify any risks.

4) Emergency Response Assistance

Uses sound detection and thermal imaging technology to quickly locate and rescue pinned miners.

5) Data-Driven Safety Improvements

Records operational and environmental data that may be analyzed for improved safety protocols and predictive maintenance.

VIII. CONCLUSION

The project's main goal is to send a prototype surveillance robot to help rescue workers stay safe in hazardous environments, such coalmines. After incidents like explosions, the robot is dispatched into dangerous areas to measure the temperature and gas content, providing crucial data for safe rescue operations. Future improvements include adding more sensors, like oxygen and humidity sensors, for a more thorough environmental study and using longer-range transceivers for extended coverage. Including a robotic arm would improve operational functionality by making sample collection and cleaning easier. Better components can be included in the prototype to enable real-time, efficient deployment in additional risky scenarios.

IX. FUTURE SCOPE

The existing technology and design have a lot of room for improvement, and many more features might be added. Different kinds of sensors, like temperature, pressure, heat, position, and proximity sensors, can be applied to deploy robots in many fields. Wireless networks can be applied to create multifunctional robots for industrial applications, home security, and surveillance, where the user can operate from home instead of having to physically be at the workplace.With further funding, we might implement the project's concept and build a real-time robot that could prevent some catastrophic catastrophes involving coal mine workers.

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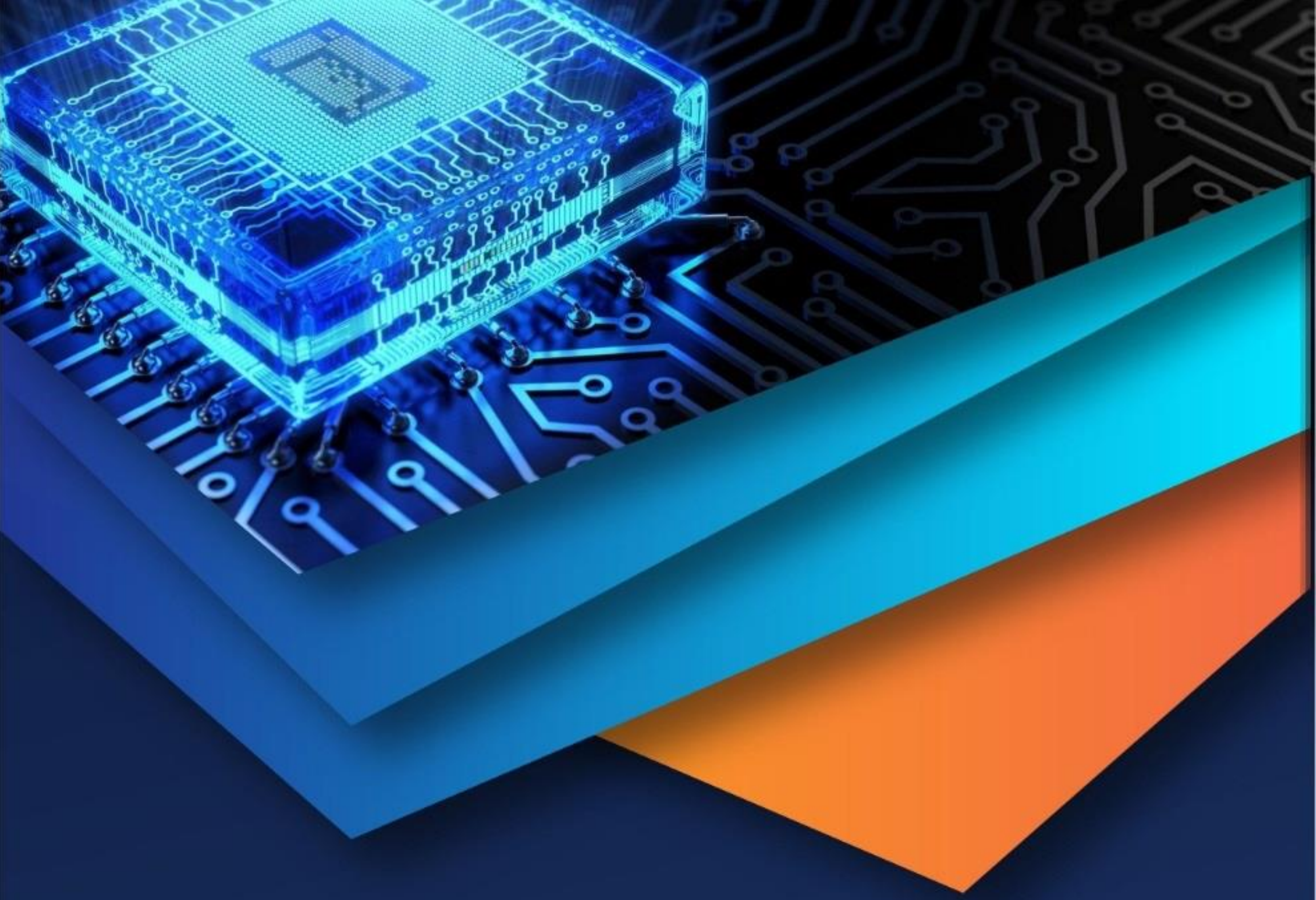

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