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DETECTING AVALANCHE VICTIMS EFFICIENTLY IN HARSH CONDITIONS

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Abstract:
Ensuring the safety of miners and other individuals in hazardous environments remains a significant challenge. In this paper, we propose a robust system for detecting avalanche victims using an IoT platform to transmit data. The system is designed to monitor and control various parameters critical for detecting avalanche victims, including light detection, temperature, and humidity conditions. The sensors, integrated into a unified IoT module, continuously upload data to the IoT system for real-time analysis.
In the event of any deviations from normal temperature levels, a buzzer is activated to alert individuals in the vicinity. The microcontroller triggers an alert when predefined threshold conditions are met, sending the information to the monitoring section via the IoT module. The collected data is then displayed on a web page through the IoT system, enabling continuous monitoring and timely response to potential threats.

Keywords: Arduino, Detecting Victims, Transmit Data, IoT Embedded Systems

1. INTRODUCTION

The Internet of Things (IoT) plays a crucial role in enhancing safety in hazardous environments, such as coal mines, where traditional communication systems may fall short. Mining operations, inherently fraught with risks, require innovative solutions to safeguard workers against various dangers. The integration of IoT technologies offers a promising approach to address these safety challenges by deploying advanced devices and systems designed to monitor and respond to potential hazards in real-time.
In mining environments, where communication systems can be expensive and challenging to maintain, IoT solutions provide a cost-effective and reliable alternative. The proposed system utilizes various IoT devices, including collision detectors, gas detectors, and smart helmets, to continuously monitor critical parameters. These devices are designed to detect potential hazards such as collisions, gas leaks, and helmet removal, and to trigger timely alerts to ensure the safety of miners.
Collision Detectors: These sensors are essential for identifying and alerting workers to potential collisions or hazardous impacts within the mine. By integrating collision detection technology, the system can provide immediate warnings to prevent accidents and injuries.

Gas Detectors: Mining operations often involve exposure to harmful gases. Gas detectors are used to continuously monitor air quality and detect the presence of toxic or flammable gases. When dangerous gas levels are detected, the system alerts miners through integrated warning systems.

Smart Helmets: Equipped with advanced sensors and communication capabilities, smart helmets play a pivotal role in the safety system. They are designed to monitor various parameters, including helmet removal, and communicate with other IoT devices via a Wi-Fi-based monitoring system.

The proposed system employs an ESP32 Arduino-based tracker circuitry to gather and transmit data wirelessly. This approach ensures efficient and cost-effective data transmission, avoiding the high costs and maintenance associated with wired communication systems in underground environments. The system's wireless capability allows for real-time monitoring and response, improving overall safety and reducing the risk of accidents.

Each helmet within the system is equipped with a panic/emergency button, which provides a critical means for miners to signal distress in case of emergencies such as toxic gas exposure, cave-ins, or physical injuries. This feature ensures that miners can quickly alert their colleagues and supervisors to any life-threatening situations, enabling rapid intervention and support.

By leveraging IoT technology, the proposed system aims to enhance mining safety through real-time monitoring, efficient communication, and timely alerts. This innovative approach not only improves the safety of miners but also contributes to more effective and proactive management of hazardous conditions in mining operations.

Existing System

Ensuring the safety of coal miners, who are regularly exposed to various hazards, remains a significant challenge. Existing safety systems have been developed to address some of these concerns by employing a range of sensors and technologies designed to monitor environmental conditions and the health of miners. The current system includes several key features:

1. **Hazard Detection:** The system incorporates sensors to detect dangerous gases, such as methane and carbon monoxide, which are commonly present in mining environments. These sensors continuously monitor air quality and alert miners and control rooms when hazardous gas levels are detected.
2. **Health Monitoring:** To safeguard miners' health, the system includes biometric sensors to monitor vital signs, such as heart rate. This feature is crucial for detecting health issues in real-time and responding to medical emergencies promptly.
3. **Environmental Monitoring:** The system tracks various environmental conditions within the mine, including temperature and humidity. This data helps in assessing the overall safety of the mining environment and identifying potential risks.
4. **Location Tracking:** GPS technology is used to pinpoint the location of miners within the mine. This feature is vital for locating workers in case of emergencies and ensuring their safety during rescue operations.
5. **Data Transmission:** The collected data, including sensor readings and location information, is transmitted via a secure Wi-Fi channel to a dynamic internet protocol system. This ensures that the data is readily accessible for analysis and decision-making.
6. **Emergency Response:** In the event of an emergency, such as the detection of hazardous gases or health issues, the system provides alerts through a wireless module. This alert

system is designed to facilitate quick response and intervention by notifying both the miners and the control room.

Despite its advantages, the existing system has some limitations:

- **Bluetooth Limitations:** The use of Bluetooth technology for communication presents challenges due to its short-range capabilities, which can be insufficient for extensive underground environments.
- **Cabling Difficulties:** The reliance on cabling for data transmission can be cumbersome and difficult to maintain in the challenging conditions of a coal mine.
- **GPS Limitations:** While GPS technology is useful for location tracking, it may be less effective in deep underground environments where satellite signals are weak or unavailable.

The current system employs a client-server architecture where miners' mobile devices can register, log in, and access their data. The server stores user credentials and other relevant information in a database, facilitating secure access and management.

Proposed System

The proposed IoT-based avalanche victim detection and monitoring system addresses the safety challenges faced by miners and other workers exposed to hazardous environments. The system is designed to enhance safety through continuous monitoring and timely alerts, leveraging both hardware and software components. Here's an overview of the proposed system:

System Overview

The proposed system comprises two main hardware modules: a transmitter and a receiver. These modules work together to monitor critical parameters and transmit data to a remote server for analysis and display.

Hardware Modules

1. **Transmitter Module:**
    - **Location:** Installed inside the avalanche area or on the victim.
    - **Components:**
        - **Arduino Board:** Acts as the main controller for the transmitter module.
        - **Sensors:**
            - **Smoke Sensor:** Detects the presence of smoke, which could indicate fire or other hazardous conditions.
            - **Temperature Sensor:** Monitors temperature changes to detect extreme conditions or fires.
            - **Ultrasonic Sensor:** Measures distances to detect obstacles or potential risks.
            - **Heartbeat Sensor:** Monitors the victim's vital signs to assess their health status.
        - **LCD Display:** Shows real-time data from the sensors on the transmitter module.
        - **Wi-Fi Module:** Transmits the sensor data to a remote IoT server every two minutes.
    - **Functionality:**
        - The Arduino board collects data from the sensors and displays it on the LCD screen.

        - The data is periodically sent to the remote IoT server via the Wi-Fi module.
        - If any sensor values exceed predefined threshold levels (e.g., high temperature or low heartbeat), a buzzer is activated to alert nearby personnel of potential dangers.
2. **Receiver Module:**
    - **Location:** Located remotely, typically in a control room or monitoring station.
    - **Components:**
        - **Remote IoT Server:** Receives and processes data transmitted by the transmitter module.
        - **IoT Platform:** Hosts a graphical user interface (GUI) that displays the collected data and allows users to monitor conditions and control the system.
    - **Functionality:**
        - The IoT platform provides a real-time visualization of sensor data, allowing users to monitor the status of the avalanche site.
        - The GUI enables system control and analysis, helping users make informed decisions and respond to emergencies.

System Benefits

- **Real-time Monitoring:** The system provides continuous monitoring of critical parameters, ensuring timely detection of hazardous conditions and health issues.
- **Automated Alerts:** The automatic triggering of alarms (buzzer) ensures immediate attention to potential dangers, enhancing safety.
- **Data Transmission:** Wireless data transmission using the Wi-Fi module enables efficient communication between the transmitter and the remote server, reducing the need for physical cabling.
- **Remote Access:** The IoT platform allows remote access to data, facilitating effective management and control of the monitoring system.

Modules:

IoT (Internet of Things)

The Internet of Things (IoT) connects devices through the internet, enabling them to exchange data and be controlled remotely. This connectivity optimizes processes, enhances efficiency, and introduces innovative services across various sectors. From smart homes that automate lighting and climate control to industrial automation systems that improve manufacturing efficiency, IoT is transforming our interaction with the physical world by integrating digital intelligence into everyday objects and systems.

Sensors

Sensors are devices that detect and measure physical properties such as temperature, pressure, humidity, and light. They convert these physical measurements into electrical signals that can be processed by electronic systems. Sensors are pivotal in enabling automation and IoT applications, as they provide the data needed to monitor and control environments. For example, temperature sensors can trigger cooling systems, while light sensors can adjust lighting based on ambient conditions. Their versatility spans across numerous fields, including healthcare, automotive systems, environmental monitoring, and smart home technology.

GPS Module

The GPS (Global Positioning System) module is a critical component for determining geographic location, velocity, and time by receiving signals from satellites. Utilizing trilateration, the GPS module calculates precise coordinates based on signals from multiple satellites. It is widely used in navigation systems, vehicle tracking, and mapping applications. The GPS module's ability to provide accurate location data makes it essential for applications requiring precise positioning and tracking.

LCD (Liquid Crystal Display)

LCD screens are used in IoT devices to provide visual output, displaying real-time data and facilitating user interaction. They enhance the user experience by showing information such as sensor readings, system alerts, and operational status. In IoT systems, LCDs enable users to monitor and control connected devices efficiently by offering clear and immediate feedback. They play a crucial role in making complex data accessible and actionable through intuitive visual displays.

Buzzer

Buzzers are components used in IoT devices to emit audible alerts or notifications based on specific conditions or events. They provide real-time auditory feedback for occurrences such as alarms, system errors, or critical warnings. By incorporating buzzers, IoT systems can alert users to important events or changes in status, adding an additional layer of notification and enhancing the system's responsiveness and effectiveness.

ATmega328

The ATmega328 is a popular microcontroller used in various IoT devices due to its low power consumption and versatile functionality. It facilitates the processing of sensor data, manages communication protocols, and controls device operations. Compatible with Arduino platforms, the ATmega328 enables efficient development and implementation of IoT solutions. Its integrated features support a wide range of applications, from simple automation tasks to complex data processing, making it a valuable component in the design and deployment of IoT systems.

Advantages

- **Cost-Effective and Easy Maintenance**: The project utilizes easily available and reasonably priced components, making it cost-effective. This accessibility also simplifies maintenance, ensuring that the system remains affordable and manageable over time.
- **Enhanced Safety for Mine Workers**: This system is crucial in the coal mining industry, significantly contributing to the health and safety of mine workers by continuously monitoring hazardous conditions and providing timely alerts.
- **Remote Monitoring Capabilities**: Supervisors and managers can monitor critical parameters from inside the mine remotely via the IoT platform, providing real-time oversight and control from anywhere in the world.
- **Compact and Lightweight Design**: The system is designed to be compact and lightweight, making it convenient to install and use in various environments, including challenging underground mining conditions.
- **Low Power Consumption**: The system consumes 50-70% less energy compared to traditional CRT monitors, making it more energy-efficient and reducing operational costs.

- **No Geometric Distortion**: The use of LCD technology eliminates geometric distortion, ensuring clear and accurate display of information.
- **Minimal Flicker**: Depending on the backlight technology used, the system can exhibit little or no flicker. LCD panels are typically refreshed at 200 Hz or more, minimizing flicker regardless of the source refresh rate.
- **Reduced Eye Strain**: The thin design of LCD monitors allows them to be placed further from the user, reducing close-focusing related eye strain. Additionally, LCD monitors do not suffer from geometric distortion, enhancing visual comfort.
- **Sharp Image Quality**: LCD screens offer razor-sharp images with no bleeding or smearing, especially when used at their native resolution, providing clear and detailed visual output.
- **Lower Electromagnetic Radiation**: LCD monitors emit less electromagnetic radiation compared to CRT monitors, contributing to a healthier working environment.
- **No Screen Burn-In**: Unlike CRT monitors, LCD screens are not affected by screen burn-in, though they can experience image persistence. This means the display remains consistent without permanent ghost images.
- **Flexible Size and Shape**: LCD technology allows for the creation of displays in virtually any size or shape, offering versatility in design and application.
- **No Theoretical Resolution Limit**: LCD technology does not have a theoretical resolution limit, enabling high-resolution displays that can accommodate detailed and intricate information.

3.4. Architecture Diagram:

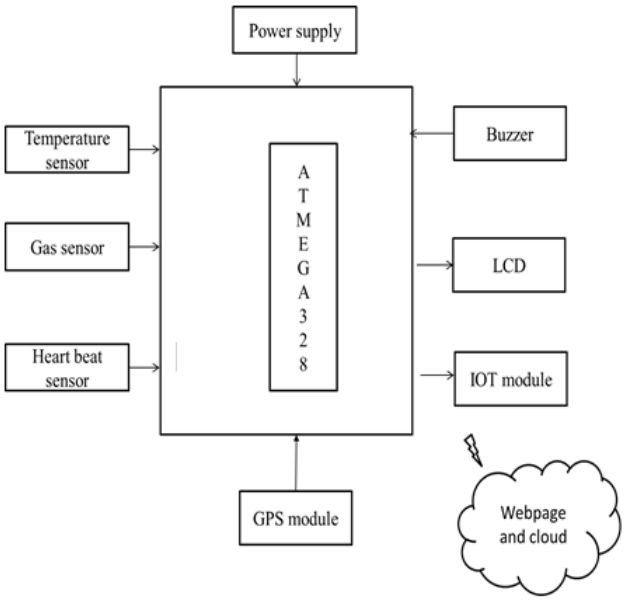

Figure1.3: Architecture Diagram

Conclusion

The proposed prototype aims to enhance miner safety by continuously monitoring environmental and health parameters in real-time and taking appropriate actions when conditions become unsafe. This prototype utilizes a three-tier architecture to achieve its objectives:

1. **First Tier**: Health and environmental parameters are measured using an Arduino Uno. This initial stage gathers critical data about the miner's surroundings and their health status.
2. **Second Tier**: The fuzzy classifier analyzes the data from the first tier to categorize the environment. This classification helps in assessing whether the working conditions are safe or hazardous.
3. **Third Tier**: The data is stored in a cloud database for future reference and to generate health reports for the miners. Additionally, this tier is responsible for alerting the monitoring and rescue teams if an emergency occurs, including providing the GPS location of the miner for quick intervention.

The prototype has been evaluated in three different environments: indoor, outdoor industry, and coal mining settings. The results indicate high accuracy for the prototype, with performance metrics of 99% for indoor environments, 97% for outdoor industry environments, and 96% for coal mining environments.

These findings demonstrate that the proposed prototype effectively assesses the suitability of working conditions for miners based on real-time health and environmental data. In the event of hazardous conditions, the system first alerts the miner and, concurrently, notifies the monitoring and rescue teams with the miner's GPS location to facilitate a swift response.

Comparative analysis with existing prototypes shows that the proposed model performs equivalently in indoor environments and outperforms existing models in outdoor and coal mining environments. This indicates that the proposed prototype offers a significant improvement in safety monitoring and emergency response capabilities for miners, making it a valuable tool for enhancing occupational health and safety in various settings.

Future Enhancements

In future iterations of the AI/ML-based technology designed for detecting avalanche victims in harsh conditions, several advancements will be targeted to improve real-time responsiveness and adaptability:

1. **Advanced Deep Learning Architectures**: By integrating cutting-edge deep learning models, the system will enhance its ability to analyze complex and dynamic avalanche scenarios. Techniques such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs) will be employed to improve the accuracy of victim detection and environmental assessment.
2. **Reinforcement Learning**: Implementing reinforcement learning methodologies will enable the system to adapt and optimize its decision-making processes based on real-time feedback. This approach will allow the system to continuously learn from new data and evolving conditions, enhancing its effectiveness in diverse and changing avalanche situations.
3. **Edge Computing and Decentralized Processing**: Incorporating edge computing capabilities will reduce data processing latency and improve the system’s responsiveness in remote areas. Decentralized processing will ensure that critical data can be analyzed

locally, even when connectivity to central servers is limited, thus enhancing the system's reliability in challenging environments.

4. **Advanced Robotics and Autonomous Drones**: The future system will integrate autonomous drones equipped with sophisticated sensors and imaging technologies. These drones will perform rapid aerial assessments of avalanche-prone areas, extending the reach of the technology and providing valuable real-time data from otherwise inaccessible locations.
5. **Enhanced Sensor Integration**: The addition of advanced sensors capable of detecting various environmental conditions, such as ground vibrations and snow density, will improve the system's ability to predict and respond to avalanches. These sensors will provide comprehensive data, facilitating more accurate victim detection and environmental monitoring.
6. **Real-Time Data Fusion**: Future enhancements will include the development of systems capable of fusing data from multiple sources, including ground-penetrating radar, satellite imagery, and on-site sensors. This data fusion will provide a more holistic view of the avalanche conditions, enabling better decision-making and response strategies.

These enhancements are designed to fortify the system's efficacy, scalability, and adaptability, ensuring it remains a critical tool in mitigating the impact of avalanches on human lives in challenging environments. By advancing these technologies, the system will not only improve safety for individuals in avalanche-prone areas but also contribute to more effective and timely rescue operations.

REFERENCES

1. Lin, B., & Raza, M.Y. (2020). Coal and economic development in Pakistan: A necessity of energy source. *Energy*, 207, 118244.
2. Jeong, M., Lee, H., Bae, M., Shin, D.B., Lim, S.H., & Lee, K.B. (2018, October). Development and application of the smart helmet for disaster and safety. In *2018 International Conference on Information and Communication Technology Convergence (ICTC)* (pp. 1084-1089). IEEE.
3. Ghulam E Mustafa Abro, Shoaib Ahmed Shaikh. (2018). Prototyping IoT based smart wearable jacket design for securing the life of coal miners. In *2018 International Conference on Computing, Electronics & Communications Engineering (ICCECE)*.
4. Tian, J., & Zhu, J. (2011). Positioning system for miners based on RFID. In *2011 International Conference on Multimedia Technology*.
5. Kock, D., & Oberholzer, J.W. (1997). The development and application of electronic technology to increase health, safety, and productivity in the South African coal mining industry. *IEEE Transactions on Industry Applications*, 33.
6. Gaidhane, M.D., & Qureshi, R. (2016). Smart helmet for coal miners using ZigBee technology. *Imperial Journal of Interdisciplinary Research (IJIR)*, 2(6), ISSN: 2454-1362.
7. Cheng, Q., Sun, J.P., Zhang, Z., & Zhang, F. (2009). ZigBee based intelligent helmet for coal miners. In *World Congress on Computer Science and Information Engineering*.
8. Wu, Y., Guo, F., & Zhang, M. (2014). The study on coal mine using Bluetooth wireless transmission. In *2014 IEEE Workshop on Electronics, Computer and Applications*.

9. Al-Suwaidi, G.B., & Zemerly, M.J. (2009). Locating friends and family using mobile phones with global positioning system (GPS). In *IEEE/ACS International Conference on Computer Systems and Applications*.
10. Jesudoss, A., Vybhavi, R., & Anusha, B. (2019, April). Design of smart helmet for accident avoidance. In *2019 International Conference on Communication and Signal Processing (ICCSP)* (pp. 0774-0778). IEEE.
11. Mohammed, M.N., Syamsudin, H., Al-Zubaidi, S., AKS, R.R., & Yusuf, E. (2020). Novel COVID-19 detection and diagnosis system using IoT based smart helmet. *International Journal of Psychosocial Rehabilitation*, 24(7), 2296-2303.