Safety Jacket for Securing the Life of Coal Miners

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Abstract

According to the statistical report, mining and construction industry research has established that accidents are always brought on by a combination of hazards and causes. Gas blast or residue could be the cause of the breakdown and surge in underground work. In a similar vein, a fire may cause dangerous substances to be released. Miners' excessive proximity to the blast was the primary cause of explosive related fatalities, followed by poisoning from explosive fumes, misfires, and premature blasts. Explosives may have caused an earthquake that shattered the structure of the mine and trapped miners underground. Mine activated seismicity ought to be added to that overview. The excavators will get an unsafe sickness because of the risky gases, like carbon dioxide, carbon monoxide, methane, ethane, propene, and others, that are available in the mining region. All of the previously mentioned issues can be tried not to by go to fitting precaution lengths. The solution to this issue is the Smart safety jacket, an IoT device that is affixed to the jacket. This shrewd security coat interfaces with various sensors, including a heart beat sensor,temperature sensor, buzzer, accelerometer,GMS module .These sensors, which are connected to the network via Wi-Fi, have never been more important or valuable. At the core of our solution lies the NodeMCU microcontroller, serving as the central control unit for data acquisition and transmission. Interfaced with an array of sensors including temperature, heartbeat and motion sensors, the NodeMCU facilitates continuous collection of key physiological data, essential for comprehensive patient monitoring. Leveraging the ESP8266 module, the collected data is wirelessly transmitted to the cloud-based ThingSpeak IoT platform in real-time, overcoming geographical barriers and enabling seamless remote access for healthcare providers.

Introduction:

In today's era where safety and security is the top most priority in various critical processes similarly in coal industries the people assure the same thing. While studying the latest facts it has been reported about one incident by International Alliance in Support of Workers in Iran. This incident held inside sanjdi coal mine near Quetta, Baluchistan in which 6 people died due to poisonous gases. The Industrial Global Union along with Pakistan Central Mines Labor Federation is very much conscious about this problem and yet this issue is unsolved with any optimum solution. This system will not only locate the exact depth and GPS location of miner but it will continuously be updating the pulse rate of miner. These systems in this way help the rescue team to dig at right places with exact depth to take out miners back to ground. At the heart of our endeavour lies the NodeMCU microcontroller, a versatile platform renowned for its adaptability and efficiency. By interfacing with an array of sensors including temperature, heartbeat sensor and motion sensors, the NodeMCU forms the nucleus of our real-time monitoring system. These sensors serve as vigilant sentinels, continuously capturing vital physiological data

Problem Statement

In the challenging and demanding environment of mining, where workers face numerous risks and potential health hazards, there is a critical need for innovative solutions to enhance both safety and overall well-being. The problem at hand revolves around the lack of comprehensive health monitoring systems tailored specifically for miners. Traditional work attire fails to address the unique health concerns of individuals working in mines, leaving them vulnerable to undetected health issues and potential emergencies.

Objectives

• Develop a scalable and adaptable system architecture for real-time remote monitoring of patients' vital signs, integrating advanced sensor technology, wireless communication, and cloud-based analytics.

• Interface the NodeMCU microcontroller with a comprehensive suite of sensors, including temperature, heartbeat and motion sensors, to enable continuous collection of key physiological data.

• Implement continuous heart rate monitoring to detect abnormal fluctuations in heart rate, providing early indications of potential health issues. This proactive approach to monitoring cardiovascular health can lead to early intervention and better health outcomes.

• Utilize buzzer alarms and LED lights to provide both auditory and visual cues to guide patients in taking their medication. This feature ensures that patients, including those with visual or hearing impairments, can adhere to their medication schedule effectively. Develop a jacket that provides protection against environmental hazards typically faced by miners, such as dust, chemicals, and low visibility conditions.

Literature review

[1] Chaitanya Kulkarni “Safety of Coal Miners using IoT” (ICICNIS 2021)
In this paper, the coal mine safety system is implemented. With the emergence of Industrial Internet of Things (IIoT) a smart safety jacket is developed which will monitor the miner’s health and also provide precautionary measures for miner’s safety using concept of IoT. Integrating smart safety jackets with different health sensors such as pulse sensor, temperature sensor, blood pressure sensor, Electroencephalogram (EEG) sensor and then connects it with NodeMCU which is a Wi-Fi module and connect it with the internet. Sensors constantly send the sensor data to the cloud and if any abnormal situation occurs it will send a message to the responsible person in the control room as well as it will alert the miners.
[2] Siddhesh Dambe “Smart Safety Vest For Miners” e-ISSN:2395-0056 Volume: 10 Issue: 03 | Mar 2023 www.irjet.net p-ISSN: 2395-0072

Mines are found all across the globe and are used to mine various metals, non-metals as well as other resources. The concept of mining brings along various other aspects such as accidents, flammable gasses, toxic gasses, etc. These attributes prove to be a major risk to life and health. In certain events, it has been observed that zones of high concentration of Nitrogen or Carbon dioxide are formed, or mines may even contain some zones of oxygendeficient air in some sealed passages.The developed product is used to detect the presence of toxic and flammable gasses in the environment of the miner, the miner's pulse rate, the zonal location of the miner, and other

attributes of his environment such as temperature, pressure, and humidity. The measured parameters are sent to the administrator or supervisor through the Wifi module(ESP8266-01) via the Thingspeak Channel which is used for the visualization and storage of data.

[3] Aman Ul Azam Khan 1 "Development of the Smart Jacket Featured with Medical, Sports, and Defense Attributes using Conductive Thread and Thermoelectric Fabric" November 2022.

The exigency of humans is boosting the necessity of Smart Textiles in this modern era. A decade ago, envisioning sophisticated outerwear with several uses were considered a challenge. This study aims to a jacket with 15 features; divided into 7 groups, including defense, sports, health, medical, women, and children safety mechanisms, 4 out of these 15 functions can be controlled by an Android app, "Smart Jacket BUFT". To avoid nonrenewable energy sources, solar power and energy harvesting technology to produce electricity from body heat and foot-powered energy were used, Smart jacket has embedded circuits and sensors alone with AD8232, MAX30100, NEO6m GPS, and ESP32 microcontrollers & voice and app-control. It is hoping that; his initial stage of growth and improvement will pave the way for subsequent activities.

Methodology

The methodology for developing the smart jacket for miners with integrated health monitoring systems encompasses a systematic and comprehensive approach aimed at addressing the specific challenges and requirements of the mining industry. It begins with a thorough requirement analysis, where the unique health risks and environmental conditions faced by miners are identified and analyzed in depth. This analysis serves as the foundation for subsequent decision-making processes. Following the requirement analysis, the appropriate sensors are carefully selected to monitor vital signs such as heart rate, body temperature, and respiratory rate, as well as environmental factors like air quality and temperature within the mine. The chosen sensors must be capable of providing accurate real-time data while being durable and non-intrusive in order to ensure continuous monitoring without impeding the miner's movements.

Once the sensors are selected, they are integrated into the design of the smart jacket, along with a communication module for data transmission. This integration process requires careful consideration of factors such as sensor placement, power management, and user interface design to optimize the functionality and usability of the jacket. Data processing and analysis algorithms are then developed to interpret and derive meaningful insights from the collected sensor data. These algorithms filter and analyze the data to identify potential risks or anomalies, enabling the system to trigger alerts in real-time if any health parameter falls outside the normal range. The alert system is implemented with both visual and auditory cues to ensure immediate attention to critical situations. Additionally, a user-friendly interface is designed to allow miners to interact with the smart jacket and access real-time feedback on their health status and environmental conditions. Throughout the development process, durability and ergonomics are prioritized to ensure that the smart jacket can withstand the harsh conditions of mining environments while providing comfort and ease of movement for the miner.

DISSERTATION PLAN:

Components Used:

Hardware components:

1. Node MCU
2. Heartbeat Sensor
3. DHT11 temperature sensor
4. ADXL345 Accelerometer

5. GSM module

Software components

1. Arduino IDE

Hardware Components:

1. Node MCU:

Fig 1: Node MCU

The NodeMCU is an open-source firmware and development board based on the ESP8266 Wi-Fi module. It's designed to make it easier to prototype IoT (Internet of Things) applications and projects. The board combines the ESP8266 with a USB-to-serial converter and a power regulator, making it easy to connect and program via USB. NodeMCU boards are popular for IoT projects due to their low cost, built-in Wi-Fi capabilities, and the ease of programming with Lua or Arduino IDE. They're widely used for home automation, sensor monitoring, and various other IoT applications.

Specifications:

1. Operating Voltage: 2.5 to 3.3V
2. Operating Current: 800 mA
3. On-board Voltage Regulation: 3.3V, 600mA
4. Switches: Reset and Flash buttons for resetting and firmware upgrades respectively
5. LED Indicator: Connected to D0 pin
6. USB to UART Module: CP2102 for USB to serial data conversion
7. Power Pins: VIN for input power supply, three 3.3V pins for output supply
8. Ground Pins: Three GND pins for ground supply
9. I2C Pins: Used for connecting I2C sensors and peripherals
10. GPIO Pins: 17 pins assignable to various functions
11. UART Interfaces: UART0 and UART1 for asynchronous communication
12. SPI Interfaces: Support for SPI in both slave and master modes
13. SD Card Interface: Direct control of SD cards

2. ADXL345 Accelerometer:

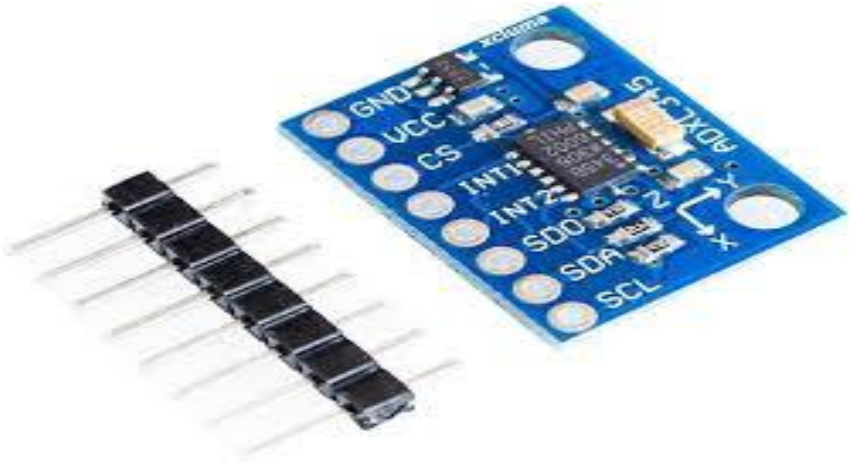


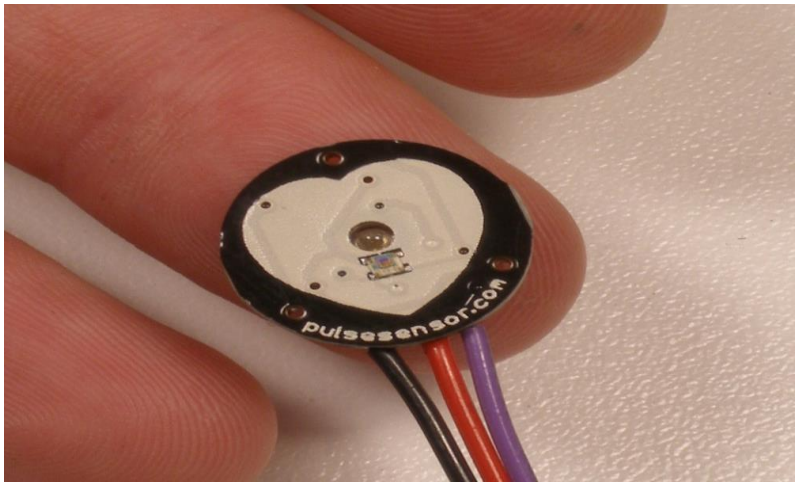
Fig 2: ADXL345 Accelerometer

The ADXL345 Accelerometer is a sensor capable of detecting motion and changes in acceleration across three axes (x, y, and z). Widely used in various electronic devices and systems, it provides data on movement magnitude and direction, making it valuable for applications like activity monitoring, fall detection, tilt sensing, and gesture recognition. With options for high-resolution output and selectable measurement ranges, it communicates seamlessly with microcontrollers via I2C or SPI protocols. Its compact size, low power consumption, and robust design make it suitable for integration into diverse projects, from consumer electronics to industrial automation, enhancing functionality and enabling precise motion tracking and control.

Specifications:

1. Ultra-Low Power: Measurement mode: as low as 23 µA, standby mode: 0.1 µA at VS = 2.5 V (typical)
2. Automatic Power Scaling: Power consumption adjusts automatically with bandwidth
3. Resolution: Selectable resolution with fixed 10-bit resolution and up to 13- bit resolution at ±16 g
4. Memory Management: Embedded FIFO technology minimizes host processor load
5. . Detection Features: Single tap/double tap detection, activity/inactivity monitoring, and free-fall detection
6. Voltage Range: Supply voltage range: 2.0 V to 3.6 V, I/O voltage range: 1.7 V to VS
7. Interfaces: Supports SPI (3- and 4-wire) and I2C digital interfaces
8. Interrupts: Flexible interrupt modes mappable to either interrupt pin
9. Selectable Parameters: Measurement ranges and bandwidth selectable via serial command
10. Temperature Range: Wide temperature range: -40°C to +85°C
11. Shock Survival: Survives shocks up to 10,000 g

3. Heart Beat Sensor



Designed with the unique needs of miners in mind, this innovative wearable incorporates a comprehensive health monitoring system, including a state-of-the-art heart rate sensor. The heart rate sensor is seamlessly integrated into the fabric of the jacket, allowing for continuous and real-time monitoring of the miner's cardiovascular activity. This vital sign data is then transmitted to a central control system, providing immediate insights into the miner's well-being.

The heart rate sensor operates with exceptional precision, ensuring accurate readings even in challenging underground environments. This feature is particularly crucial for miners who often face physically demanding conditions and potential health risks associated with prolonged periods of exertion. By continuously monitoring heart rate, the Smart Jacket enhances safety measures by detecting any abnormal cardiac activity promptly.

Additionally, the Smart Jacket goes beyond basic heart rate monitoring, incorporating various health sensors to track other vital signs such as body temperature and respiratory rate. This holistic approach to health monitoring ensures a comprehensive overview of the miner's physiological condition. In the event of any anomalies or signs of distress, the Smart Jacket can trigger alerts to both the miner and the control center, enabling swift intervention and potentially preventing more serious health issues.

Ultimately, the Smart Jacket for miners with its integrated heart rate sensor and comprehensive health monitoring system not only prioritizes the safety and well-being of miners but also represents a significant leap forward in utilizing wearable technology to enhance occupational health and safety standards in the mining industry.

4. GSM

GSM/GPRS Modem-RS232 is built with the Quad-Band GSM/GPRS engine-SIM800C, works on frequencies 850/900/1800/1900MHz. The module comes with RS232 interface, which allows you to connect PC as well as microcontroller with RS232 Chip (MAX232). The baud rate is configurable from 9600-115200 through AT command. The GSM/GPRS modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. This module is suitable for SMS, Voice as well as DATA transfer application in M2M interface. The onboard Regulated Power supply allows you to connect wide range of unregulated power supply. Using this modem, you can make audio calls, SMS, Read SMS, attend the incoming calls and internet etc., through simple AT commands.

Fig 4: GSM Module SIM800C

Features

1. Quad-Band GSM/GPRS 850/900/1800/1900MHz.
2. RS232 interface for the direct communication with computer or MCU kit.
3. Configurable Baud Rate.
4. Power controlled using 29302WU IC.
5. ESD Compliance.
6. Enable with MIC and Speaker socket.
7. Enable with Audio Jack
8. With push-push sim card holder.
9. With Stub antenna and SMA connector.
10. Input Voltage: 12V DC.

5. Temperature Sensor

This innovative garment integrates various health monitoring systems, including a temperature sensor, to ensure the well-being of miners in challenging work environments. The temperature sensor embedded in the smart jacket constantly measures and records the ambient temperature, providing real-time data to alert miners to potential hazards such as extreme heat or cold. This feature is crucial for preventing heat-related illnesses or hypothermia, which are common risks in mining operations. Moreover, the smart jacket goes beyond temperature monitoring, incorporating a comprehensive health monitoring system.

Sensors embedded in the fabric continuously track vital signs such as heart rate, respiratory rate, and even oxygen levels. This real-time health data is transmitted wirelessly to a central monitoring station, allowing supervisors to remotely assess the well-being of each miner and respond promptly to any signs of distress. The integration of these monitoring technologies enhances overall safety by enabling proactive measures to be taken in the event of an emergency. In addition to its health monitoring capabilities, the smart jacket is designed with durability and comfort in mind. The fabric is resistant to environmental hazards common in mining, such as dust, moisture, and abrasions, ensuring the longevity of the garment in challenging conditions. The jacket is also equipped with ergonomic features to provide miners with flexibility and ease of movement during their work.

Fig 5: Temperature Sensor

6. Safety Jacket –

High-visibility clothing, sometimes shortened to hi vis or hi viz, is any clothing worn that is highly luminescent in its natural matt property or a color that is easily discernible from any background. It is most commonly worn on the torso and arm area of the body. Health and safety regulations often require the use of high visibility clothing as it is a form of personal protective equipment.[1][2][3] Many colors of high visibility vests are available, with yellow and orange being the most common examples. Colors other than yellow or orange may not provide adequate luminescence for conformity to standards such as ISO 20471.

As a form of personal protective equipment, high-visibility clothing is worn to increase a person's visibility and therefore prevent accidents caused by persons not being seen. As a result, it is often worn in occupations where hazardous situations are created by moving vehicles or low lighting conditions. These occupations include railway and road workers, airport workers and emergency services. Cyclists and motorcyclists may also use high-visibility clothing to increase their visibility when operating amongst motor traffic.[4] Hunters may be required to wear designated high-visibility clothing to prevent accidental shooting.

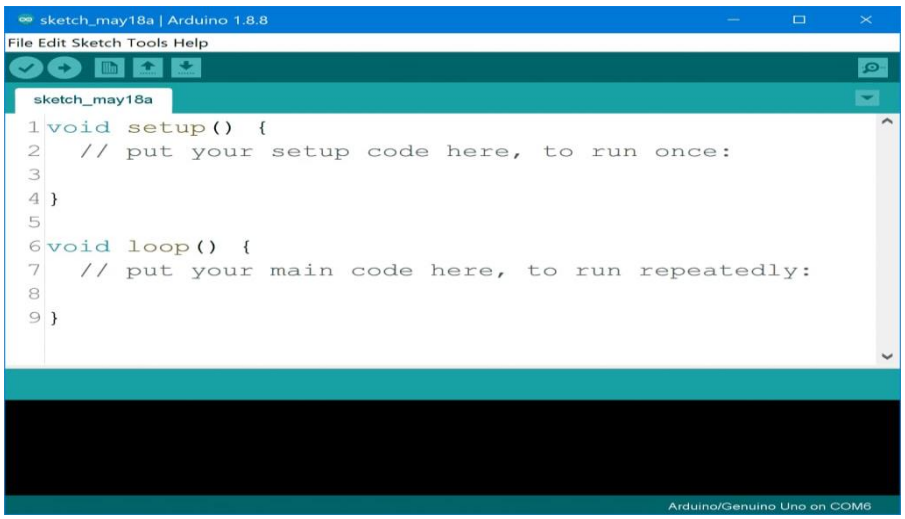


Fig 6: Safety Jacket

Software components:

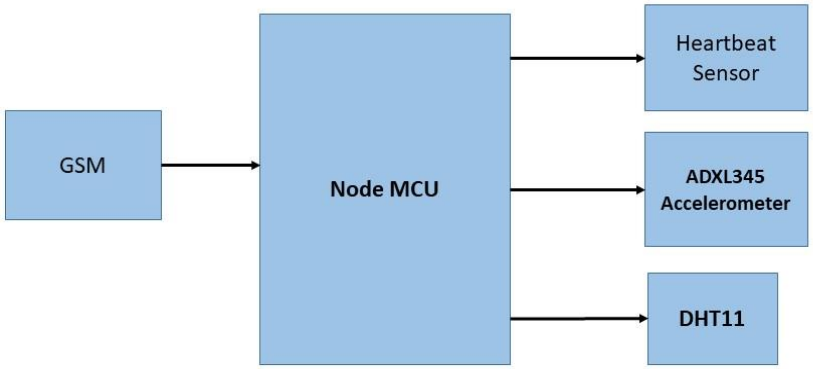
Arduino IDE

The Arduino Integrated Development Environment (IDE) is a user-friendly software platform designed for programming and developing applications for Arduino microcontroller boards. It provides an intuitive and versatile environment for writing, uploading, and debugging code for a wide range of projects. The Arduino IDE is open-source and supports a simplified version of the C and C++ programming languages, making it accessible to both beginners and experienced developers. It comes with a comprehensive library of pre-written code, or "sketches," that can be easily customized, enabling users to interact with various sensors, actuators, and other electronic components. The IDE also offers a straightforward interface for managing board configurations, including selecting the specific Arduino board and its associated parameters. With its built-in serial monitor for real-time data communication and a simple upload process, the Arduino IDE has become an
invaluable tool for countless makers, hobbyists, and professionals in the world of embedded electronics and microcontroller programming.

Specifications:

- Function: Integrated Development Environment for Arduino.
- Programming Language: Simplified C/C++.
- Open-Source: Free and community-supported.
- Code Library: Extensive collection of pre-written code for various components.
- Board Support: Configurable for different Arduino boards.
- Serial Monitor: Built-in for real-time data communication.
- User-Friendly: Suitable for beginners and experienced developers.
- Versatile: Used for a wide range of embedded electronics projects

BLOCK DIAGRAM:



PROPOSED WORK

The proposed work for this project involves the comprehensive development and deployment of a sophisticated smart jacket meticulously engineered to safeguard miners' health and safety within the challenging confines of mining environments. It's a multifaceted endeavor, commencing with an exhaustive needs assessment and requirements gathering phase, which entails meticulous scrutiny of the unique occupational hazards and health risks prevalent in mining activities. Leveraging insights gleaned from this analysis, the project proceeds to intricately select and integrate cutting-edge sensors into the fabric of the jacket. These sensors, meticulously positioned to ensure unobtrusive yet accurate monitoring, encompass a spectrum of vital signs including heart rate, respiratory rate, body temperature, and environmental factors such as air quality and temperature variations. The data harvested from these sensors is subjected to rigorous processing and analysis through advanced algorithms meticulously designed to detect anomalies or deviations indicative of potential health hazards. In tandem, the project meticulously integrates communication functionalities, enabling seamless transmission of real-time health data and facilitating swift and effective interaction between miners and supervisory personnel. Moreover, paramount emphasis is placed on the jacket's design, prioritizing durability, comfort, and regulatory compliance to ensure it seamlessly integrates into miners' routines without impeding their productivity or mobility.

Conclusion

In conclusion, the health monitoring project represents a significant advancement in healthcare technology, offering a comprehensive solution for remote patient monitoring and management. By integrating sensors, microcontrollers, and cloud-based platforms, the project enables continuous monitoring of vital signs and early detection of health issues, leading to improved patient outcomes and quality of care. The project has a wide range of applications across healthcare, wellness, and safety domains, including remote patient monitoring, elderly care, occupational health, and clinical research. Future developments hold great promise for further enhancing the project's capabilities through the integration of advanced sensors, machine learning algorithms, telemedicine integration, and scalability for global deployment. With its potential to revolutionize healthcare delivery and improve access to quality care, the health monitoring project represents a significant step towards the realization of personalized, proactive, and accessible healthcare for individuals worldwide.

Result

The implementation of the smart jacket for miners with integrated health monitoring systems yields tangible improvements in safety and well-being within the mining industry. Through continuous real-time monitoring of vital signs and environmental conditions, the smart jacket enables early detection of potential hazards, reducing the incidence of accidents and health emergencies. Miners and supervisory personnel benefit from enhanced awareness and accountability, empowered by actionable insights into on-the-ground conditions. Additionally, the project drives advancements in occupational health management practices, leveraging data-driven insights to optimize safety protocols and foster a culture of continuous improvement. By setting a precedent for the integration of wearable technology in high-risk industries, the project inspires similar initiatives across diverse sectors, ushering in a future of safer, smarter, and more sustainable workplace practices.

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