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An Industrial Helmet for Air Quality and Hazardous Event Detection using Smart Band

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***Abstract:** A smart helmet has been developed that is able to detect of hazardous events in the mine industry. In the development of helmet, we have considered the two main types of hazard such as air quality and collision (miners are struck by an object). The first is the concentration level of the hazardous gases such as CO, SO2, NO2, and particulate matter. The second hazardous event is defined as an event where miners are struck by an object against the head with a force exceeding a value of 1000 on the HIC (Head Injury Criteria). An accelerometer was used to measure the acceleration of the head and the HIC was calculated in software. The layout of the visualization software was completed, however the implementation was unsuccessful. Tests were successfully done to calibrate the accelerometer. PCB's that were designed and made included a breakout board and a prototype board. A whole software implementation was done based on Aurdino operating system in order to do the control of the measuring of sensors and of calculations done with the measured values. This paper presents the undertaken design detailing solutions to issues raised in previous research.*
***Key Terms:** Air quality, Mining, Safety, Wireless sensor networks, ZigBee*.

I. INTRODUCTION

Today's world is known for its extensive and diverse mineral resources and large number of mining and Construction industries. Supervisors are held responsible for all injuries sustained under their supervision, and should therefore be aware of potentially risky situations. The improvement of a industrial helmet in order to ensure more safety awareness between employees. When working with noisy and risky equipment, being aware of one's surroundings can sometimes be challenging. In the industries employees tend to remove some of their safety gear because the gear is too heavy, warm or uncomfortable to work with. However, employees generally do not remove their helmets. Presently safety helmets only have the purpose of protecting the employees head against potential hazardous bumps. The safety helmets do not have any technology added to it to let employees know when a fellow has encountered a hazardous event. Therefore the purpose is to modify an existing safety helmet to make the helmet even safer by adding a wireless sensor node network. The task was extended to designing the system small enough to fit into the safety helmet and last long enough while running on battery power. A further challenge was to modify the helmet without changing its physical structure. The added weight had to be kept to a minimum. A helmet needs to be modified to improve employees safety by adding intelligence to the helmet. If an object falls on an employee even when wearing his helmet he can become unconscious or immobile. The system must determine whether or not a employee has sustained a life-threatening injury. Than dangerous gases need to be detected and announced. In the area of mining technology, real-time monitor and control of mine hazard are more complex. Mine safety modules are configured to communicate to ground control or a central station. A real critical issue in industries is hazardous gases. Systems used in an industry can create intense vibrations and increase the level of hazardous gases such as CO, SO2, NO2 and particulate matter. The working conditions can be very noisy and employees don't watch each other constantly. Employees tend to stay in groups and will be no more than 5 meters (m) from each other. A warning system needs to be incorporated that will warn employees within a 5 m radius that an employee is experiencing a hazardous event. This system needs to process and transmit the event within 1 second (s). These systems measure the environment around the employees with gas sensors and are then used to implement evacuations. This system also alerts the employee with the help of a vibrator band. The systems warn employees, but when a employees is obstructed or injured, an external input is required from ground control.

II. RELATED WORK

Mining and mineral exploration play an important roles in the global economy. In mining operations, communication systems play vital roles in ensuring personnel safety, enhancing operational efficiency and process optimization. Over the period 1920-2012, this article surveys the evolution of wireless communications in underground mines, the developments of the underlying technology, and progress in understanding and modeling the underground wireless propagation channel. Current and future trends in technology, applications and propagation modeling are also identified. About ninety relevant references have been reviewed that consider: 1) the emergence of technology and applications, 2) analytical, numerical and measurement based propagation modeling techniques, and 3) implications of the physical environment, antenna placement and radiation characteristics on wireless communication system design. Affected systems include narrowband, wideband/ultra-wideband (UWB) and multiple antenna systems.[1]. A low power, cost-effective and Zigbee protocol based wireless sensor network that provides an intelligent surveillance and safety system for underground coal mines. The system is proposed for safe Coal Mine Monitoring, which plays an important role in coal mine safe production. With continuous enlarging of exploiting areas and extension of depth in coal mine, many laneways become monitoring blind areas, where are lots of hidden dangers. It is very difficult to lay cables which are not reliable and not effective. To overcome this, a new system is proposed with the help of Zigbee technology, which can improve the level of monitoring production safety and reduce accident in the coal mine. And this system proposes a low An Industrial Smart Helmet for Air Quality and Hazardous Event Detection using Smart Band complexity parameter to determine the optimal placement of sensor nodes. The system realized real time surveillance with early-warning intelligence on LPG, FIRE, Humidity, Metal, PANIC in mining area, and used voice alerts to reduce potential safety problems in coal production.[2]. In [3] a voice controlled wireless smart home system has been presented for elderly and disabled people. The proposed system has two main components namely (a) voice recognition system, and (b) wireless system. LabView software has been used to implement the voice recognition system. On the other hand, ZigBee wireless modules have been used to implement the wireless system. The main goal of this system is to control home appliances by using voice commands. The proposed system can recognize the voice commands, convert them into the required data format, and send the data through the wireless transmitter. Based on the received data at the wireless receiver associated with the appliances desired switching operations are performed. The proposed system is a low cost and low power system because Zig Bee is used. Additionally the proposed system needs to be trained of voice command only once. Then the system can recognize the voice commands independent of vocabulary size, noise, and speaker characteristics (i.e., accent). In [4] the concept of sensor networks which has been made viable by the convergence of micro electro- mechanical systems technology, wireless communications and digital electronics. First, the sensing tasks and the potential sensor networks applications are explored, and a review of factors influencing the design of sensor networks is provided. Then, the communication architecture for sensor networks is outlined, and the algorithms and protocols developed for each layer in the literature are explored. Open research issues for the realization of sensor networks are also discussed. Effective communication is critical to the success of response and rescue operations; however, unreliable operation of communication systems in high-stress environments is a significant obstacle to achieving this. The contribution of this article is threefold. First, it outlines those common characteristics that impair communication in high-stress environments and then evaluates their importance, specifically in the underground mine environment. Second, it discusses current underground mine communication techniques and identifies their potential problems. Third, it explores the design of wireless sensor network based communication and location sensing systems that could potentially address current challenges. Finally, preliminary results are presented of an empirical study of communication using WSN constructed from commercially available wireless sensor nodes in an underground mine near Parkes, New South Wales, Australia. [5]. Green IT and smart grid technologies have changed electricity infrastructure more efficiently. Recent advances in wireless and mobile communications technologies facilitate context-aware power management systems which can offer situation-based services in digital home. In this paper, we propose a novel smart home energy management system (SHEMS) with hybrid sensor networks. Hybrid sensor networks consist of two types of sensors: the power information monitoring sensor (PIMS) and the environment information monitoring sensor (EIMS). To maximize the hybrid sensor network lifetime, we propose a new routing protocol based on cooperation between PIMS and EIMS, which we named the CPER. In order to verify the efficiency of our system, we implemented our system in real test bed and conducted some experiments. The results show that the reduction in service response time, the average number of packet.[6]. The design and development of underground coal mine monitoring using ARM7 and ZigBee is presented here. A sensor node is developed for sensing different environmental parameters of underground mine. The sensor node has feature of wireless communication using ZigBee Transreceiver. Thus, sensor node can be deployed in different parts of mine using efficient topologies. All sensed data is digitized by internal ADCs of LPC2148 microcontroller which gives low power platform with fast execution. The system prototype developed has many advantages that makes it convenient to work in harsh environment of underground mine, monitoring concentration of deadly gases in its atmosphere along with temperature and humidity.[7]. Many technical communities are vigorously pursuing research topics that contribute to the Internet of Things (IoT). Today, as sensing, actuation, communication, and control become ever more sophisticated and ubiquitous, there is significant overlap in these communities, sometimes from slightly different perspectives. More cooperation between communities is encouraged. To provide a basis for discussing open research problems in IoT, a vision for how IoT could change the world in the distant future is first presented.[8] Advances in smart grid technologies have been proven to improve energy efficiency.

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These technologies will drive significant changes of energy consumption operation, energy management, energy using patterns, and customer services. In order to achieve energy saving efficiently and provide smart services automatically for users, the architecture of a smart energy monitoring and management system is proposed in this paper. By monitoring the power consumption information, environment information and users' situation information, the system based on the architecture can calculate the proportion of wasted energy consumption based on the energy consumption statistic, provide smart services based on the person-device interaction, and forecast the energy consumption based on the user energy consumption behaviors. The system is combined with cloud computing for data storage and processing. This paper describes the design and partial implementation of the system architecture.[9] Wireless communication inside mines and tunnels is very different from that in terrestrial environment because of the strong attenuation of signals. Here, we are developing an empirical model for the underground wireless communication channel based on experimental data which help in predicting the average received signal strength at a given distance from transmitter. The model aims at adding correction factors to the available outdoor and indoor propagation models such as Okumara-hata model, cost231 model, ITU indoor propagation models etc. Modeling is done by choosing the most appropriate model among the available ones and performing regression methods to the model based on experimental data. Correction factors are then added based on two parameters which we are considering namely- Penetration and Scattering loss for 0.3GMSK.[10]

III. PROPOSED SYSTEM

The proposed mechanism is divided into the following steps:-

In the development of helmet, we have considered the two main types of hazardous event such as air quality, and collision (miners are struck by an object) and detecting the process using vibrator band. The first is the concentration level of the hazardous gases such as CO, SO_2, NO_2. The second hazardous event is defined as an event where Employees are struck by an object against the head with a force exceeding a value of 1000 on the HIC (Head Injury Criteria).Fig.1 shows the proposed architecture.

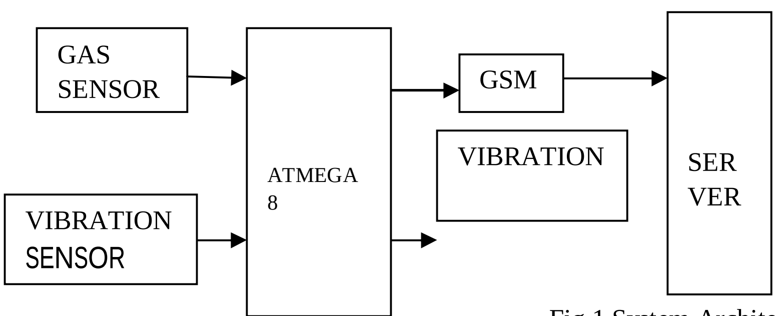

Fig.1.System Architecture Diagram

IV. IMPLEMENTATION

A. Gas Sensor

The Gas sensor composed by micro AL_2O_3 ceramic tube, Tin Dioxide (SnO_2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-2 have 6 pin, 4 of them are used to fetch signals, and other 2 are used for providing heating current.

B. Viberator Sensor

Vibration sensor is used originally as vibration switch because of its high sensitivity; it is sensitive to environment vibration, and generally used to detect the ambient vibration strength. When module did not reach the threshold in shock or vibration strength, DO port output gets high level and when external vibration strength exceeds the threshold, D0 port output gets low level. Small digital output D0 can be directly connected to the microcontroller, for the microcontroller to detect low level, thereby to detect the ambient vibration. Small digital output DO can directly drive the relay module, which can be composed of a vibration switch.

C. Gprs /Gsm sim900a Modem With Arduino Compatible

This is a very low cost and simple Arduino GSM and GPRS shield. We use the module SIMCom SIM900A. The Shield connects your Arduino to the internet using the GPRS wireless network. Just plug this module onto your Arduino board, plug in a SIM card from an operator offering GPRS coverage and follow a few simple instructions to start controlling your world through the internet. You can also make/receive voice calls (you will need an external speaker and microphone circuit) and send/receive SMS messages.

V. RESULTS

The Following screenshots shows the working of the proposed system. The advantages are listed below:-

A. Fast response time.
B. It is portable.
C. Low cost with precisely acceptable accuracy.

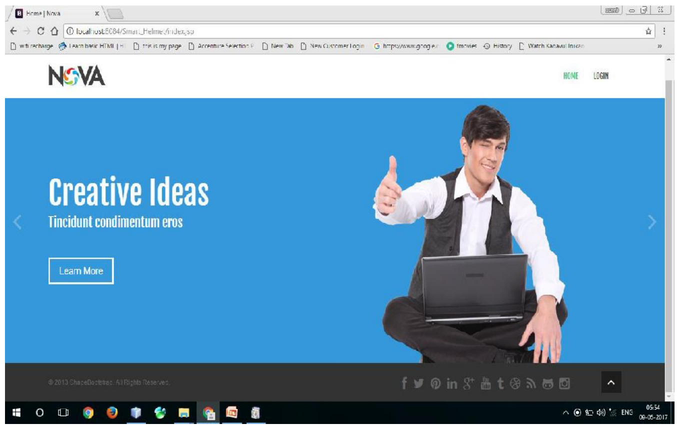

Fig 2.Home page

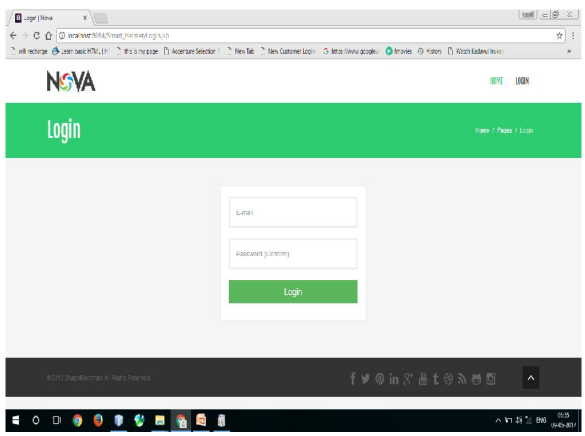

Fig 3.Login page

Fig 4.Retrieve gases Data

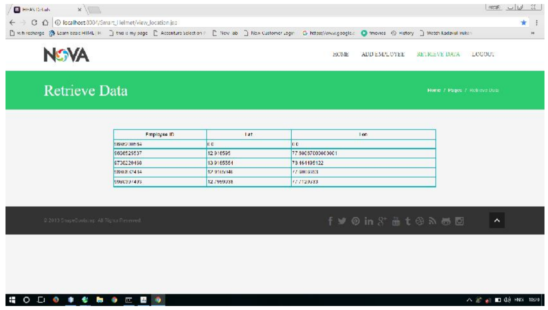

Fig 5.Location Data

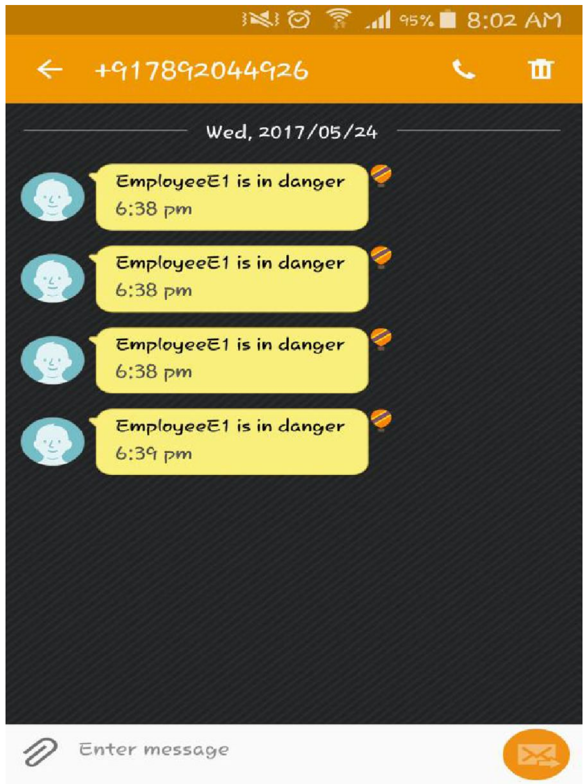

Fig 6.Receive Messages Data

VI.CONCLUSION AND FUTURE WORK

A smart mining helmet was developed that is able to detect two types of hazardous events such as danger level of hazardous gases, collision or impact (miners are struck by an object). Another hazardous event is defined as an event where miners are struck by an object against the head with a force exceeding a value of 1000 on the HIC (Head Injury Criteria). An accelerometer was used to measure the acceleration of the head and the HIC was calculated in software. The layout of the visualisation software was completed. Tests were successfully done to calibrate the accelerometer. PCB’s that were designed and made included a breakout board and a prototype board. A whole software implementation was done based on Netbeans in order to do the control of the measuring of sensors and of calculations done with the measured values.

The system was extensively tested in order to determine whether or not the system works to the requirements. It was observed that the accelerometer should be placed on the inside of the helmet and not on the plastic harness inside the helmet to compensate for the weight difference. The accelerometer calibration was then modified to correctly calibrate the accelerometer. A few aspects of the system can be improved. Adding an external antenna would extend the range or improve the signal strength in order to allow for more human interference. The distance might still want to be limited as it would be impractical to warn miners that are too far away to find the miner who is experiencing a hazardous event. The processing speed of the system can be improved to allow for more accurate accelerometer measurement. The IR sensor can be improved to work within the helmet by not triggering because of reflections. Node hopping can be implemented to allow transmissions to the supervisor or even a central control station. This can be done by adding stationary nodes that are programmed to only bounce any signal that is received. The system can be improved by adding more measuring devices to check the miner's blood pressure and heart rate. Gas concentrations can be measured as well. In future, it could also be considered if such modules can also be used for secondary services, such as localization of workers relative to each other.

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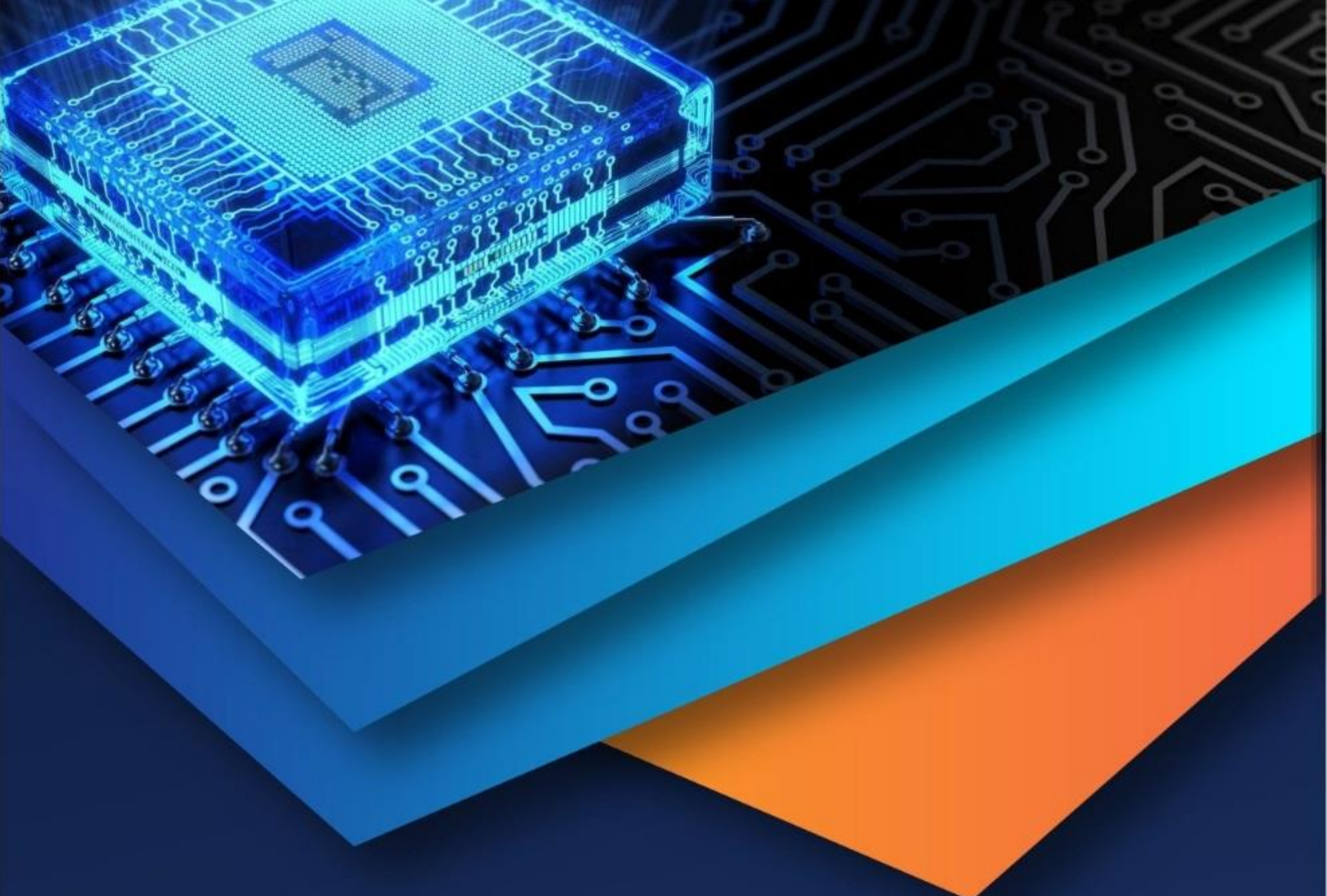

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