Prototyping IOT Based Smart Wearable Jacket Design for Securing the life of Coal Miners

Ghulam E Mustafa Abro
Department of Electronic Engineering
Hamdard Institute of Engineering & Technology HIET. Hamdard University
Karachi, Sindh, Pakistan
mustafa.abro@hamdard.edu.pk

Shoaib Ahmed Shaikh
Department of Electrical Engineering
Hamdard Institute of Engineering & Technology HIET. Hamdard University
Karachi, Sindh, Pakistan
shoaib.Ahmed@hamdard.edu.pk

Safeeullah Soomro
College of Computer Studies
AMA International University
Salmabad, Kingdom of Bahrain
s.soomro@amaiu.edu.bh

Ghulam Abid
Department of Electrical Engineering
Faculty of Engineering Science & Technology FEST, Indus University
Karachi, Sindh, Pakistan
ghulam.abid@indus.edu.pk

Kundan Kumar
Department of Electronic Engineering
Hamdard Institute of Engineering & Technology HIET. Hamdard University
Karachi, Sindh, Pakistan
Kundan.Kumar@hamdard.edu.pk

Fiaz Ahmed
Department of Electrical Engineering
Usman Institute of Technology UIT.
NED University of Engg. & Tech.
Karachi, Sindh, Pakistan
Fiaz.ahmed@gmail.com

***Abstract*—Engineer is the person who is always keen interested in providing best alternative solution to any social problem to meet the scarcity. Keeping this mindset and visualizing social problems in Pakistan and other several countries; it is observed that annually several people die working inside coal mines. By identifying this problem, this paper suggests a wearable smart jacket design for securing the life of coal miners in Pakistan. This Prototype senses the various health related parameters i.e. the presence of hazardous gas, pulse rate of miner, updated temperature/humidity, exact depth location & global positioning of miner. These all parameters will be then transmitted through a Wi-Fi shield to a dynamic internet protocol. In this way, one may monitor all labors working inside the mines and moreover in case of disaster the life of miner can be secured immediately. This proposed wearable embedded system will not only send the last GPS location to a specific IP but will also send continuous update of pulse rate of miner which is sensed by pulse sensor; to base camp hence if someone dig the coal mine in case of disaster, they may set the priority to retain maximum life back from a coal mine.**

Keywords— GPS, humidity, Internet Protocol, Temperature, , wireless communication

I. 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.

The suggested system can never be implemented inside coal mine but if managed on a wireless sensor network and then implemented accordingly as proposed in this paper; the thousands of lives which are wasted inside several local coal mines can be saved at right time. Moreover, the number of efficient sensors proposed in this paper make this solution one of its kinds.

There are several ways out which can be implemented on same issue and various are implemented previously as well but they have one major issue of monitoring when the coal mine has been collapsed due to any reason. In such scenario the disaster management authority start digging the complete site which is time consuming. It happens most of the time when rescue team cannot save maximum lives just because the lives those have proper pulse rate cannot be located properly.

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. This system in this way help the rescue team to dig at right places with exact depth to take out miners back to ground.

II. LITERATURE REVIEW

Before initiating for designing an autonomous system which may detect the parameters related to the miner who is working in local mines of Pakistan; it was very important to study the previous suggested systems being proposed in past for same issue and do comparative analysis. There are huge manuscripts available describing the same autonomous systems by which one can get an accurate and exact situation awareness along with alert generation for rescue teams. One may get a rapid support from data acquiring if it is done through pervasive or ubiquitous computing technology. This will not only increase the computational capability for communicating but it will also provide an ease to perform useful tasks that minimizes the less interaction with computers [1]. In some of literature, the usage of audio communication is also proposed but this may create an overload and a confusion for rescuers as this system design is proposed to provide an easy way out for rescuers to set a priority to dig at particular places where one may find maximum chances to retain the live of a miner [2]. Moreover, there are several systems, which are easy to carry, and wearable i.e. a wrist band using Arduino Platform for the rescuer [3].

The main objectives of various papers are related to generating an alert to rescue team using android applications [4] but what rescue team will do if they do not know where the exact miner is lying beneath the debris. Discussing some of very sensitive solutions i.e. designing of incubators where proper data acquisition and transmitting that wirelessly both are challenging tasks but yet one may find various systems being designed on micro-controller based and receiving some of essential data [5]. Being an engineer, people expect us to provide a solution which should be under community services and due to this various research scholar strive hard

978-1-5386-4904-6/18/$31.00 ©2018 IEEE

to proposes various solutions [6]. These solutions are majority proposed in the area where one sewer may go underground and clear the drain line [7].

Discussing further one may see such autonomous systems which may not only detect the various gases using Average Slope Multiplication techniques [8]. In Proposed papers there are plenty of papers which will not only detect the gas leakage but recognize it as well i.e. Methane or any hazardous or poisonous gases which may harm the labor inside a drain line [9] or in mines in our case.

The main issue in the establishment of such an underground monitoring system is to have a communication alive and in this regard one may explore the use of low frequency magnetic fields for communication, and present a new hardware platform that features triaxle transmitter/receiver antenna loops [10]. Furthermore, one may study the literature related to MEMS based sensors which are used to monitor the underground parameters as per the requirement; several systems are suggested which are mostly based on digital communication and are based on IEEE 802.15.4 standard [11] which describes the operation of low rate wireless area network. In the field of robotics, various manuscript suggests the same rescue strategy using robots. In such manuscripts all rescue & surveillance activities such as the detection of explosion, leakage of gases all are done using various types of robots i.e. wolverine v2 acquired by Mine Health & Safety Administration MHSA, USA in 2001 [12].

This was just a beginning because robotics field then suggested number of robots such as Gemini Scout, ground hog and Numbat for resolving the same issue. After going through the detail literature review paper mention a brief table of all suggested techniques with their pros. & cons. As given below:

TABLE I
COMPARATIVE ANALYSIS OF SUGGESTED AUTONOMOUS SYSTEMS

Sr. No:	Smart Autonomous Systems	Pros.	Cons.
1.	Ubiquitous Computing Method[1]	System is very small in size and can be carried easily	Highly complex algorithm to amend it
2.	Audio Communication based Systems[2]	Easily accessible & Cost effective tool.	Not reliable in our scenario.
3.	Smart Wrist Watch Design[3]	Easy to carry and can be used for communication	In our case the mobile communication cannot be take place inside mines and miners are mostly uneducated people to use smart watch
4.	Micro-controller & Amalgamated Android Application based Systems[4]	Quicker to use, wider installers 7 Provide a perfect user interface	For this system every miner must have smart phones in order to communicate their current situation.
5.	Average Slope Multiplication Techniques[5]	One of the efficient methods	The processing speed decreases in our scenario
6.	Low Frequency Magnetic Communication Systems[6]	Low power design, energy transferable, cost effective and field penetration capabilities	Low frequency magnetic communication is hazardous to health i.e. it may cause cancer
7.	MEMS Based Sensors Deployment[7]	Smaller in size and widely used in various applications	Unavailability of their utility in our domain i.e. pulse sensors are not available
8.	Robotic/Autonomous Systems [8]	Very fine with repeated tasks	In our scenario the structure of coal mines are different hence the robots must be efficient enough which is a costly solution

The above table provides a comparative analysis of all suggested techniques. Few of them are fully focused on alert generation whereas few are restricted to some of sensors hence they cannot properly communicate to boot camp for the exact GPS Location, exact depth and the status whether the miner is alive or not through incorporation of pulse sensor.

III. METHODOLOGY

In this paper, the applied methodology is slightly different in terms of sensors incorporation. The paper suggests some specific components in order to prototype the smart wearable jacket design for securing the life of coal miner and they are mentioned as below:

1. DHT 11 Temperature and Humidity Sensor
2. Pulse Sensor
3. MQ-2 Hazardous Gas Detecting Sensor
4. BMP 180 Pressure & Depth Sensor
5. GPS Module & ESP8266 Wi-Fi Shield
6. Arduino Mega
7. Toggle Switch

Fig.1. Proposed Sensors and Components

Discussing from the toggle switch, when one may trigger it the all sensors including the controller Arduino Mega will be powered up and will start communicating with sensors attached to it. For computing temperature and humidity, the system is incorporated with DHT11, for hazardous gas MQ-2, for knowing exact depth along with pressure one may see BMP 180 sensor interfaced within the system and for global positioning system has GPS module. When all necessary data will be received along with a pulse rate for which paper suggests a pulse sensor easily available in market; this whole data will be fed into a Wi-Fi shield module named ESP-8266 whose primary job is to configure itself with the router attached and get a dynamic IP. Once IP is assigned, the whole data will be wirelessly transmitted to that particular IP. The whole methodology/procedure can easily be understood by mentioned block diagram shown in figure 2.

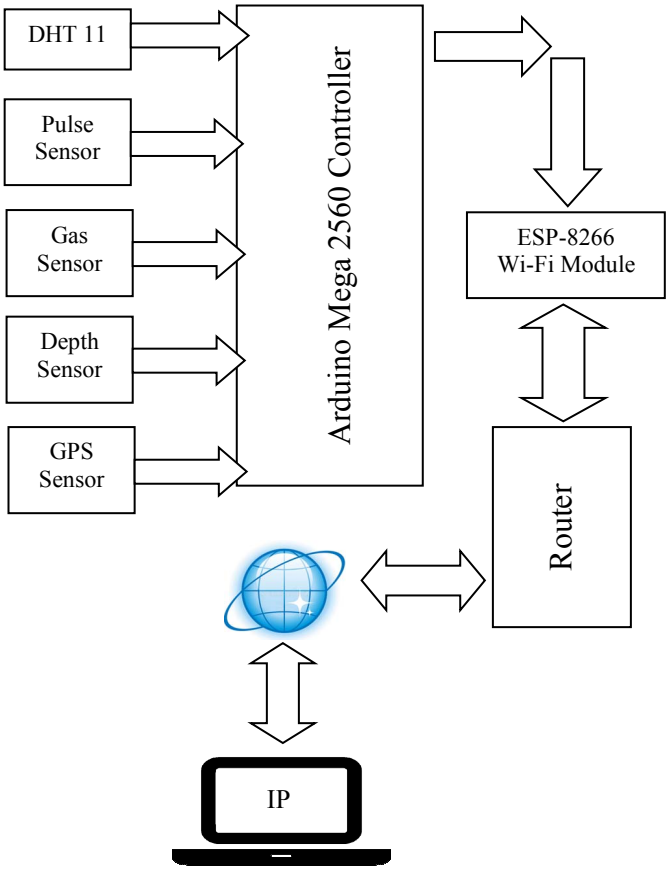

Fig.2. Block Diagram of Suggested Methodology

Firstly this whole prototype was initiated on a simple acrylic sheet and later on fixed in a jacket as shown in figure 3.This mentioned prototype will be later on fixed in any jacket depending on the temperature conditions inside coal mines. If the temperature is greater and hotter than the jacket would be thin so that one may carry it while working inside. Similarly, if the conditions are colder than the same jacket can be changed simply hence this portability of the system make it one of its kinds.

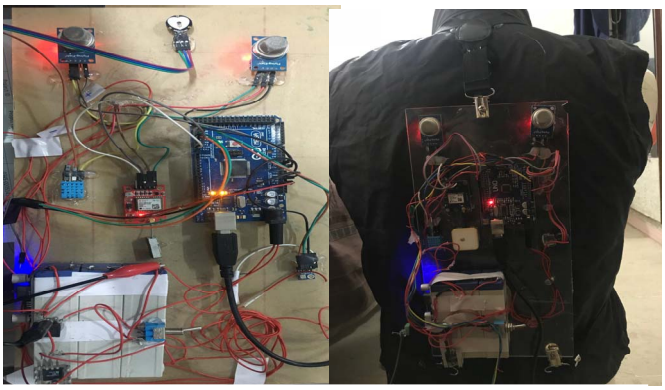

Fig.3. Prototyping IOT based smart wearable Device

IV. Results

The results have been achieved by hanging the jacket into a rope from a certain height of building to downstairs in order to check out the depth measurements. For checking out the pulse sensor simply one may place his/her finger on pulse sensor and this sensor may show you the actual pulse rate on specific IOT. The GPS Location similarly traced out by this device at various locations; this sensor basically provides longitude and latitude coordinates as shown in below mentioned figure 4.

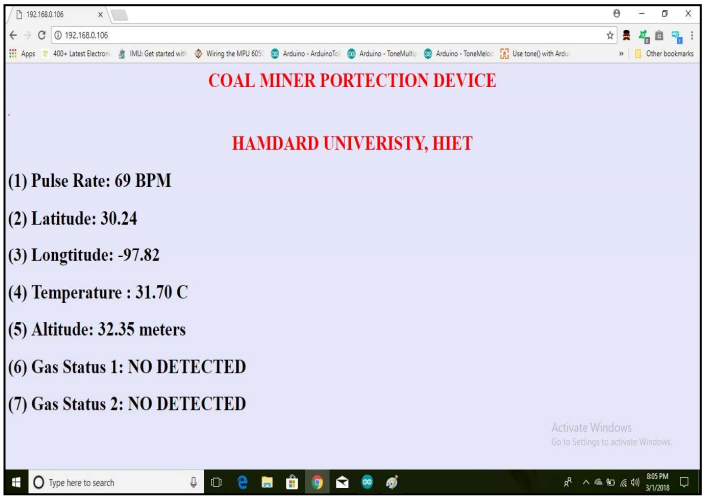

Fig.4. Results received at a dynamic Internet Protocol

The GPS Location mentioned above are 24.91 and 67.09; are the exact location where the experiment take place and once these longitude and latitude values may enter on Google it may show the exact pin location where this jacket is currently worn by experiment performer as shown in below figure 5.

Fig.5. Exact Pin location with the same longitude and latitude

The status labeled as GAS Status 1 and 2 show if there is leakage of any hazardous gas inside mine and hence it is at a normal site therefore the status visible at IP address is N1 means Normal condition of gas sensor 1 and N2 for another. These sensors can be triggered and can be watched using a simple triggering of lighter nearer to these sensors and may monitor the change. Similarly, the pulse sensor will also send the data and show the actual pulse rate of miner. The best feature of this system is the last data may be seen too at IP and rescue team can perform the rescue operation accordingly with maximum efficiency.

Moreover this system had also been tested at Hamdard University Karachi where a student carried this jacket and went into the various places the below mentioned readings were taken as shown in below mentioned figure 6 and 7.

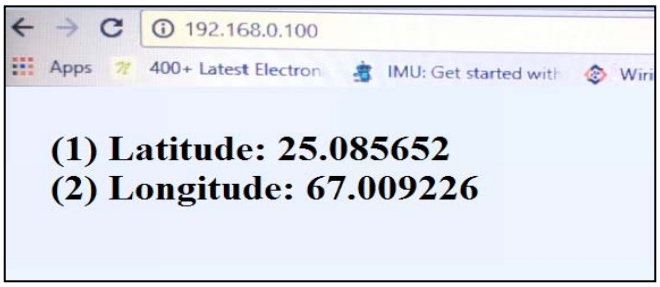

Fig.6. Latitude and Longitude Values received at IP

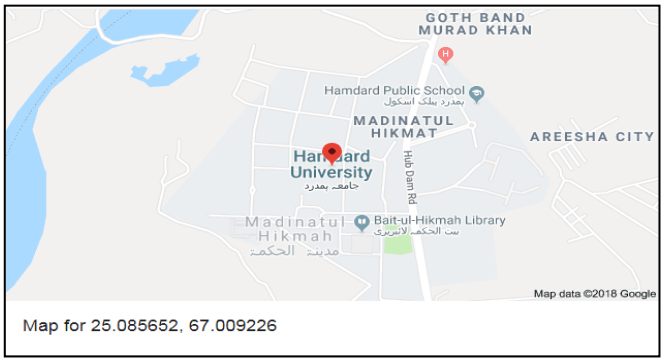

Fig.7. Exact Pin location of Hamdard University, Karachi

When working in mines specially in coalmine there are lot of factors that affect the human health conditions, these effect involves the presence of hazardous gas, temperature, oxygen level depth of mine etc. lot of accidents have already been reported in such work. Rescue teams spend lot of money and time to recover the effected person from the accidental site. To overcome this problem, a system has been introduced which is not only providing exact location, depth and GPS locator but will also monitor pulse rate of miner to provide quick medical assistance with best priority if required. In this paper, a brief comparison has been performed among other techniques used for monitoring any uncertain incident and rescuing the influenced coal miners inside coal mines. Hence proposed embedded system dully designed for coal miners is not only providing the essential parameters in order to be in contact with all miners & get to know about their current health status i.e. availability of hazardous gas, oxygen level, pulse rate etc. In addition to this, suggested system will provide an ease to rescue them and to dig the site where they may have greater probability for saving maximum lives.

ACKNOWLEDGMENT

While bringing out this work to its final form, there had been number of people who come across and helped in the completion of this research manuscript. It is an immense pleasure to acknowledge here Engr. Asim Raza; Senior Faculty member at Hamdard University Karachi for his suggestions from an early stage of this research and providing extra ordinary mentorship throughout the work. Their involvement with pure originality has nourished my intellectual maturity.

REFERENCES

[1] Lukowicz, P., Baker, M.G., Paradiso, J.: Guest Editors' Introduction: Hostile Environments. IEEE Pervasive Computing. 9, 13–15 (2010).

[2] Kwon, G.H., Smith-Jackson, T.L., Bostian, C.W.: Socio-cognitive aspects of interoperability: Understanding communication task environments among different organizations. ACM Transactions on Computer-Human Interaction. 18, 1–21 (2011).

[3] Cernea, D., Mora, S., Perez, A., Ebert, A., Kerren, A., Divitini, M., Gil de La Iglesia, D., Otero, N.: Tangible and Wearable User Interfaces for Supporting Collaboration among Emergency Workers. In: Herskovic, V., Hoppe, H.U., Jansen, M., and Ziegler, J. (eds.) Collaboration and Technology. pp. 192–199. Springer Berlin Heidelberg, Berlin, Heidelberg (2012).

[4] Divitini, Monica, Babak A. Farshchian, Jacqueline Floch, B. M. Mathisen, Simone Mora, and Thomas Vilarinho. "Smart jacket as a collaborative tangible user interface in crisis management." In Proceedings of the Workshop on Ambient Intelligence for Crisis Management. 2012.

[5] Chen, Wei, Son Tung Nguyen, Roland Coops, Sidarto Bambang Oetomo, and Loe Feijs. "Wireless transmission design for health monitoring at neonatal intensive care units." In Applied Sciences in Biomedical and Communication Technologies, 2009. ISABEL 2009. 2nd International Symposium on, pp. 1-6. IEEE, 2009.

[6] A. Özmen, F. Tekce, M.A. Ebeoˇglu, C. Taşaltin, Z.Z. Öztürk, Finding the composition of gas mixtures by a phthalocyanine-coated QCM sensor array and an artificial neural network, Sensors Actuators B Chem. 115 (1) (2012) 450–454.

[7] Markham, Andrew, and Niki Trigoni. "Magneto-inductive networked rescue system (MINERS): taking sensor networks underground." In Proceedings of the 11th international conference on Information Processing in Sensor Networks, pp. 317-328. ACM, 2012.

[8] Maity, Tanmoy, P. S. Das, and Mithu Mukherjee. "Rescue and protection system for underground mine workers based on ZigBee." International Journal of Advanced Computer Engineering and Architecture 1 (2011): 101-06.

[9] Reddy, A. Hemanth, Balla Kalyan, and Ch SN Murthy. "Mine Rescue Robot System–A Review." Procedia Earth and Planetary Science 11 (2015): 457-462.

[10] https://www.cdc.gov/niosh/mining/content/emergencymanagementandresponse/commtracking/advcommtrackingtutorial3.html

[11] https://pdfs.semanticscholar.org/d60c/0fd4782ab327ff61625f0863cba0e20bf67f.pdf

[12] Li Jing, Shi Yingchun, Chang Wenhui, Bo Xufang, Application research on gas detection with artificial olfactory system, Sensors Actuators 3 (2012) 233–254.