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Live Health Monitoring and Mining Menace Detection Using Light Fidelity (LiFi)

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Abstract: The never-ending need for coal and other renewable resources, requires huge mines to be dug up, involving numerous people working in hazardous and unreliable conditions. The people working in such mines are susceptible to dangerous environmental conditions at all times which leads to death of such workers more often. These conditions are difficult to monitor without placing someone's life at risk. The older methods of mine condition monitoring involved using a person to go down and report back. This method is however dangerous as the person who is monitoring a specific hazard could be harmed by that very same hazard. This type of first hand monitoring is invasive. The proposed methodology which uses LiFi will be responsive enough to overcome these hazardous issues. This LiFi based health monitoring system will monitor the vital signs of people working in hazardous places like coal mines and transmit information in case of emergency. The worker's pulse rate is measured using a pulse sensor, the temperature of the place is measured using DHT11 Temperature sensor, and the presence of poisonous gases is detected using MQ135 gas sensor. The collected data is transmitted through LiFi and further stored in cloud using an IoT device. LiFi is deployed in order to avoid slow transmission of data encountered in other modes of data transmission. Thus, LiFi based systems can pave way to a new era of technology due to its high possibilities of being deployed in the near future.

Keywords: Light Fidelity (LiFi); Visible Light Communication (VLC); LED, Raspberry Pi; Arduino Uno; Sensors.

1. INTRODUCTION

As technological advancements are taking place at a much faster rate, millions of devices are being connected to the internet for faster communication. This ever growing trend leads to radio frequency congestion as all wireless communications make use of radio frequencies to transmit the signals efficiently. This further leads to higher bandwidth requirements which at the present stage has been utilized and exhausted to a large scale. As an alternative people around the world are working on using other frequencies for successful communication. Fiber optics make use of light signals which are transmitted through long fiber optic cables connecting countries across the globe buried under the earth's crust and the ocean beds. But this technology is far expensive. Rather Visible light communications (VLC) have emerged as a new technology, which theoretically has proven to provide a speed of 10Gbps in indoor environment. It is also known that VLC has a much wider spectrum when compared to RF (Radio Frequency). This could help in adhering to the bandwidth requirements across the globe. Moreover, as light sources are ubiquitous, moving from RF to VLC or inter linking of RF and VLC would be possible at a much faster pace. Radio frequencies are known to cause harm to the health of human beings and other organisms. While VLC is not known to cause much harm to the living organisms. Moreover, VLC could provide much more secured communication as it cannot be intercepted easily. As RF can interfere with signals coming from different equipment at hospitals, air crafts, it is more appropriate to use VLC at such places to enable faster and safer communication. Moreover, VLC can also be used at nuclear power plants safely. LiFi which is also a part of VLC is an alternative to WiFi (Wireless Fidelity) and aids in wireless communication using visible light. LiFi is much cheaper when compared to WiFi as it requires much simple circuitry for data transmission and reception. LiFi can achieve dual goal of providing illumination as well as allowing data transfer [1]. The transmitter and receiver that are used for LiFi are highly energy efficient and consume much less power. Thus LiFi can pave way to a highly advanced mode of much faster and secure communication in the near future.

LIFI – AN OVERVIEW

LiFi is a booming technology with intensive researches taking place across the globe looking out for viable options for practical implementation of the technology. LiFi is a form of visible light communication [2]. Industrial revolution is moving towards IoT (Internet of Things) where millions of additional devices are yet to be connected to the already overflowing RF spread spectrum. Moreover, on the other side people are extensively working on deploying 5G technology to achieve greater data rates. Thus, there is a great need for capacity and speed. LiFi is expected to bridge this gap through its much wider bandwidth and high speed. Light waves do not penetrate through walls which makes them more appropriate for military and other critical applications as it does not allow message interception. As LiFi requires a separate channel for uplink and downlink communication, the entire bandwidth can be utilized for both uplink and downlink communication. LiFi based applications require LOS (line of sight) propagation for data communication [3]. This would increase the need for a lot of repeaters. This could be eliminated by using parabolic reflectors or other mechanical devices that can be aligned for perfect light reception. Moreover, repeaters are required as the intensity of the light decreases as the distance increases. This decrease in luminous intensity can be due to atmospheric conditions, interference from external light sources which requires a lot of care when the system is designed. Interference from light sources can be a major drawback in such LiFi based communication systems.

As sunlight is available throughout the day, much care has to be taken to mitigate the effects of the interference of sunlight. To overcome this different colours sources can be used at the transmitter and at the receiver optical filters can be used to filter the required wavelength of light. This also allows parallel transmission of data as all the wavelengths can be exploited to transmit the required data [4]. As LiFi is based on the laws of physics, mechanical devices such as parabolic reflectors can be used to concentrate the light waves at the receiver side which would help to mitigate the effects of multipath propagation. At the transmitter side, such reflectors can be used to increase the intensity of the light sources for long distance communication. Reliable indoor communication can be achieved using LiFi using the available led lights. Outdoor communication requires other environmental factors to be taken into account to design an effective system for full duplex communication.

2. LITERATURE SURVEY

Human safety is far more important than anything else in an industry, especially in the mining industry. Communication is needed to ensure the safety of the workers. A lot of solutions have been proposed for this situation but each of these has some disadvantages. In wired communication, it is quite risky in underground mining areas since the wired network has real-time monitoring drawbacks and also difficulties in the physical implementation.

As a standard of unified global short-range wireless communication, Bluetooth technology establishes a low-power, low-cost wireless air interface system. The system uses CAN bus technology with combination of wired and wireless data transmission system [5]. The main drawback of this system is that Bluetooth is a short distance wireless technology and the use of cables is difficult. When a natural calamity or a roof fall occurs, damage to the physical cables could take place. So the reliability and longevity of conventional communication systems is poor. Due to the harsh environment inside the mines, the installation and maintenance of the wired communication is very difficult.

Zigbee based systems address a cost-effective, flexible solution of underground mine workers' safety. A module of MEMS based sensors are used for underground environment monitoring and measurement of data through digital wireless communication technique. This proposed work shows high accuracy, smooth control and reliability. A microcontroller is used for collecting data and making decisions, based on which the mine worker is informed through alarms as well as voice systems. The voice systems with both microphones and speakers are effectively used to communicate wirelessly with the ground control center computer. Zigbee, based on IEEE 802.15.4 standard is used for this short distance transmission between the hardware fitted with the mine worker and the ground control center [6]. Zigbee is a short distance wireless communication network, so it is not possible to intimate the responsible authorities who are at a longer distance.

The applications of visible light communication in location-based services, where visual imagery is combined with visible light communication has wide potential use. Indoor navigation is convenient for everyone, and it is especially indispensable for the visually impaired. Such a navigation system is proposed for the visually impaired. LED lights emit visible light with location data and a smartphone with visible light receiver receives the data. The smart phone calculates the optimal path to a destination and informs the visually impaired via headphone [7].

Visible light communication can be used for vehicle communication in order to reduce accidents. The speed of the vehicle is read using a sensor, processed by microcontroller and transmitted through the LED driver. Upon data transmission wirelessly through light, the photodiode will detect the transmitted light in form of current. Trans-impedance amplifier function is used to convert the received current into voltage. Finally, voltage will be processed through a microcontroller to be readable by the LCD. [8]

An Automatic Billing System that uses LiFi technology is deployed as a component of IoT to help in data transfer quickly through an android application. The android application is completely free of cost and is easily accessible, which has to be installed in the user's mobile so that the user can view the complete product details and the total amount to be paid. The billing is processed in the mobile phone of the user by using IoT. For security purposes, the

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finally selected products are verified in the gate section. The main objective of this paper is to avoid the long queues in supermarkets and malls.[9]

LiFi is a bi-directional wireless communications technology that allows high speed transmission of data via uplink and downlink simultaneously. The bidirectional LiFi device has cells which contain both LED and photodiode which acts as transmitter and receiver respectively within each and every cell present. Thus, it can transmit and receive data via light signal with the neighboring devices.

IoT market is expected to expand vastly in the coming years. Under this context, novelty of the VLC device described in [10] is its integration into a CMOS chip, which will permit it to integrate it in routers and any mobile device. It is multichannel and modular with emission/reception cells each specific in wavelength+frequency. Current mainstream Wi-Fi protocol: WiFi-802.11-ac allows data rates up to 1.3 Gbit/s. LiFi is capable of operating at much higher data rates while LiFiX solution will allow it to reach even higher bandwidth. LiFiX, is a fully integrated LiFi CMOS device. It contains 64 emission-reception cells and architectured in a similar way as a memory array with bitlines and wordlines to read and write data via an access transistor of each cell. Each row in the array is specific in terms of frequency and each column is specific in terms of wavelength. Individual cells contain one LED for light emission and one photodiode for light reception. This fully bi-directional device can reach upto a bandwidth of 26 Gb/s for 64 cells and has high level of data transmission security via frequency hopping. In order to be able to enable communication to the outside world, E/R cell array requires to be connected to series of electronic circuits capable of doing the data encoding, encryption, modulation, pre-equalization right after data reception, but also the data decoding, decryption, demodulation and post equalization prior to data emission. Furthermore, a synchronization module will be required to align emission and reception between two devices. The way signal processing and synchronization will be achieved using this device as well as the methodology used to enhance data security with cell-to-cell hopping are also discussed in this paper.[10]

The use of visible light for bidirectional communication in regular smartphones and small LEDs that are integrated in consumer electronics raise new challenges. This work [11] introduces the key components that are necessary to build a robust Bidirectional communication system between an LED and an unmodified smartphone. An efficient decoding algorithm to detect the position of LED is processed and decoded with an average of 18.4ms for each frame on a smartphone. This implementation is convenient for low latency indoor localization or real-time transmission with a moving receiver. Also, as the ROI detection is the most complex step of the algorithm, scenarios with several transmitters can be envisaged, enabling MIMO-like transmissions. The experimental evaluation shows a throughput of 30 bit/s, which is suitable for feedback, wake-up or even some limited communication purposes.

In visible light communication data can be encoded and transmitted by varying the flickering rate of the LEDs [12]. Due to its low power consumption and low cost, fluorescent lights are widely used for illuminating the room. Fluorescent lights can be switched on and off at a faster pace to transmit data. White LEDs are efficient to use as they have high brightness, long life time and consume low power. White LEDs are used in this system as they are cheaper than incandescent lamps and fluorescent lamps. Colour LEDs such as red, green and blue can also be used as their combination produces white illuminance. The expected reasonable distance upto which VLC can be used, is about 5 meters. With increase in the distance between the transmitter and the receiver, error in data transfer will also be increased

The existing VLC systems are not able to fully comply with the requirements imposed by vehicle safety applications. One of the main aspects that need further enhancement is the communication distance. [13] presents the preliminary experimental results of a novel VLC system achieving a 130 m traffic light to vehicle communication distance.

The concepts of IoT and LiFi are integrated to propose a multilayered LiFi-based IoT architecture for indoor and outdoor deployment of LiFi systems. LiFi generated data are analyzed and processed to build an intelligent decision-making system to enhance services in many sectors. LiFi is considered as an appealing IoT application since it is related to transforming light into an effective means of connectivity. To generate data for analysis with an aim of establishing a LiFi based IoT system, an architecture is proposed to deploy LiFi in multiple indoor and outdoor environments [14].

3. PROPOSED DESIGN METHODOLOGY

The LiFi system can be broken down into two sub-systems; the Transmitter (TX) and the Receiver (RX). Each sub-system is made up of components such as the LED (Light Emitting Diode) electrical control circuit, the LDR (Light Dependent Resistor) electrical control circuit, the software in the TX and RX modules, the peripherals (keyboard, monitor, mouse etc.) and support software. The transmitter module contains Raspberry Pi 3B microcontroller and the receiver module has Arduino microcontroller. The output from the transmitter pin of the Raspberry Pi is given as input to the LED array which is driven by a Transistor. The light from the LED is decoded using an LDR and after signal conditioning, the binary data is converted to original data at the Arduino board [15]. Fig. 1 depicts the LiFi system.

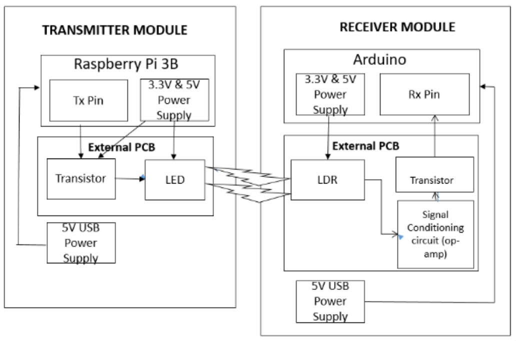

Fig. 1. LiFi System Block Diagram

Coding is carried out in python to control the transmitter module and in Arduino IDE to control the Arduino board accordingly. Fig. 2 represents the flow diagram for transmitter module. The sensor data collected from different sensors is read serially and the bytes are extracted from it. The bytes are converted into bits and the LED is programmed to turn on for a bit 1 and turn off for a bit 0.

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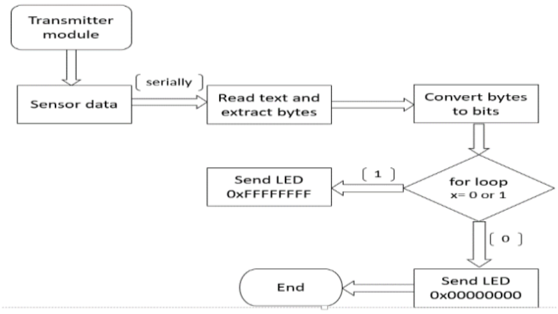


Fig. 2. Transmitter flow diagram

Fig. 3 represents the flow diagram for receiver module. The LED on and off will be detected by the photosensitive device. An on in the LED will be decoded as 1 and an off will be decoded as 0. The bytes retrieved from the bits will be converted to data and sent to the receiver PC.

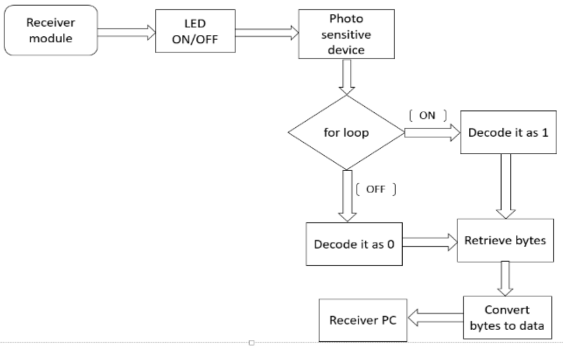


Fig. 3. Receiver flow diagram

IMPLEMENTATION AND RESULT ANALYSIS

1.1. Transmitter section

The Transmitter module consists of three sensors - DHT11 temperature sensor, MQ135 gas sensor, pulse sensor, a Raspberry Pi 3 model B board, MCP3008 ADC, BC547 Transistor and LED’s. All the three sensors are interfaced with the Raspberry Pi 3 model B board through SPI protocol using MCP3008 ADC [16]. The three sensors are connected to different GPIO pins of Raspberry Pi and MCP3008 ADC is used to convert the analog output from the sensor to digital form. The circuit diagram of the transmitter module after integration of all the individual components in shown in Fig. 4.

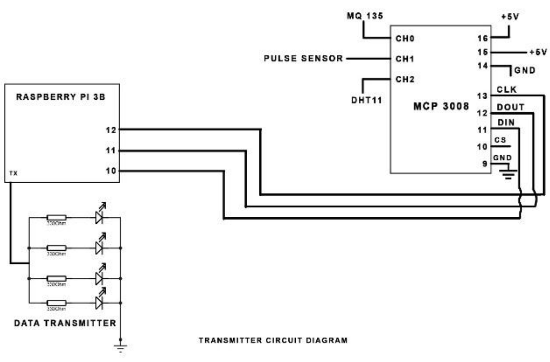


Fig. 4. Circuit diagram of Transmitter section

The Transmitter hardware implementation is shown in Fig. 5. The MQ135 gas sensor, DHT11 temperature sensor and Pulse sensor are connected to Raspberry Pi 3B board through MCP3008 ADC and LED is used to transmit data via serial communication [17].

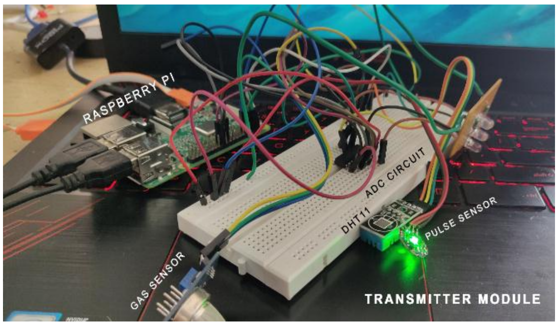


Fig. 5. Hardware implementation of Transmitter section

1.2. Receiver section

The Receiver module consists of a LDR, Arduino Uno-IDE board, LM741 OP-Amp, Node MCU - ESP8266. The transmitted data is received as light signal by the LDR which acts as a photo-receiver. Data is received as analog signals whose amplitude varies. These signals are not binary signals, hence the received signal is in analog form and can't be fed to the microcontroller. This signal is converted to digital form using comparator with the help of Op-Amp LM741. Comparator output is given as input to the microcontroller. The signals detected by the LDR are fed to the comparator where the received voltage is compared with the reference voltage [18]. If the received voltage is higher than the reference voltage, it is considered as binary high. If the received voltage is lower than the reference voltage, it is considered as binary low. Thus the LM741 Op-Amp acts as a signal conditioning unit. The processed data is further sent to the Arduino Uno - IDE board. The data is finally stored in cloud using Node MCU - ESP8266 which is a development board specially targeted for IoT applications. The circuit diagram of the receiver module after integration of all the individual components in shown in Fig. 6

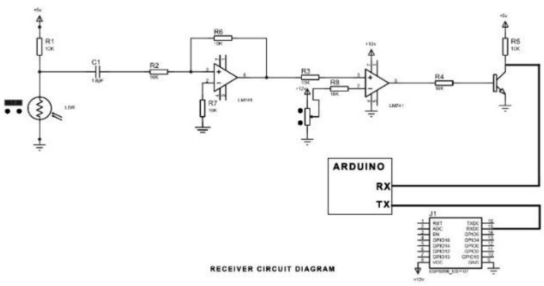


Fig. 6. Circuit diagram of Receiver section

The receiver hardware implementation is shown in the Fig. 7. In The reception end LDR is used to receive data from the LED and LDR is connected to the signal conditioning module for the amplification of signal and it is then connected to Arduino Uno board.

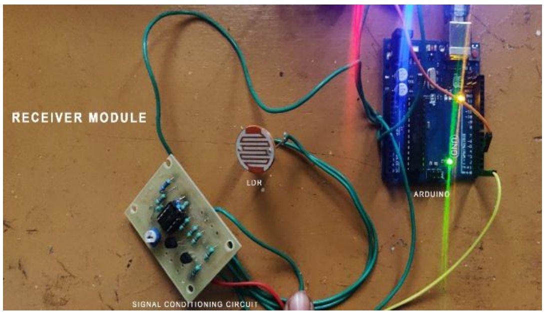


Fig. 7. Hardware implementation of Receiver section

1.3. Results

Raspberry Pi board is programmed with Python code and the output consists of three values. The first value is the Temperature of the atmosphere from DHT11(Temp Value in Fig 8). The second value is the Gas level in the atmosphere(Gas Value in Fig 8).The third value represents pulse rate of the workers(Pulse Rate in Fig 8). The Python shell output is shown in Fig. 8.

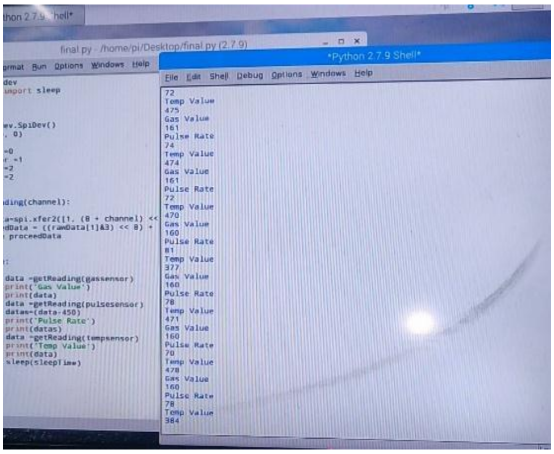
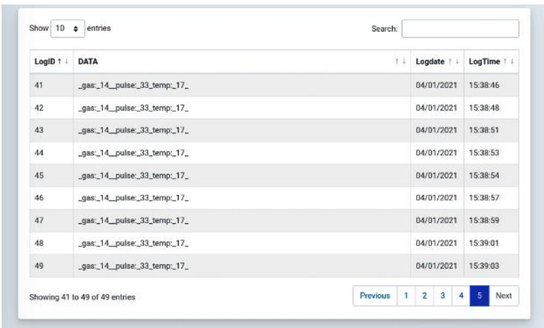


Fig. 8. Python shell output

The Arduino board is programmed to receive the data from LED and displays the output consisting of three values in serial monitor and communicates the data with Node MCU.

After interfacing Node MCU with the Arduino board, Node MCU is connected with WiFi and the data is sent to iotclouddata.com webpage through WiFi network[19] .The output is displayed in the webpage as clearly shown in Fig. 9. The sensor data will be updated in the webpage every second.



Show 10 entries Search:

LogID	DATA	Logdate	LogTime
41	_gas:_14__pulse:_33_temp:_17_	04/01/2021	15:38:46
42	_gas:_14__pulse:_33_temp:_17_	04/01/2021	15:38:48
43	_gas:_14__pulse:_33_temp:_17_	04/01/2021	15:38:51
44	_gas:_14__pulse:_33_temp:_17_	04/01/2021	15:38:53
45	_gas:_14__pulse:_33_temp:_17_	04/01/2021	15:38:54
46	_gas:_14__pulse:_33_temp:_17_	04/01/2021	15:38:57
47	_gas:_14__pulse:_33_temp:_17_	04/01/2021	15:38:59
48	_gas:_14__pulse:_33_temp:_17_	04/01/2021	15:39:01
49	_gas:_14__pulse:_33_temp:_17_	04/01/2021	15:39:03

Showing 41 to 49 of 49 entries Previous 1 2 3 4 5 Next

Fig. 9. Webpage Output

Thus the required data is transmitted and received successfully using LiFi and finally the processed data is uploaded in the cloud successfully.

4. CONCLUSION

LiFi can be used in all fields of engineering and technology. It can be used for routing information through networks at a tremendous speed thus making the overall process to be superfast. It can be used comfortably at hospitals for telemedicine, document and information sharing adhering to its security norms. It can be used without any issues at petrochemical stations for emergency situations and also for reliable data transfer [20]. It can be used in nuclear power plants and other hazardous places for monitoring the resources as well as the health of the employees. It could also be effectively used for under water communication. It can be set up even at hard terrains allowing even the remotest parts of the globe to have access to internet facilities with dual purpose of illumination and data transfer. Visible light communication can pave way to a new world of digital data transfer with not much harm to the environment and to the human health fulfilling the bandwidth needs and speed requirements. The proposed work will be advantageous over the existing live monitoring systems available in the market. The future scope of this project includes adding some more sensors and to design a real time low cost, weightless, wearable and easily portable device.

5. REFERENCES

[1] N. Soni, S. Chopra, M. Mohta, and T. Choudhury, "A Brief Case Study on Li-Fi Technology", IEEE International Conference on Contemporary Computing and Informatics(IC3I), 2019.

[2] H. Haas, L. Yin, Y. Wang, and C. Chen, "What is lifi?" Journal of Lightwave Technology, vol. 34, no. 6, pp. 1533–1544, 2016.

[3] M. Leba, S. Riurean, and A. Lonica, ''LiFi—The path to a new way of communication,'' in Proc. Iberian Conf. Inf. Syst. Technol. (CISTI), Jun. 2017, pp. 1–6.

[4] S. Yadav, P. Mishra, M. Velapure, and P. P. S. Togrikar, '''Li-Fi': Data transmission through illumination,'' Int. J. Sci. Eng. Res., vol. 6, no. 10, pp. 1432–1436, 2016.

[5] Yongping Wu and Guo Feng, "The study on coal mine monitoring using the Bluetooth wireless transmission system", 2014 IEEE Workshop on Electronics, Computer and Applications, pp. 1016-1018, 2014.

[6] Tanmoy Maity and Partha Sarathi, "A wireless surveillance and safety system for mine workers based on Zigbee", 1st Int'l Conf. on Recent Advances in Information Technology RAIT-2012

[7] Monika Ramchandra Botre and Anjali. R. Askhedkar, "LiFi and Voice Based Indoor Navigation System for Visually Impaired People", IEEE Pune Section International Conference, 2019.

[8] Noof Al Abdulsalam, Raya Al Hajri, Zahra Al Abri, Zainab Al Lawati, and Mohammed M. BaitSuwailam, "Design And Implementation of a Vehicle to Vehicle Communication System using Li-Fi Technology". IEEE publications International Conference on Information and Communication Technology Research, 2015.

[9] Zubin Thomas, Nikil Kumar and D. Jyothi Preshiya, "Automatic Billing System using Li-Fi Module", International Conference on Communication and Signal Processing,

April, 2016.

[1] Merelle, T and Bataillou, B, "LiFiX: A fully bidirectional CMOS light communication device: Multichannel dedicated device for high bandwidth secured wireless data transmission", Global LIFI Congress (GLC), 2018.

[2] Duquel, A, Stanica, R, Rivano, H and Desportes, A, "Decoding methods in LED-to-smartphone bidirectional communication for the IoT", Global LIFI Congress (GLC), 2018.

[3] Zashi P.Choudhari and satish R. Devane, "High sensitivity Universal LiFi receiver for enhance data communication", Online International Conference on Green Engineering and Technologies, 2016.

[4] Alin-Mihai Căilean, Mihai Dimian and Adrian Done, "Enhanced design of visible light communication sensor for automotive applications: Experimental demonstration of a 130 meters link", Global LIFI Congress (GLC), 2018.

[5] Lamya Albraheem, Lamia Alhudaithy, et. Al., "Toward Designing a LiFi-based Hierarchical IoT Architecture", IEEE Access, pp. 40811 – 40825, 2018.

[6] Aarthi. K, Elango .S, "Coal Mine Safety Monitoring System Using ARM9",International Journal of Science and Research (IJSR), Volume3,Issue-11,November 2014

[7] Dania Eridani, Eko Didik Widianto, "Performance of Sensors Monitoring System using Raspberry Pi through MQTT Protocol", IEEE Xplore, Nov 2018.

[8] Qian Luo , Min Xie, "Temperature and Humidity Detection System of Communication System Based on Raspberry Pi", IEEE Xplore , Jan 2018.

[9] Valdo Henriques and Reza Alekian,"Mine safety date system using wireless sensor network", IEEE Trans. Ind. Appl., of publication June 16, 2016.

[10] "Integration between wireless sensor and cloud"**,** International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud), 2017.

[11] Arunapriya V, Praveen Kumar S, Kalimuthu K, **"**LIFI for Medical care using Visible Light Communication**",** International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 11 (2018) pp. 9273-9276

[12] Subrahmanyam, S.; Panicker, V. Microcontroller Based Self-Regulating Devices in Enclosed Environments. IARS' International Research Journal, v. 4, n. 1, 2014. DOI: 10.51611/iars.irj.v4i1.2014.35.