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LIGHT FIDELITY APPLICATION IN TELEMEDICINE

(LI-TEL)

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Abstract: Although we have seen positive advances in healthcare, we still have problems in the health sector mainly with a shortage of physicians (doctors) many countries fall short of the standard of 1 per 1000 with other countries reaching more than 1 per 10,000, doctor-patient ratio. Due to the shortage of medical personnel, we have developed systems like HIS, E-Health, and telemedicine. This study will mainly focus on Light Fidelity (LiFi) applications in telemedicine (remote health). The idea is to have more reliable, low latency, secure, safe, and green technology systems. Light Fidelity system (Li-Tel) uses the light spectrum to transmit measured data by sensors during the monitoring of a patient, inform the physicians in case of emergency, and track movement. This will be done by the usage of Arduino, LEDs, photodiodes, sensors, and the usage of GSM or cloud. The project focus on the transmission of data generated by the remote operation that includes live communication, live patient readings, and movement of the subject.

Index Terms - Light Fidelity, Line of Sight, Internet of medical things, radio frequency Communication,

I. INTRODUCTION

In our era, we have seen technology alter the healthcare system but the number of deaths arising due to chronic illnesses is still at high levels. According to WHO as of this year NCDs kill 41 million people each year, equivalent to 74% of death globally [1]. Also, the recent Corona Virus pandemic has brought to light the biggest challenge we have which is the difference between patients and health staff. All the above problems require constant monitoring, early detection, and preventive measure but since we don't have enough personnel that's where telemedicine was born. According to the health telematics policy in 1997 telemedicine definition was proposed as follows “Telemedicine is the delivery of health care services, where distance is a critical factor, by all health care professionals using information and communications technologies for the exchange of valid information for the diagnosis, treatment, and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities”. Telemedicine in other words can be explained as the integration of wearable sensors and communication devices to facilitate healthcare services remotely or from distance. In telemedicine, we have services like live patient monitoring and live communication, which most of the time use wireless communication. With an increase in the Internet of Medical Things (IoMT), sensors and devices are connected. They have been required to have communication means that can match the demand for high bandwidth, high density, and low consumption reliability. Studies have shown that telemedicine is capable to take of chronic diseases like diabetes and cardiac. But we have the limitation of transferring the number of devices, and user increasing, radio frequency cannot able to satisfy the growing demands. the light fidelity technology was then developed to eradicate most of the defects while transferring data via radio frequency.

In most smart healthcare presently, we are using wireless communication. we have several means of wireless communication which include radio frequency, Visible light communication, free space optic, infrared and light fidelity. A pupilar example is a WIFI which is a short form of wireless fidelity, this technology uses radio frequency to transmit data using radio waves with the help of a WIFI router. We even have many pieces of equipment which use Wi-Fi such as anesthesia machines. defibrillators, infusion pumps and lung ventilators. When a condition arises that a doctor needs to use an MRI scanner along with a lung ventilator it results in electromagnetic interference (EMI). The increase in devices is directly proportional to Electromagnetic interference. Longer exposure to EMI is proven may cause negative effects on the body and in some instances, it may result in cancer.

LIFI vs WIFI

PARAMETER	**LIFI**	**WIFI**
Spectrum	Visible light communication (VLC)	Radiofrequency (RF)
Components	The photodetector, LED, lamp driver	Routers, devices like phones, or PC
Interference	No	High (EMI)
Bandwidth	Unlimited	Limited
Speed	High (up to 10 Gbps)	Medium (< 450 Mbps)
Range	Low (< 10 m)	Medium (< 300 m)
Data Density	High	Low
Security	High	Medium
Reliability	Medium	Medium
Power availability	High	Low
Transmit/Receive Power	High	Medium
Ecological Impact	Low	Medium
Device-to-device connectivity	High	High
Obstacle interference	High	Low
Bill of initial materials	High	Medium
Market maturity	Low	Medium

Table 1

II. RELATED WORKS

In 2019 Ibrahim in his paper presented his findings that his experiment outcome shows that by removing the optical background noise power, the result accuracy was 100%. His system of Li-Fi healthcare monitoring was created to convey data through diverse propagation links from an FBG sensor passed by a patient to an optical receiver install in a ceiling room using Li-Fi technology. His prototype was equipped with affordable components and low power consumption. It also adapted to diverse other systems of transfer or processing operation. The created system accepts the desired signal and ignores the unwanted one. He proved that the system using the LiFi network was able to receive and send data with high accuracy. [2]

The Limos framework analysis was performed based on basic metrics like Cost, Throughput, and Time. The findings proved that LiFi attained better performance compared to its other methods. While by cost wise the was a reduction in the costs of traveling to a doctor. There was also better time management since most services were handled online. In conclusion, the authors stated that complete monitoring and early observation of a patient is essential, and with no radiation. Their system was a simple receiver, and transmitter using LiFi combined with medical monitoring kit (MMK). In this system, the focus study was only on the ICU in the hospital other parts of the hospital were not considered hence the system was for a static patient. [3]

In this paper, the authors introduced an argument in the extended application that the LIFI can make the medical field diagnosis faster. This proposed system was fully automated and might be a milestone in the medical field if effectively applied. Since we already have introduced in the industries Li-Fi-based speech-controlled robots. We can regulate the actions of the robot. Instructions for this operation are conveyed

to the robot by Li-Fi technology. With current research at the University of Nebraska medical center which has run multi-campus energy to provide a joint study on mini-robotics among engineers, computer scientists, and surgeons, Automated surgery will require a lot including adaption to the constant changes in the operating room. But overall, they manage to prove that Li-Fi network can be used as a secure, high-speed, and safe for humans, it can also data communication to provide real-time monitoring of various parameters. [4]

One writer demonstrated an adaptive algorithm for multiple-input-multiple-output (MIMO) VLC for increasing energy efficiency. According to channel circumstances, the wanted spectral efficiency, and a target error rate, the MIMO technique is selected from three possible options: repetition coding (RC), spatial multiplexing (SMP), and spatial modulation (SM) modified version. In every possible place, the MIMO method with less input energy requirement is selected, and therefore the energy consumption is minimized. Such a method could be notably beneficial in diverse applications like Internet-of-things (IoT) where energy is the main factor. In this paper, the authors offered an adaptive way that chooses the least energy-consuming MIMO method in several room locations for a desired spectral efficiency and a target bit error proportion. It was proven that energy consumption could be abated if the exact MIMO method is designated. The authors claimed that the presented Received: technique is useful in IoT applications due to energy consumption might be lessened by applying the most effective MIMO method wherever the user is placed. [5]

This paper introduced a stationary indoor patient monitoring structure using uplink VLC suitable fixed hospital settings. VLC was used instead of RF communication for health worries regarding continuous RF contact with patients for health monitoring. In the end, multiple patient data transmissions remotely using the spatial diversity of photodetectors. The simple OOK modulation with a low data rate is found to be adequate for transmitting the sensor data and properly placing photodetectors for minimal interference from ambient illumination. VLC can suffer from ambient noises from other illumination sources exposed to the photodetector; however, the Signal-to-Noise Ratio (SNR) can still be minimal if proper color filtering is implemented. [6]

In the paper "Light Fidelity: The Future of Data Communication" in his remarks, he stated that LiFi is a great technology that has the influence or capacity to alter the entire wireless technology. The abilities which are presented by LiFi are innovative. Even though there are very scarce things of Li-Fi currently in the marketplace, because of its virtues, it will deferentially be an instant success in the market. He proposed that LiFi can also be used by scientists to execute various scientific experiments and studies. it is often realized that many scientists need secure dependable and faster communication for their research. [7]

"LiFi Experiments in a Hospital", focuses mostly on measurements and data transmission rates. The testing was made on a static material and position [8]

The author, gives a brief introduction of the topic, modulation technique, security concerns, and available challenges, It does provide the solution to the challenges that have been raised. [9]

The author stated that medical surgeries would be more accurate and less risky at the moment telemedicine is deployed, turning it into optimizing services from healthcare centers. Li-Fi research is still on in different fields with different applications. With Li-Fi each transmission will become faster and safer compared to wireless technologies based on radio wavelengths. [10]

III. SYSTEM IMPLEMENTATION

3.1 Proposed system

In this study, we will develop a LIFI system that can be able i). To convey live communication (text, video). ii). a basic biomedical (patient) live monitoring to transmit through the LIFI network and cloud for emergencies. iii). To track the movement of the patient or object. All this will be transferred by using the light fidelity network. The objective is to show how light fidelity has been used or how it can be applied in telemedicine.

3.2 The architecture of The Proposed Solution

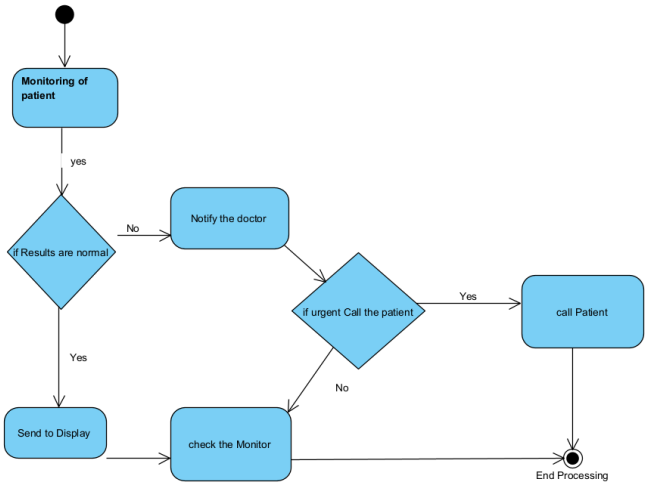

Fig 1. Proposed architecture diagram

This diagram represents the flow of communication and decision in the Light fidelity transmission. The operation begins by turning on the LED with the other monitors to start monitoring. Then the sensors have calculated the readings of patients for normal readings the transmission is just sent to the display but if un normally occurs then the is transferred by a bolt to the cloud which proceeds and then sent to a virtual machine to notify the API connected. The API is programmed to send an email and SMS to the doctor for him to make a call and see what is the change.

3.3 System Design

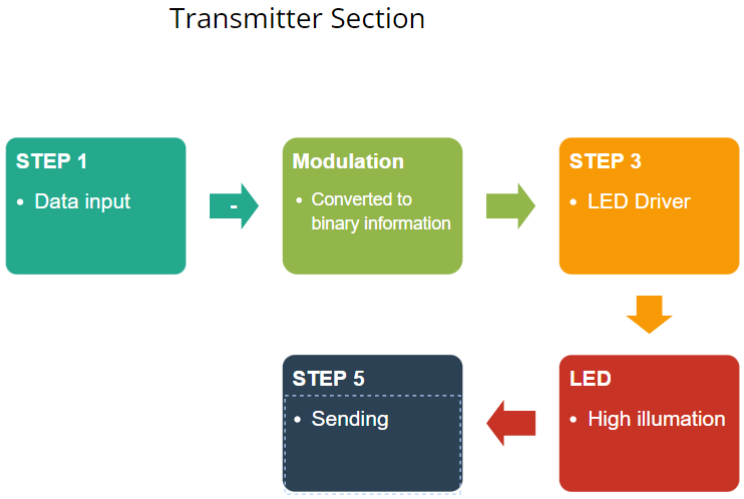

Fig 2. LiFi transmitter Side

Transmitter

In fig. 1 explains, the process involved on the transmitter side. The data from an external source might be text, audio, video, or readings from sensors. The data is the modulation from every signal into a light signal and send as binary data. The binary data is then sent using the available LED. The data can be seen when being sent since it is sent through illumination only that the data transfer is done at a high rate hence you can see the led blinking but the light is visible during the whole process.

RECEIVER SIDE (RX)

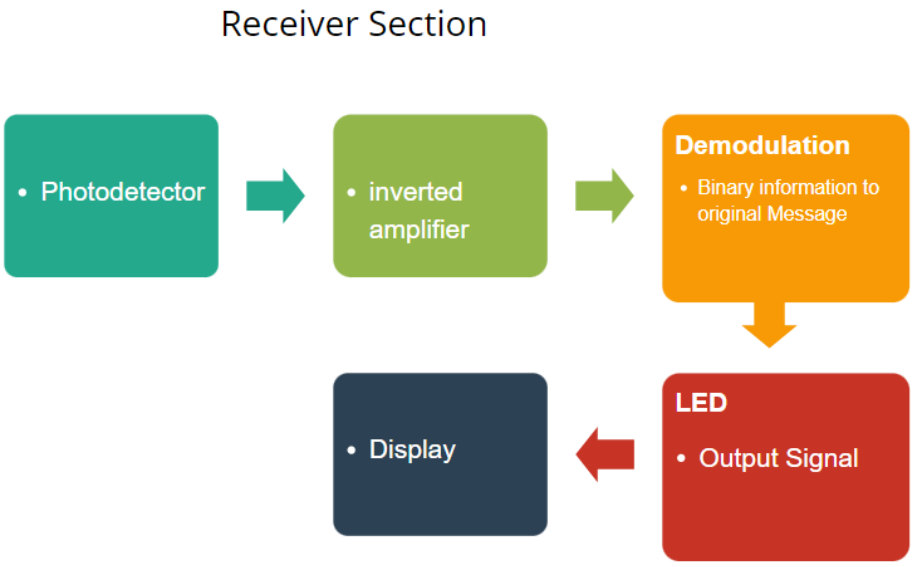

Fig 3. Receiver Side process

Receiver side

At the receiver side, the data is received by a photodetector which can be able to receive high illumination from the LED. From the photodetector, the data is then sent for amplification. In this stage, the data is still in light format, after being amplification to remove the noise in the transmission it is transmitted to a demodulator where the data is returned to its original format. The data can now be sent to the output device connected either a monitor. Lcd, or even a web browser. On RX side we can even use a simple panel to reduce energy consumption such that the same transmission also generates energy hence increasing efficiency while reducing energy consumption.

Modulation.

The device connected for simple text transmission can be achieved using simple OOK modulation which uses less energy even a 5 DC volt battery can manage to send and receive data.

Working

The data is connected to a source where it can collect readings, video, or even sensors. Using USB TTL cables, we connect the USB to the Arduino Mega 2560 which is equipped with a 5-dc power supply regulator, and potential meter. Which is then connected directly to the TX LiFi. For the automatic uploading of data, we connect it to the Wi-Fi bolt which is connected to the cloud. The sensors all are connected to the board which has a microcontroller that will perform the modulation from data to an electrical signal. The electrical signal is sent using the LEDs.

The Electrical sent from LiFi Tx is received by a photodetector in this case solar is used to receive the transmission. Because of noise and disturbance, the signal is amplified to reduce noise, in the signal. In the RX then it is modulated back into normal signal data, voice, or light. Then transmitted either to the monitor which is being used or to the other device connected to the Arduino on the receiver side. For the light transmission and tracking the principle is the same only that the data is transmitted on a blynk app.

IV. RESULTS AND DISCUSSION

The feasibility study of the project shows that most of the requirements needed are available and it is worth all efforts to start developing the system at a large scale. The physical, economical, and all the needs required to build the system are readily available but some features are still under research conducted so shortly I believe LiFi will reform the whole of telemedicine and the entire healthcare. With a simple LED, we can use it as a transmission device to share data in real time. Some of the advantages of this method are its high bandwidth, contrasting with more problems when it comes to real-time transmission.

v. CONCLUSION

The work to prove that the LiFi system in telemedicine can transmit data at low latency is reliable, flexible to deploy, more secure, and safe for health workers was successfully implemented. With the current technology, we still need more infrastructure to implement a fully LiFi system. The LiFi system has the potential even to replace RF. The system was able to communicate, able to monitor, and track movement which is a good sign with the coming of the Internet of Medical Things (IoMT). This communication will be able to connect more devices to perform all operations at high bandwidth, and ultra-low latency even performing remote surgery operations. Despite all its capabilities as of now, it cannot completely replace Wi-Fi technology but it complements the existing transmission communication modes.

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