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LIGHT FIDELITY USING VLC

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ABSTRACT: Li-Fi technology, which stands for Light Fidelity technology, utilizes light as a medium of communication to transmit data through the variation in intensity of an LED bulb. This technique is also referred to as optical wireless technology or visible light communication and has a speed faster than the human eye can detect. In comparison to Wi-Fi, which is suitable for transmitting data within buildings, Li-Fi offers higher efficiency, bandwidth, security, and availability in the industry due to its impressive speed. This report aims to investigate this remarkable technology and compare it with other wireless communication technologies such as Wi-Fi and also it aims at creating a prototype where Li-Fi can also be used in military operations where radio frequency communication is prohibited or could give away the location of troops. For example, in covert operations or special forces missions, where it is necessary to communicate without being detected, Li-Fi can provide a secure and reliable means of communication.

KEYWORDS: Light Fidelity, VLC, Arduino Uno, Visible Light.

I. INTRODUCTION

The visible light communication technology known as Light Fidelity (Li-Fi) was developed by a research team, including Professor Haas, at the University of Edinburgh. The term was coined by Professor Haas himself. Li-Fi allows for wireless data transmission using LED light, leveraging the ability of solid-state lighting systems to create binary code with LED illumination imperceptible to humans. Electronic devices equipped with a photodiode can access this information within the range of visible light, meaning that any location with LED lighting can also have wireless connectivity. Unlike Wi-Fi, which is best suited for wireless data coverage within buildings, Li-Fi offers exceptional data coverage density in specific areas without radio interference issues. It also provides better latency, performance, accessibility, and security, and has even reached extreme speeds of over 1 Gbps in laboratory conditions. This technology is particularly useful in high-security military areas where RF communication is susceptible to eavesdropping. Li-Fi offers a greener, cleaner, and safer alternative to traditional wireless networks and can help alleviate the heavy loads currently faced by wireless systems. Additionally, Li-Fi avoids the radiation produced by Wi-Fi and provides a better, more efficient, secure, and faster connection. In short, Li-Fi is a wireless communication technology that uses LED lamps for transmitting and receiving information, and it provides numerous advantages over traditional wireless systems like Wi-Fi.

One of the application which we are focusing on in this project is Military Support. Li-Fi technology has the potential to be used in various military communication systems. It can offer secure communication in situations where traditional wireless communication is not reliable or secure enough, without the risk of electromagnetic interference. Due to its directional signal and inability to penetrate walls, Li-Fi communication can be difficult to intercept, making it ideal for covert operations or special forces missions where communication without detection is crucial. Additionally, Li-Fi can be utilized in military vehicles and aircraft, as it can provide high-speed data transfer without bulky cabling or the risk of electromagnetic interference, which can interfere with sensitive equipment. With these advantages, Li-Fi technology offers a promising solution for secure and efficient military communication systems.

II. RELATED WORK

Haas, H. (2018) [1] defined in this article, the author first explains what Light-Fidelity (Li-Fi) is and claims it is the fifth generation (5G) technology. Transfer speeds up to 8 Gbps are delivered from a proven light source and a fully Li-Fi based cellular network. He discusses many misconceptions and shows the impact this technology can have on various existing and emerging industries. He also talked about new apps that Li-Fi might unlock in the future. We have shown that there is a clear trend towards using higher frequencies in wireless communications. This is a result of the simultaneous exponential growth in wireless traffic over the past decade that has limited the RF spectrum in the lower frequency bands. This growth will continue. This paper on Li-Fi physical layer technology has seen a lot of research in the last 15 years, with data rates increasing from a few Mbps around 2002 to 8 Gbps from a single LED in 2016. Over the past five years, his research on Li-Fi network technologies such as multi-user access and interference mitigation has increased.

Ramadhani, E., & Mahardika, G. P. (2018, March) [2] described that light Fidelity (Li-Fi) is a technology based on Visible Light Communication (VLC) that uses light as a communication medium to replace wired communication. Li-Fi is evolving to surpass Wi-Fi's nominal speeds, but with Li-Fi, nominal speeds can reach 14Gbps. This article provides an introduction to Li-Fi technology including architecture, modulation, performance and challenges. In this article, the author explained how his Li-Fi works, the modulations used, its architecture, performance and finally the challenges. The purpose of Li-Fi technology is to provide high-speed data communication using the visible light spectrum. Li-Fi, which is currently under investigation, has potential advantages that can be used to complement RF communications and improve the performance of wireless networks. Li-Fi is excellent in terms of transmission speed, but when used outdoors under conditions such as sunlight, Li-Fi does not perform well. Li-Fi is unlikely to completely replace Wi-Fi, and the two technologies can be used together to create more efficient and secure networks. The results of this paper can be used as reference and knowledge for the development of Li-Fi technology.

Wu, X., Soltani, M. D., Zhou, L., Safari, M., & Haas, H. (2021) [3] proposed that growing number of mobile devices and growing demand for Internet services are driving network convergence, which brings together different technology domains. A promising approach for indoor wireless communication is to combine Light Fidelity (Li-Fi) and Wireless Fidelity (WiFi), especially Li-Fi and WiFi hybrid networks (HLWNets). This hybrid network combines the high-speed data transmission of Li-Fi with the wide coverage of WiFi. With the coming RF spectrum crisis, Li-Fi has emerged as a promising technology for in-home wireless communications in recent years. On the other hand, WiFi is becoming more and more prevalent in our daily life. The coexistence of Li-Fi and WiFi is facilitated by the commercial deployment of his Li-Fi products by companies such as Pure Li-Fi and Signify. This document introduces the system design framework for HLWNets, followed by an overview of key performance indicators and outcomes that validate the superiority of HLWNets over standalone networks. The existing research was then categorized and analyzed on his three main technical themes: noise management, forwarding, and load balancing, with unique challenges in supporting user mobility.

Haas, H., Yin, L., Chen, C., Videv, S., Parol, D., Poves, E [4] discussed that Li-Fi is a two-way wireless network connection using light. Used to connect fixed and mobile devices at very high data rates using the visible and infrared spectrum. Combined, these spectrum sources are 2600 times larger than the entire radio frequency (RF) spectrum. This work showed that future mobile systems based on optical communication in free space can be built. Relatedly, it has been shown that to achieve this goal, the focus must shift from the point-to-point link layer of wireless networks to lightweight free-space communications. This paper showed that using Li-Fi in combination with Wi-Fi can significantly improve data density. In fact, Li-Fi is enabling incremental improvements in cell density and radical reuse of data transmission.

Kouhini, S. M., Kottke, C., Ma, Z., Freund, R., Jungnickel, V., Müller, M., & Linnartz [5] Precise location information is seen as a key driver for the use of intelligent manufacturing systems in Industry 4.0. This article describes a time-of-flight-based indoor navigation system for Li-Fi based on ITU-T Recommendation G.9991. Our goal is to achieve positioning by reusing existing features of the Li-Fi communication protocol adopted by many publishers. In this article, the author demonstrated an indoor location system for networked optical wireless communication called Li-Fi. The proposed navigation system is based on time-of-flight measurements between multiple optical fronts placed on the ceiling and mobile devices moving in overlapping coverage areas. For a 1 m × 1 m × 2 m test setup, the average 3D



distance errors in the x, y, and z axes at the edges are less than 8 cm and small between the optical front ends. Adopting this technology requires strict synchronization between the optical interfaces of the Li-Fi infrastructure. There is a vast literature survey on query processing on Li-Fi. This shows that it is possible to enhance the data density significantly using Li-Fi in combination with Wi-Fi. Li-Fi allows for step-change improvements in cell densification, enabling radical reuse of transmission resources.

III. METHODOLOGY

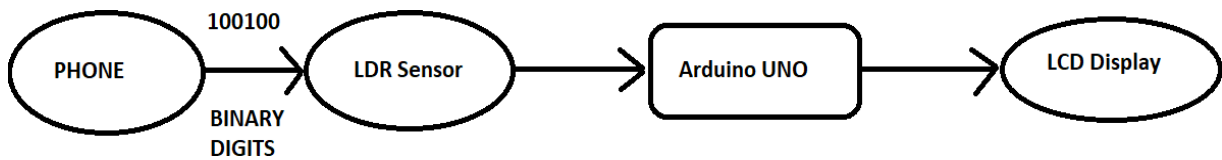


Fig 1 : Block Diagram of the System

Li-Fi technology is often implemented by using white LED light bulbs at the downlink transmitter, which are typically used only for illumination with a constant current. However, by varying the current in a fast and subtle way, the optical output can be changed at extremely high speeds, allowing for data transmission using the varying property of the optical current. The operational procedure of Li-Fi is simple: if the LED is on, a digital 1 is transmitted, and if it is off, a 0 is transmitted. The flashing of the light happens so quickly that it appears constant to the human eye, allowing for a Li-Fi data connection to resemble a simple LED. To process the data, a microchip is embedded in the LED lamp and the data is streamed to a lamp driver on one end, while a positive-intrinsic-negative (PIN) photodiode is used as the receiver on the other end. The optical signal is then intensity modulated with Direct Detection (DD) and On-Off Keying (OOK) modulation scheme is typically used to send information. The receiver using a PIN photodiode is advantageous in high noise environments, as it does not saturate like an avalanche photodiode (APD), and is also less expensive with a larger active area.



Fig 2 : Arduino Uno

The standard Arduino board, called Arduino UNO (Figure 2), was named after the Italian word for "one" and was the first USB board released by Arduino. It is based on the ATmega328P microcontroller and is widely used in various projects due to its user-friendly nature. Compared to other boards like the Arduino Mega, the UNO board is easier to use. It comes with 14 digital and 6 analog Input/Output pins, along with a USB connector, a power jack, and an ICSP header. The IDE, or Integrated Development Environment, is used to program the board and is common to all Arduino boards. The Arduino UNO board has a 16MHz crystal oscillator and 20 Input/Output pins, including 6 PWM pins, 6



analog pins, and 8 digital I/O pins. It also has an integrated WiFi module based on the ESP8266 module, making it a versatile board. The UNO board can draw power from both external power supply (7V to 20V) and USB.



Fig 3 : Jumper Wire

The jump wire, also called a jumper or DuPont wire, is a cable with a connector or pin at each end that is used to connect the components of a breadboard or prototype or test circuit internally or with other equipment or components, without the need for soldering. Male-to-male jumper wires are commonly used to connect two ports on a breadboard, while male-to-female jumper wires are used to connect the female header pin of one development board to another board with a male connector. Female-to-female jumper wires have female connectors at both ends and are useful for quick connections between header pins, FRC pins, berg pins, and other components in rapid prototyping.



Fig 4: LCD Display

The Hitachi HD44780 driver compatible LCD displays with a 16-pin interface can be controlled using the Liquid Crystal library. The microcontroller needs to manipulate several interface pins at once to control the display since the LCDs have a parallel interface. The interface consists of various pins, such as Register Select (RS), Read/Write (R/W), Enable, and 8 data pins (D0-D7) for reading and writing bits. Additionally, there are pins for display contrast (Vo), power supply (+5V and GND), and LED Backlight (Bklt+ and Bklt-) to power the LCD, adjust the display contrast, and turn the LED backlight on or off. By putting the data into the data registers and instructions into the instruction register, the image of what to display can be controlled. The Liquid Crystal Library simplifies the process of controlling the display by handling low-level instructions. The Hitachi-compatible LCDs have two modes: 4-bit or 8-bit, where the 4-bit mode requires seven I/O pins from the Arduino and the 8-bit mode requires 11 pins. Displaying text on the screen can be done in 4-bit mode, so this example shows how to control a 16x2 LCD in 4-bit mode.

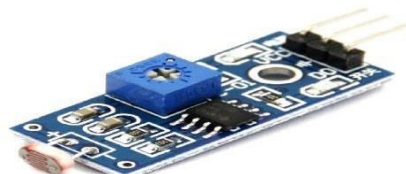


Fig 5 : LDR Sensor



The LDR sensor module, also known as the Photoresistor sensor, is a cost-effective digital and analog sensor capable of detecting and measuring light intensity. It comes with four terminals, including a digital output pin ("DO") and an analog output pin ("AO"). In the absence of light, the output of the module goes high, and in the presence of light, it becomes low. The onboard potentiometer allows for the adjustment of sensitivity. The LDR, or Light Dependent Resistor, is a type of variable resistor that operates on the principle of "Photo Conductivity." As light intensity on the LDR surface changes, so does its resistance and conductivity. The LDR sensor module also includes a 10k preset variable resistor used for setting the sensitivity of the light intensity detection, which can be adjusted by rotating the preset knob.

IV. EXPERIMENTAL RESULTS

Figures shows the results of a) The Li-Fi is ready to receive message from the Li-Fi app , b) and c) android application which is used to send data , when the user clicks on send button present in the application. It auto turns on the flashlight of the mobile phone in turn the binary data gets transferred to LDR sensor module which sends data to Arduino Uno Board and then transfers it to the LCD display which displays the message.

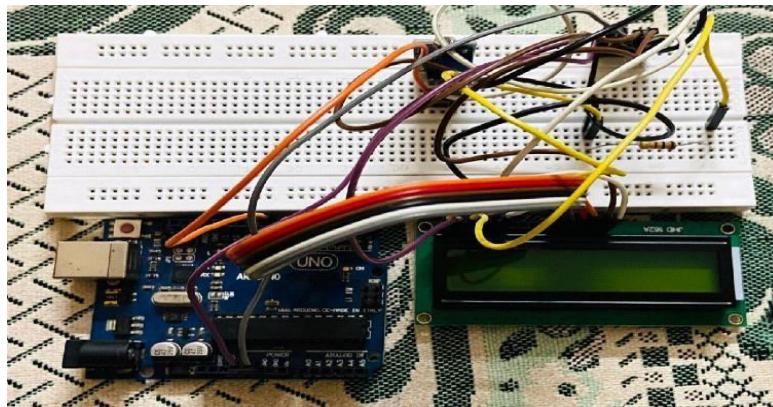
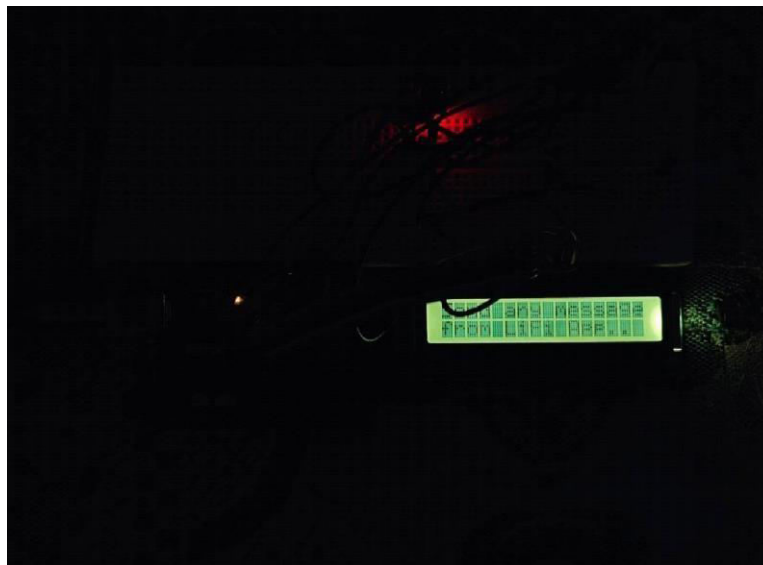


Fig : 6 Working Module of Li-Fi



a)



Send

Data sent!



Send

Data sent!



b)

c)

V. CONCLUSION

The aim of this project is to explore the potential of Li-Fi technology as an alternative wireless communication method for transmitting both text and images. However, it is important to note that the baud rate of the system is limited to certain Kbps and black and white image transmission is not possible due to the use of random encoding in three layers. To ensure successful transmission, the baud rate of the transmitter and receiver must be the same, and adding a focusing lens between the transmitter and receiver could improve the system's performance. If this technology is put into practical use, it could be used in conjunction with VLC-based Wi-Fi hotspots, enabling every light bulb to serve as a source of light and a broadcasting tool. The limitations of this technology can be overcome by using higher-end devices. The conclusion of this project is that Li-Fi technology provides a more secure, cost-effective, and health-friendly method of short-range communication compared to traditional RF wave communication, and by using high-end devices, the maximum transmission speed can be achieved.

Li-Fi technology offers several potential benefits for military communication systems. It can provide secure and reliable communication in situations where traditional wireless communication is not reliable or secure enough. Li-Fi signals are highly directional and do not penetrate walls, making them difficult for adversaries to intercept. Additionally, Li-Fi signals are not vulnerable to electromagnetic interference, which is a common issue in military environments. Li-Fi can also be used in military operations where radio frequency communication is prohibited or could give away the location of troops. It can provide high-speed data transfer within military vehicles and aircraft without the need for bulky cabling or the risk of electromagnetic interference. Overall, Li-Fi is a promising technology for military applications, offering the potential for secure, high-speed communication in a variety of settings.



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