Smart Garage Using Visible Light Communication

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Abstract— From the advent of the lock and key system to the automatic Bluetooth or Wi-Fi controlled garage doors, in regard to the security levels of different systems; there has always been a significant improvement. This paper proposes an innovative amalgamation of visible light communication with security techniques to create a garage door. The aim of this project is to combine the newly developed technologies with the already-existing ones to give top notch security. The data transmission will happen through the headlights of the car which will be intercepted by a photodiode. The received data will eventually be checked, which will control the opening and closing of the garage door. The entire system aims at being user-friendly and efficient.

Key words: Smart Garage, Light Communication

I. INTRODUCTION

Nowadays, technologies in the field of electronics and communication have been on the rise, one of them is the advancement in LED technology which has been evolved and developed drastically. LED is a simple light source device used in various electronics appliances with it increasing applications in everyday life such as electronics calculator , lighting torch , traffic signal lights , car tail light, mobile phones and smart phones as well as the applications in replacement for incandescent or fluorescent lamps in buildings and roads. The heart of Li-fi technology is high brightness LED's. These LED's can be switched on and off very quickly which gives you the opportunity for transmitting data rapidly as the operating speed of an LED is less than 1μs. Apart from digital lightning source applications, many scholars and researchers have studied and evolved the application of LED as a device used in visual light communication (VLC) in order to make the most of emitting LED light as a means of delivering data. However, despite its fast-increasing popularity, the real time applications of VLC are still very limited. This paper aims at using VLC to create a smart garage which will help in reducing cases of vehicular thefts. The VLC technology will be used as the method of transmitting data from the sender node to the receiver node and the receiver will have a photo detector which will detect the data sent. Based on the data sent, there will be a security check at the receiver which results in the opening and closing of the door. This data communication system using visible light utilizes the application of common LED lamps mostly used in the building as a data transmitting device to deliver demodulated TEXT information perceived and checked by the receiver [1].

II. LITERATURE REVIEW

A. *Visible Light Communication*

The electromagnetic spectrum is the umbrella term for all the frequencies accounted for and their linked wavelength of the photons. In laymen terms, electromagnetic spectrum is the characteristic distribution of electromagnetic radiation emitted or absorbed by an object. The figure below depicts the electromagnetic spectrum.

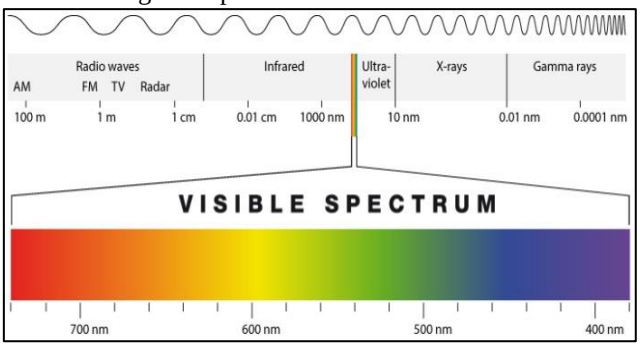

Fig. 1: Electromagnetic Spectrum

With the recent spur in levels of technology, we have managed to exploit the UV, Visible, IR, Microwave and Radio bands for communications. Narrowing down to the visible spectrum, optical communication is currently known as the fastest method of transmitting data. However, optical communication involves the usage of laser light and optic fibers and while that is a very reliable method for transmission, it cannot be applied for real time applications where data transmission occurs on a daily basis all around. This is because of the high power concentration of the laser light which is definitely not suitable for human-to-human interaction. This issue was then countered with the help of the newly developed Light-Fidelity technology. Light Fidelity (Li-Fi) was first pioneered by Harald Haas back in 2011. The technology was introduced at a TED Global Talk where he explained the idea of wireless data transmitted from every light source. It is a form of visible light communication and is a branch of optical wireless communication. Light fidelity has soon caught up with the world and is notoriously considered as the complement to Radio Frequency Communications which primarily contain Wi-Fi and cellular broadcasting and is soon emerging as the leading technology in data transmission. It is touted to become one the fastest means of data communication due to impenetrability of visible light through walls, or any other physical object, which increases its security level manifold. Light Fidelity uses the visible light for transmission which in comparison to 10,000 times more than the band required for Wi-Fi. Hence, Visible Light Communication (VLC) is another term used interchangeably. VLC uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as optical carrier for data transmission and illumination. To transfer information VLC uses fast light pulses and this communication system is depending on two components:

1) A high brightness white LED which acts as a communication source.
2) Silicon photo diode which shows good response to visible wavelength region [2].

In this table, we compare the various wireless technologies used for data transmission based on several parameters [3].

Parameter	Zigbee	Bluetooth	Wi-Fi	Wi-Max	Li-Fi
Development Year	1998	1994	1990	2001	2011
Standard	IEEE 802.15.4	IEEE 802.15.1	IEEE 802.11	IEEE 802.16d/e	IEEE 802.15.7
Range	10 to 20m(approx)	Typically less than 10m to up to 100m	About 300m	30-100m	Based on LED Light Intensity
Operating Band	Radio Frequency Band	Radio Frequency Band	Radio Frequency Band	Radio Frequency Band	Visible Light band
Frequency	2.4Ghz(GSM)	2.4Ghz(GSM)	2.4-5Ghz	2-11 GHz	400-800 THz (Visible light)
Network Topology	Mesh Topology	Piconet: Star topology	Point-to-Multipoint	Point-to-Multipoint	Point-to-Point
Data Transfer Rate	Slow	Slow	Downlink speed:10.9Mbps Uplink Speed: 2.8 Mbps	70Mbps	>1Gbps
Power Consumption	Low	Low	Medium	Medium	Medium
License required	Not required	Not required	required	Required	Not required
Environmental impact	Low	Low	Medium	Medium	Low
Cost	Low	Low	High	High	Low
Security	Less Secured	Less Secured	Medium Secured	Medium Secured	Highly secured

Table 1: Comparison of Wireless Technologies

On the basis of current trends in technology and human dependency on connectivity of devices along with demands for higher data rates, we can conclude that Li-Fi will surely grow to become the most popular technology in the near future and will be the backbone of the infrastructure of Smart Cities, providing smart services to the end users with great speeds without compromising with their health. Manufacturers will soon start manufacturing all future devices with Li-Fi interfaces to connect with Li-Fi systems just as now almost every electronic devices come with built-in Bluetooth and Wi-Fi.

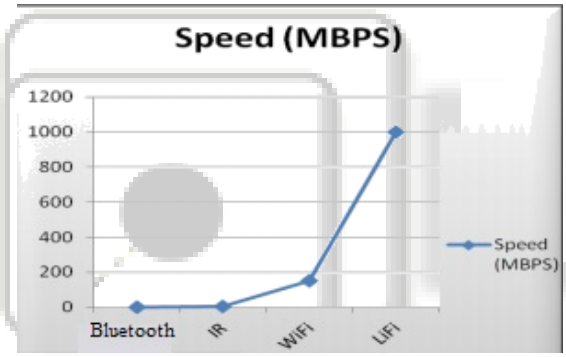

Fig. 2: Graph between Speed and Technology

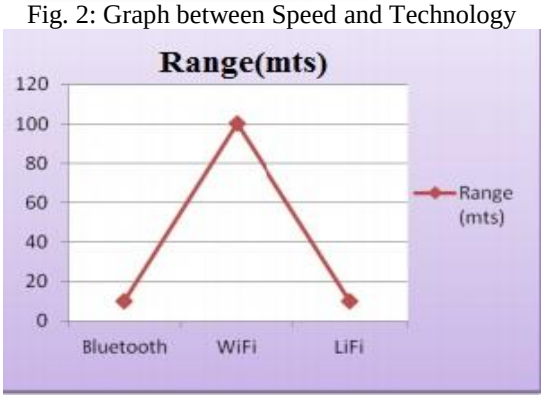

Fig. 3: Graph between Range(distance) and Technology

The above 2 graphs illustrate how technology varies with speed and distance [4].

When electing the nature of technology to use, we consider the advantages of the chosen technology over others. When reflecting on Li-Fi, we can keep many advanced and useful virtues in our minds. Some of them being security, availability, capacity, greenhouse technology, efficiency and less interference.

On the contrary, there are few disadvantages as well. The main disadvantage of Li-Fi is that the light cannot pass through objects, so if there is any solid obstacle lying in the separation between the sender and the receiver, the signal will break at once. VLC system has high initial installation cost ,but once implemented on a large scale, the cost can be reduced by its less operating costs electricity bills, less maintenance charges and fewer operational staff. Line of sight is a must for VLC system, as light cannot penetrate through solid surfaces, so transmitter and receiver needs to be aligned in[5].

III. PROPOSED METHODOLOGY

A. System Development

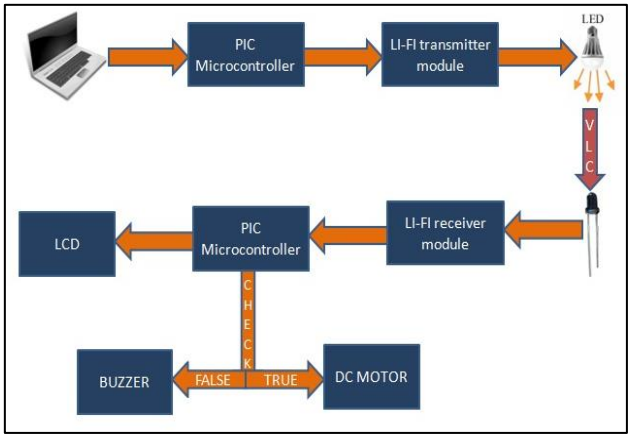

Fig. 4: System Block Diagram

The Li-Fi technology is designed by using the micro-controller PIC 16F877A, and is programmed using embedded C. This works on the principle of interfacing the LED and photodiode. In the transmitter section, the LED is connected to the Li-Fi transmitter module whereas in the receiver section photodiode is connected to the Li-Fi receiver module. The ADC in the micro-controller is put to use at the transmitter end. Both the Li-Fi modules have other components that help in amplification and filtration of the incoming and outgoing signal. The LED supports light energy according to the data sent from the hyper terminal (i.e. via desktop). The photodiode attains the light from the LED and converts the light energy into electrical energy. This electrical energy is sent to the micro-controller on the receiver end, it provokes the pulse signal in order to display the data transferred from the transmitter section using LCD[6].Apart from displaying the given data which is being transmitted, a security checking algorithm has been instilled at the receiver end as well. In short the micro-controller interfaces all the components specified above. A short list of it as follows:

1) PIC 16F877A
2) LCD (for display)
3) LED Bulb
4) Photodiode
5) Li-Fi transmitter and receiver module
6) DC Motor
7) Buzzer
8) Relay Board
9) USB to Serial Cable

IV. IMPLEMENTATION PROCEDURE

The project comprises of two major sections- the transmitter and the receiver. In the transmitter section, the data from the source (i.e., laptop) is fed in to the micro-controller with a

synchronous clock pulse. The data can be a 6 digit alphanumeric key, as security is the main objective for the garage. The interface is made by using RS232 (serial communication) from the source to the micro-controller (USART). The PIC micro-controller transfuses the data with the help of an Analog to Digital converter. Then it provides the bits of information to LED. In the receiver part, there will be a 6 digit alphanumeric password stored in the PIC Microcontroller. The light signal from LED is perceived by the photodiode. The output of photodiode is given to the PIC to reconstruct the data transmitted. The received data from the photodiode is checked with the already stored password in the micro-controller. If the two match, the gate shutter will open, i.e., the motor shall run and the message reading 'AUTHORIZED' will be displayed on the LCD, incase of mismatch, the alarm will start ringing i.e., the buzzer will switch on and the message reading 'UNAUTHORIZED' will be displayed on the LCD. These messages can be observed in Fig. 7. Therefore the data is broadcasted through serial communication using Visible Light Communication (VLC) and a security check has been implemented to enhance the safety. Fig. 5 illustrates how the project has been set up.

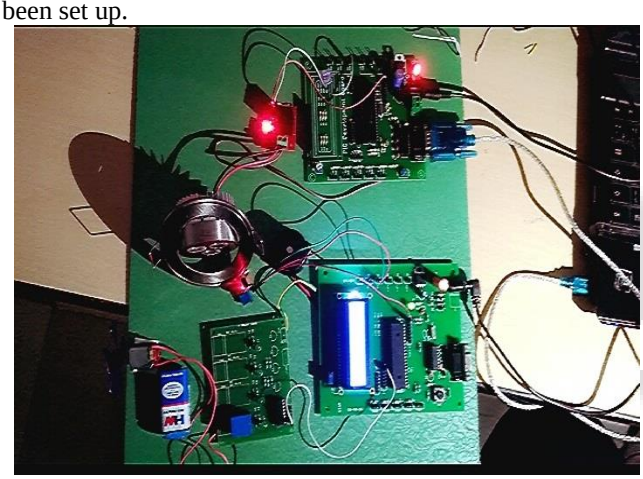

Fig. 5: Project Setup

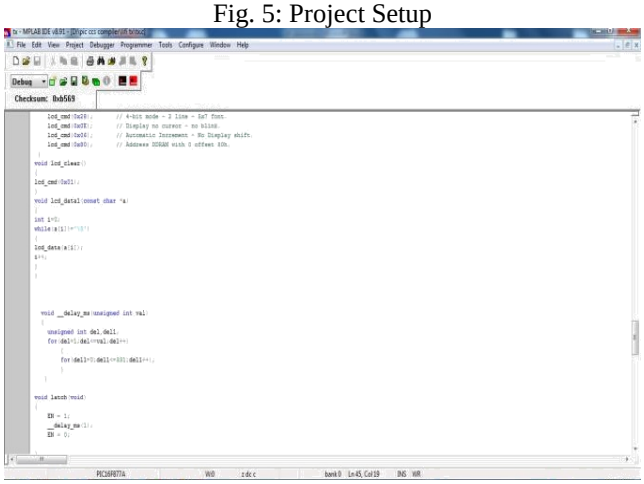

Fig. 6: Software MPLAB IDE

V. RESULTS

The data generated from the transmitter was transmitted serially with a baud rate of 9600. The distance between the transmitter and the receiver was varied and the results were analyzed to gauge the integrity and accuracy of data communication using visible light. Also, a cylindrical tube maybe used as the propagating path medium between the transmitter and receiver to avoid the problems posed due to line of sight. It was observed that the password being transmitted from the LED to the photodiode was at a maximum distance of 3m.The motor or buzzer would go HIGH as and when the password was seen to match.

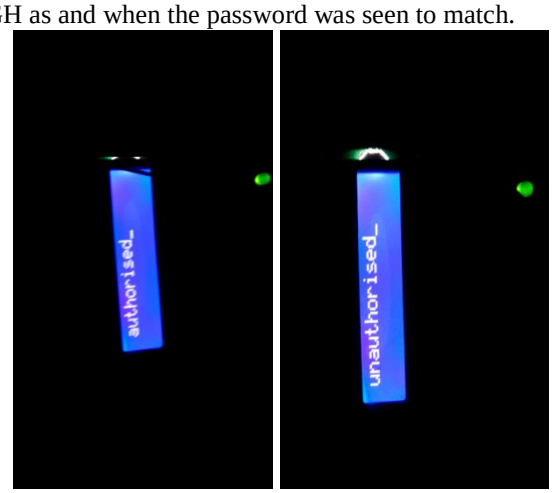

Fig. 7: Display message after checking

VI. CONCLUSION

In this paper, we have successfully implemented the smart garage using visible light communication. The password was transmitted, received and checked on the receiver side. The system would result in either ringing of the buzzer or running of the motor. Further scope for improvement is possible by increasing the baud rate which would in turn aid in increasing the distance between the transmitter and receiver. Also, the line of sight issue can be addressed by introducing an algorithm. The ultimate aim of this work is to enable a systematic approach to improve the security. We hope that by presenting this paper, we will enable such future research, both in our lab as well as by others.

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