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Gesture Controlled Rovers with Li-Fi Capabilities

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***Abstract*—Li-Fi is transmission of data using visible light by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. This paper deals with the analysis of how Li-Fi is implemented for the transmission of audio signals. Using LEDs at the transmitter and a photodiode and a speaker to play the audio, we execute transmission of audio signals. This paper also deals with the aspect of Gesture Control that gives additional mobility for the transmitters and receivers involved in data transmission.**

Keywords – Light Fidelity, Visible Light Communication, RF Spectrum, Gesture Control, Audio Communication.

I. INTRODUCTION

In the present scenario the majority of wireless communication falls under the domain of Wireless Fidelity or Wi-Fi. Through radio waves one can transmit data freely from one place to another within the vicinity of the routers signal strength. Today we strive for greater internet speeds and greater security in data transmission, which is why Li-Fi is the future. Data transmission through the simple flickering of light seemed to be the stuff of dreams, but now it is soon to be a reality.

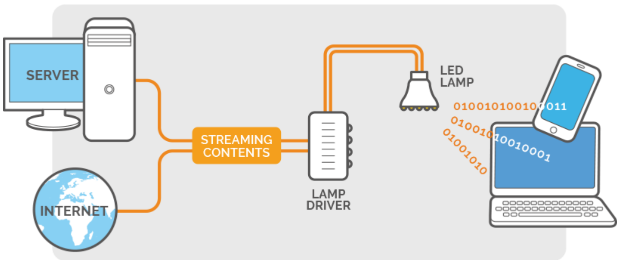

Figure 1 Basic Concept

II. LITERATURE SURVEY

This base paper for all Li-Fi Technology was presented by Harald Haas which elucidates all key component technologies and modulation techniques required to realize optical cellular communication systems referred to here as optical attocell networks. In this paper, a novel wireless backhaul solution is proposed for indoor Li-Fi attocell networks using VLC, which is already embedded in the Li-Fi base station (BS) units.[1]

Other researchers have used LED bulb for data transmission and have implemented a successful UART simulation of data. It uses an efficient LED bulb array which allows for maximum throughput which is not affected by the 120° beam angle. It also employs a powerful FPGA kit which receives and transmits serial information. [2]

A slightly more angled approach toward optical sources was undertaken where they devised three methods of effective data transmission:

a) ganging approach: all µLEDs in the array carry the same data
b) A multiple input multiple output (MIMO) approach: each µLED in an array carries an independent data stream
c) A hybrid approach, which combines a) and b)

These µLEDs are used in a CMOS LED driver array which ensures maximum coverage along with an opto-mechanical assembly that employs the use of lenses to further ensure maximum reception and transmission.[3]

Another paper was presented by Amit Jaykumar wherein he elucidates the use of voice communication through Li-Fi, wherein voice signals are converted to electrical signals using a microphone and then it is amplified by power amplifier circuits and fed into the Power LEDs. The signal is encoded and decoded using a Dual Tone Multiple Frequency keypad which has unique keys based on two programmable second order digital sinusoidal oscillators, one for the row and one for the column. [4]

The second part of our project, explores the use of Gesture Controlled Rovers whose design and working has been inspired from the following papers, firstly from a paper presented which explains the use of simple accelerometer modules to help commandeer a robot's path using hand gestures from the user. It uses a transmitter to send the gesture parameters that correspond to spatial data which is first processed by the microcontroller. This paper presents a model for gesture controlled user which uses hand motion recognition and various transmitter and receiver modules. The handheld controller is a 3D rigid body that can be rotated about the three orthogonal axes. Yaw, pitch and roll are referred to as rotation. These rotation takes place as Z-axis is called yaw , the next rotation X-axis is called pitch and last rotation about the Y-axis is called roll. [5]

These systems are highly application specific, which is justified in the paper presented by N. Geethanajali wherein she explains that controlling robots using traditional methods may not be possible during covert or hazardous missions. A wireless data glove was developed for communications in these extreme environments where typing on a keyboard is either impractical or impossible. This paper reports an adaptation of this communications glove for transmitting gestures to a military robot to control its functions. Novel remote control of robots has been an active area of research and technology, especially over the

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past decade. A miniature MEMS accelerometer based recognition system which can recognize eight hand gestures in 3-D space is built. The system has potential uses such it act as a vocal tract for speech impaired people [6].

III. DESIGN

As far as wireless technologies grow and update with every year, there will always be major challenges to design when it comes to integrating said applications in a workable environment. This is what we have strived to achieve; a wholesome design that takes into account material availability, cost-effectiveness and dedicated salient functions.

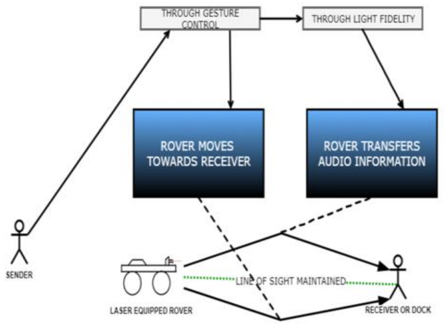

Figure 2 Overall Block Diagram

The above diagram shows the overall loci and workspace of the rover's movement and function. We see the first user who uses gesture control to move the rover towards the receiver. He then uses Gesture control to transfer information through light fidelity. In all this time line of sight is maintained with the receiver and the rover. For convenience sake, the receiver is taken as another user receiving information when it could be a variety of other things such as a dock, another rover or a person as shown above.

GESTURE CONTROL ROVER

The first aspect of this project deals with a major drawback of most wireless systems; mobility and the inability to overcome any line-of-sight problems. Movable rovers on which transmitters and receivers are built can be used to calibrate and synchronize messages faster by ensuring quick mobility which is all under the control of the user.

Essentially this part of the project mainly deals with the mobility of the rover and also the more important facet of triggering transmission of messages through Light Fidelity.

The Transmitter module consists of a battery, Diode IN4007, Accelerometer, Encoder, RF module transmitter and Antenna.

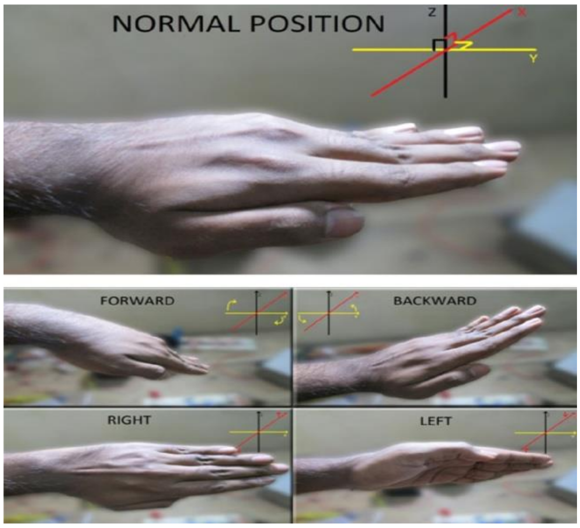

Figure 4 Gesture User Positions

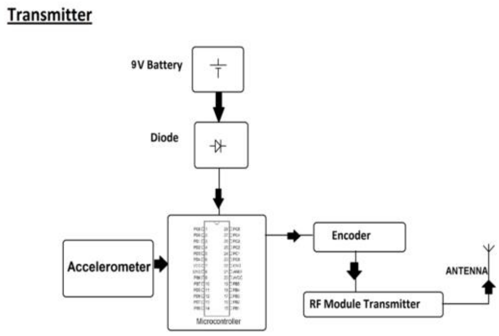

Figure 5 Gesture Control Transmitter

We begin with understanding the mean/normal position of the accelerometer responsible for movement of the rover. The transmitter in gesture control is placed on a glove worn by the user, and a horizontal positioning of the arm results in the desired normal position of the accelerometer and the coordinated movement of the rover which at this position is presently none.

Using RF transmitters any movement, tilt by the users hand results in the appropriate movement in the same direction. Suppose the hand tilted ahead, the relevant data recorded by the accelerometer is encoded and transferred using the antenna.

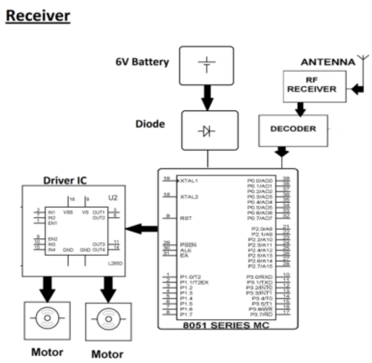

Figure 6 Gesture Control Receiver

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At the receiver, present at the rover the decoder decodes the relevant information and is then processed by the motor driver IC upon voltage regulation by 7085 and eventually the robot moves ahead after required current is fed to the motors.

Table 1 Movement Matrix

HAND GESTURE	LEFT MOTOR	RIGHT MOTOR	DIRECTION
Y-Z TILT FORWARD	ANTI-CLOCKWISE	CLOCKWISE	FORWARD
Y-Z TILT BACKWARD	CLOCKWISE	ANTI-CLOCKWISE	BACKWARD
Z-X TILT RIGHT	ANTI-CLOCKWISE	NO MOVEMENT	RIGHT
Z-X TILT LEFT	NO MOVEMENT	ANTI-CLOCKWISE	LEFT

LIGHT FIDELITY

In Light Fidelity we begin with the data that needs to be sent. Here we transmit audio information through continuous pulsation of light. Audio information is selected because of its ability to maintan throughput even in the midst of distortion due to incompatible components and even information that requires heavy processing.

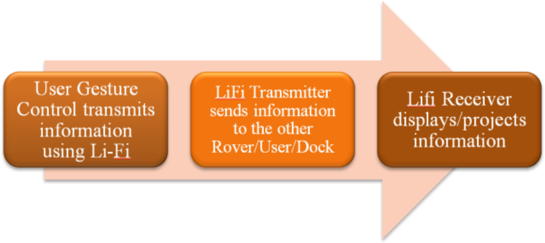

Figure 7 Li-Fi Block Diagram

For audio information to be transferred we attach a audio jack into the circuit which allows songs to be played in real time into the circuit wherein the intensities of song notes are translated into on-off keying for the laser which is the main output. The responsibility for this translation is IC LM386 which acts as a low power audio amplifier. We use a potentiometer which almost acts as a bandpass filter to transfer information of only certain band of freuquencies. Ideally we would like to transfer all information, but since some components are not so sensitive we have to compromise on quality to respect the overall integrity and message of the information sent.

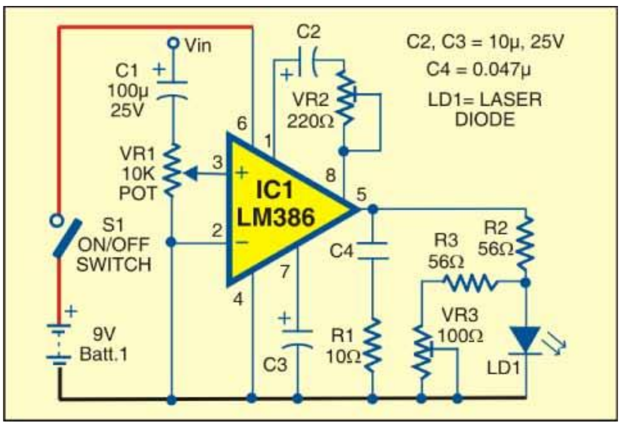

Figure 8 Li-Fi Transmitter Circuit

At the output, we have placed a laser diode which is responsible for the main transmission by on-off keying. First after ascertaining the model of laser used, we determine what sort of amplifier is required to power the LED driver circuit used to power the pulsations of light we see in Light Fidelity. All these connections are routed through a Voltage Amplifier such as LM386 that is specifically used for low power audio amplification.

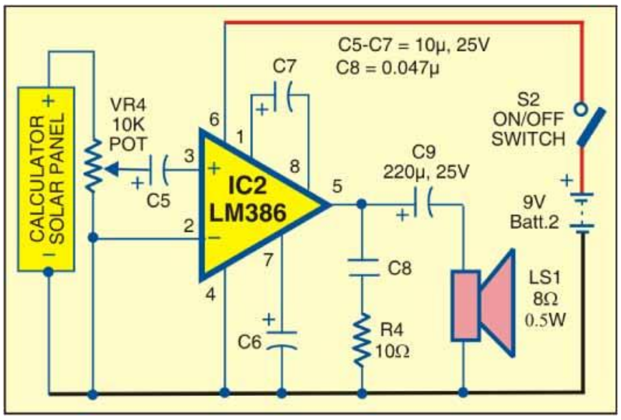

Figure 9 Li-Fi Receiver Circuit

INTEGRATED GESTURE & LI-FI

This project on its own has applications that are needed in different areas of technology, but when we integrate them together they serve to become a Swiss knife for a host of different situations and for different demands of the consumer.

We seek to incorporate two links between these two aspects of the rover, namely by a (i) power sharing mechanism as well as a (ii) trigger mechanism for transmission. It is of paramount importance that we implement power sharing mechanisms between the Light Fidelity Circuits as well as the Gesture Control Modules, so as to become more energy efficient as well as cutting down on the weight of the rover. An all terrain rover would need to be nimble but structurally solid and therefore power sharing is important.

Secondly a trigger mechanism from a User's Gesture would enable Li-Fi Transmission of locally stored messages. We stress on the importance of local because it is cheap, efficient and in totality validates the need for simultaneous calibration of transmitters and receivers along with instant transfer of information.

Table 2 Integrated Transmitter Components

TRANSMITTER				
ATMEGA328 MICROCONTROLLER	HT12E ENCODER	7805 REGULATOR	FLEX SENSOR	RF MODULE

Table 3 Integrated Receiver Components

RECEIVER				
RELAY CIRCUIT	DECODER	VOLTAGE REGULATOR	MOTOR DRIVER	MICRO-CONTROLLER
G5LE-14-DC12	HT12D	LM7805	LM293D	80C52

RESULTS & DISCUSSION

At the end we see a lot of data received, and much of it has to be seen in the light of components and not the application themselves. We notice from the spectrogram below that the distortion present at the output makes the input look like it had been passed through a band pass filter which was true. Most commercial speakers used for audio playback already have built-in pre-amplifiers but unfortunately those that are used for experimentation do not engage in any sort of amplification and that allows distortion to be present at every sample of the audio file.

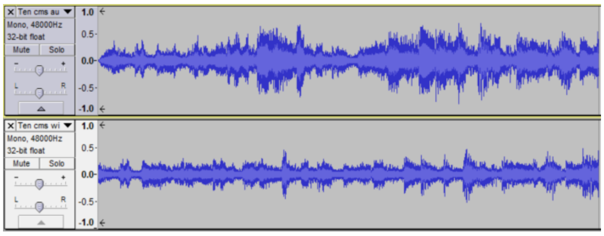

Figure 10 Distance 10cm. Above: Received Signal in Complete Darkness Below: Received Signal in Ambient Light

From Figure 10 we deduced that not only did Ambient Light play a significant role in adding noise, but that it changed the delay characteristics of the receiver used in the audio transmission.

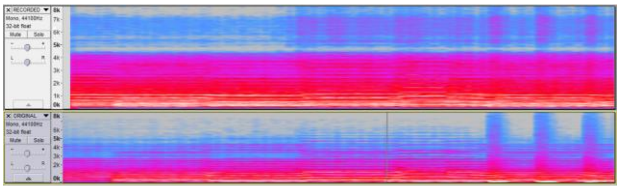

Figure 11 Distance 10cm. Above: Spectrogram of Received Signal in Complete Darkness Below: Spectrogram of Received Signal in Ambient Light

From Figure 11 we noticed that certain intrinsic characteristics of components posed noise-like components into the spectrogram in complete darkness, which was the first occurrence of any true limiting factor in terms of quality of materials used.

IV. CONCLUSION

In conclusion, Light Fidelity using a variety of different positions and under different lighting conditions has been demonstrated. The hardware prototype uses low cost commercial LEDs and PDs. We also infer that by using arrays of Transmitters and Receivers we can significantly boost the SNR along with ensuring a more defined coverage area.

Using the various gestures we have managed to impement a simulation of a variety of applications such as inter vehicle communication, gesture controlled wheelchair in a Li-Fi equipped environment and even military applications where information transfer is of utmost urgency.

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