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Navigation System using Light Fidelity

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***Abstract*— These days, the internet usage has been rapidly rising which leads to radio waves being overused. Long distance data transmission makes use of this spectrum. It has become difficult to keep up with the demand for the high speed connectivity as the number of users is increasing. This has led to the shortage of radio wave bandwidth and hence limited speed of data communication. An alternative and advantageous replacement can be visible light communication (VLC). One of the applications of VLC could be road navigation using street lights. Often drivers face issues navigating at night, due to low battery of mobile phone or network connectivity issues. This paper proposes a system to solve the problem of navigation in intra-city roads at night using Li-Fi technology. The street lights would be utilized to transmit images of the map of the area at its immediate vicinity. These would be received by the vehicles for ease of navigation, without the use of mobile data or Wi-Fi. The received image is then displayed on a display screen in the vehicle. This system provides an alternative for the present day means for road navigation.**

Keyword-LED, Light fidelity, wireless communication, photodetector, data transmission.

I. INTRODUCTION

The radio wave band has been in use by a lot of people and with the increase in the population, the band is being overused [1]. Nowadays, people depend on the internet for their necessities whether it is for learning or communicating. They wish to have a quicker internet connection for their work. In the current scenario, fast internet connection might not be great issue but in the future when there will be increase in the population; the large broadband would be missed. One of the solutions to the problem of less bandwidth can be solved by the Light-Fidelity [2]. The Li-Fi is analogous to Wi-Fi, the difference lies in the medium of data transmission [3]. The Li-Fi uses the light waves to transmit the data while Wi-Fi uses the radio waves. One of the important merits of using the Li-Fi is the large frequency bandwidth that the light waves offer [4]. The paper presents use of the Li-Fi in the navigation of roads inside a city or town during the night time. Usually for navigation we make use of the Google maps or other such navigation applications which make use of internet connection via the microwaves or radio waves. Navigation during the night is a difficult task and a map makes it quiet easier. This paper makes use of Li-Fi to transmit the map on a device screen such as smartphone screen or a tablet. Various commonly used photo detecting devices available have been studied. Some of these include PIN, LDR (Light Dependent Resistor), APD (Avalanche Photodiode), SPAD (Single Photon Avalanche Diode) and solar panel. SPAD is efficient option in case of applications using Optical-OFDM (Orthogonal Frequency Division Multiplexing) as compared to other conventional photo diodes [5]. Solar panel is sufficient for application not requiring large distance transmission.

The street lights available on the road are at an average distance of 40 m from each other. The spectrum used for Li-Fi is eco-friendly. Each of the streets light will transmit the road map of the area before the current location at a distance of 10 to 20 m. The system does not require the users to pay for the Li-Fi connection unlike the internet connection.

Navigation becomes difficult during night if the area is new for the driver. This paper presents a solution using Li-Fi which helps the driver with easy navigation and for free as well. The map being displayed includes the important destinations such as the hospitals, petrol pumps, lodges, and other major landmarks. The only thing the user will require is a receiver. Road navigation as it is or with modification can be very helpful to the society where today everything is technology based.

Organization of the paper is as follows: The Section II provides the method used for the implementation of the transceiver. Section III describes the transmitter and receiver components of the system. Its implementation has been stated in a Section IV. In Section V the observations made from the implementation has been discussed.

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II. AN OVERVIEW OF THE SYSTEM

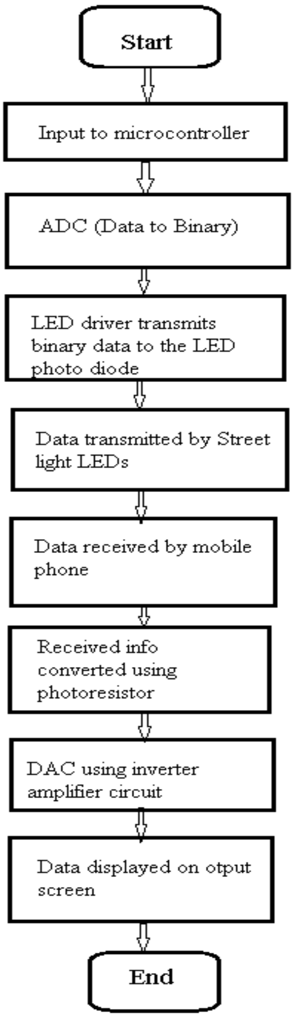

Fig 1: Flow chart describing the steps involved

Transmitter Section:-The system architecture consists of a transmit section and a receive section. The transmit section consists of the data input which is then fed into a switching control system. Based on the data, the switching control generates a stream of 1s and 0s also known as Intensity Modulation (IM) thereby encoding the data in binary [6]. The output of this control is given to the array of LEDs which turn OFF and ON at extremely high speeds. This ON-OFF modulation of the LED light transmits the data. Receiver Section: - The receiver section consists of solar panel as a receiver having high sensitivity. Photo detector such as LDR (Light Dependent Resistor) can also be used for same purpose [7].

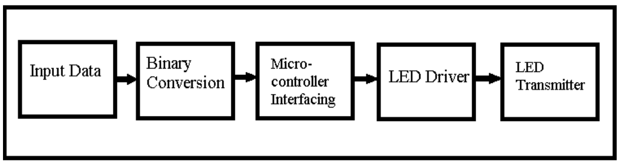

Fig 2: Li-Fi Transmitter section

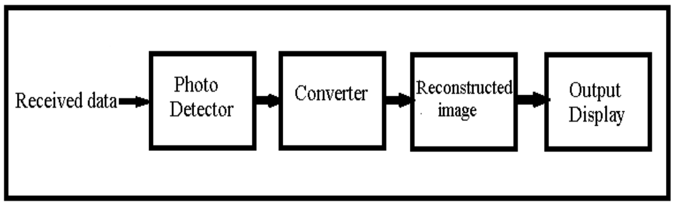

Fig 3: Li-Fi Navigation system Receiver section

Solar Panel detects the incoming received signal. Based on the sequence of 1s and 0s the signal is decoded. Then the decoded signal is sent to a signal conditioning unit, it is then fed to the microcontroller, which decodes that signal and then given to an output device such as a mobile device.

III. TRANSMITTER AND RECEIVER COMPONENTS

The construction of a Li-Fi system comprises of a transmitter block and a receiver, both of which have various components which can be inferred from the block diagrams.

The components used were: microcontroller, LED light source, solar panel, display device, and software for image processing. The LED driver is used at the transmitter side. The signal is sent from the computer to the LED driver via microcontroller which then amplifies it and uses it as a control signal for the LED. A high power LED must be used so that there are no detection issues at the receiver side [8]. The reception of the data is adversely affected if intensity is not enough [8]. The receiver circuitry placed over a vehicle is at a certain distance from the LED transmitter that is the street light. A detector is the most basic requirement at the receiver side. The circuitry consists of solar panel and resistors of appropriate values. The photodiode receiver detects the variations in the light of the LED [9] and converts it into voltage signals. Solar panels are highly sensitive photo detecting type of devices and simple to implement [10]. No additional module is required for the solar panel to function [10]. The voltage signals from the detector are then compared to get the two levels of the output signal so as to retrieve back the original transmitted binary signal. This converted signal of bit streams are sent to the microcontroller which then sends it to the image processing software. The data is then converted back into the image form and sent to the display device being used, that is the computer or the mobile.

IV. IMPLEMENTATION

The use of microcontroller is required in both the transmitter and receiver section. The LED light source is capable of turning on and off at extremely high frequency [11]. The data which is to be transmitted by the light source is the image of a segment of the road map. Images are in binary format as shown in the Fig. 5.2 and Fig. 6.2. Image processing software converts the image to string of data of 1s and 0s. The microcontroller uses this data to control the turning on and off of the LED source. The LED source can transmit the data at high frequency which is not visible to the human eye and hence the street light seems to be emitting light all the time [11].

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START bit	Data bits	STOP bit

Fig. 4. Data frame

The image of the map was first converted into a stream of bits, that is, in the form of an array. The array elements are the data sent to the microcontroller which performs the Intensity Modulation of the LED light source.

The data being sent to the receiver of the system is sent in the format as shown in the Fig. 4. This format of data ensures that all the data bit reaches the receiver attached to the car [12]. The microcontroller serially transmits the data bits to the image processing software.

The implementation of the system is shown in Fig. 5.1 and Fig. 6.1. The street lights are placed at certain distance and accordingly the map is displayed at a range of tens of meter. As shown in the figure, the map displayed at position A is Map 1 and at the position B, the map of the further area is being displayed.

The receiver circuit is interfaced with another microcontroller. Once the data is received, it is converted back into the original image by using the MATLAB software [13]. The receiver circuit is interfaced with another microcontroller. Once the data is received, it is converted back into the original image by using the image processing software.

This image is then displayed at the display screen (mobile phone). The image data of highway routes are fed in to the microcontroller. For the experimental setup one image is taken and transmitted using the image processing toolbox of MATLAB [13] and it is checked whether the same image is reconstructed at the receiver side as shown in the Fig 5.2 and Fig 6.2. The test bed is proposed for a scenario with streetlights and the vehicles with a receptor.

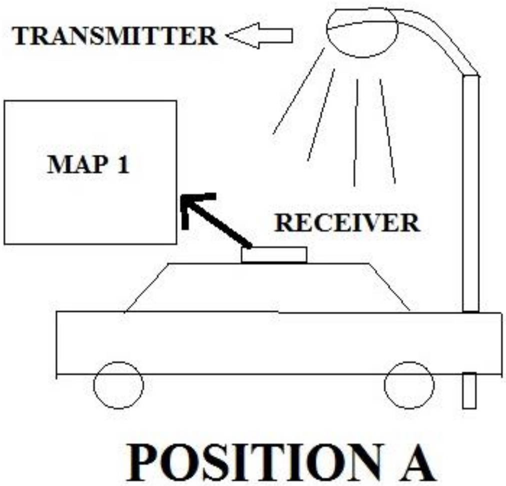

Fig 5.1: The vehicle at position A

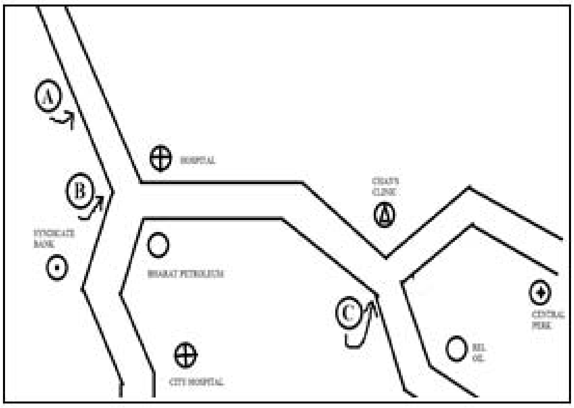

Fig 5.2: Map 1 being displayed when vehicle is at position A

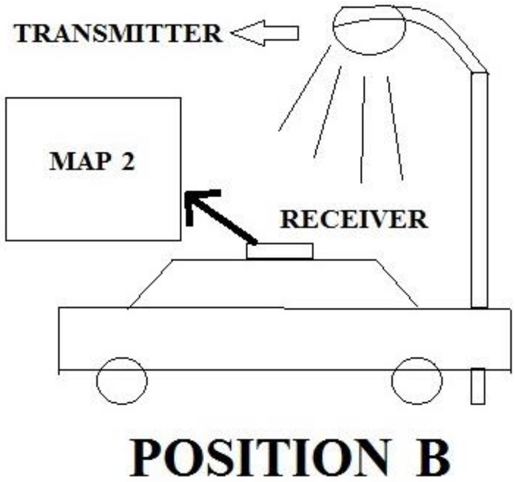

Fig 6.1: The vehicle at position B

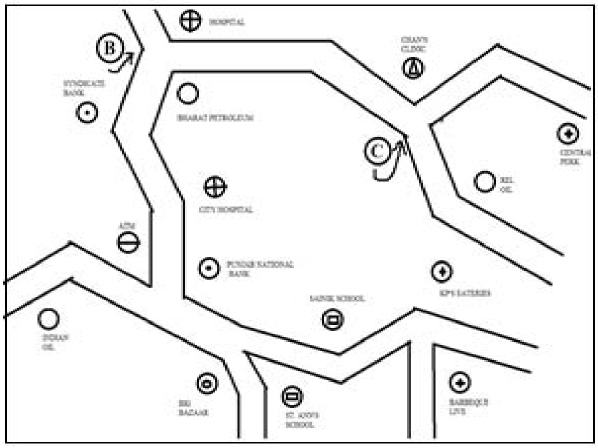

Fig. 6.2: Map 2 being displayed when vehicle is at position B

V. OBSERVATIONS MADE DURING SYSTEM IMPLEMENTATION

In the cities or towns of India, the average distance between any two street lights is approximately 30 to 50 m. The proposed system requires both the transmitter and the

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receiver to be in a line of sight for the data to transmit properly [14]. The car with the receiver will be under the street light for 1 or less than 1 second. And it will reach the next streetlight after 2 or 3 seconds. Hence, the image of the map will be displayed with better accuracy when the receiver is just under the streetlight [15]. To keep the map displayed for a longer time, a delay of 2 s is introduced until the vehicle reaches the next street light.

The LED street lights are not in use during the day hence this system will be helpful during the night time. There might be other light sources from the nearby building which might interfere with the main source of data from the street light. The use of high intensity LED light sources is essential to get the correct map display.

The maximum distance between the LED light source and receiver at which proper map is received using the proposed system is 5.5 m when transmitted during the night time. The minimum distance between the street light and the various vehicles is estimated from the table 1 to be in the range of 1 to 7.73 m. The maximum distance between the different vehicles and street lights is 3.5 to 10.1 m.

Table 1: Standard heights of vehicles and street light pole

Sl. no.	Object	Standard Height in meter(s)
1	Pole	5-12
2	Car	1.5-1.9
3	Bus	3.15 - 3.30
4	Truck	4.11-4.27

VI. CONCLUSIONS

The possibilities of Li-Fi application are numerous and can be further explored. The transmission of the proper image of the map using the proposed system depends highly on the light source intensity and the distance between the transmitter and receiver. Another factor which affects the proper transmission is the type of LED light source used in the system. The transmitter and the channel have been tested and the results vary as the distance between the streetlights and the vehicle increase and with the presence of any obstacle between the two. The delay needs to be varied according to the distance between any two street lights for proper image display. The implementation of this system would help drivers navigate, especially at night. It can act as a useful resource.

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