

OBSTACLE DETECTION AND NAVIGATION SYSTEM FOR VISUALLY IMPAIRED PEOPLE EMPLOYING LI FI TECHNOLOGY

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ABSTRACT

Electronic Travel Aids are used by the visually impaired people for their navigation system. This paper proposes a new electronic cane that detects obstacles along the path of the user inside an unfamiliar indoor environment. Emerging Li-Fi Light Fidelity technology (Visible Light Communication) is employed to inform their current location and to assist them to reach their destination inside the building. The obstacle detection has been realized by the use of ultrasonic sensors positioned at different angles in a cane to cover all the directional sides and it alerts the visually challenged people through the audio voice signal about their next movement. The experimental set-up is constructed and the results are verified.

Index Terms: Electronic travel aid; obstacle detection; indoor navigation; light fidelity.

I.INTRODUCTION

Vision is the primary sensory modality that provides knowledge about the surrounding environment. Total blindness or low vision is a condition that affects many people across the globe causing them a major challenge to lead a normal life. According to recent survey taken by WHO (World Health Organisation), 285 million people are estimated to be visually impaired where 39 million people are totally blind and 246 million have low vision[1]. While India accounts for 20% of it and majority of them come under low income status [2].

The visually challenged people need an assistive tool to perform their day to day activities for their easy mobilisation. The widely used assistive tools are long white cane, that serves as a low maintenance tool but it cannot detect head level obstacles and provides no information about the size, distance and speed of an object. Guide dogs were trained to obey hand and voice signals, but it remained expensive and many are not comfortable with dogs [3].

The technical evolution helped researchers to design different electronic travel aids (ETA) that can detect obstacles in their pathway and intimate the user through acoustic and haptic signals for their easy navigation [4]. Few devices were designed to know about their actual position in an indoor and outdoor environment that helps them to reach their desired destination.

II EXISTING TECHNOLOGIES

The mobility cane developed using Laser sensor like Teletact [5] had a narrow beam of detection area but failed to detect transparent glasses. The need for regular scanning of environment and high cost is a major concern to operate these devices. Infrared sensors are employed in canes like Tom Pouce and Minitact [6] are not efficient. Ultrasonic sensors are used in K sonar cane [7], smart cane [8] and Ultra cane [9] that scans wide range of surrounding area. Guide cane [10] is a robotic cane rolled on wheels that uses collision avoidance algorithm to avoid obstacles and guides the user in an obstacle free path. This cane remained bulky and has limited scanning area.

Ultra sonic spectacles, Waist-belt [11] and Navbelt[12] are electronic wearable aids that are designed in the shape of spectacles and belts. It detects floor level obstacles alone. Way-finding Electronic bracelet [13] is a portable electronic aid where ultrasonic sensor is mounted on bracelet to detect obstacles. It needs regular hand movement for scanning the surrounding.

Smart clothing [14] is designed using sensors and vibration motors placed in the textile structure to detect obstacles. Though the prototype was tested for wash ability, heating temperature and power consumption, maintenance of the garment is tedious and needs additional care.

VENU cane [15] is an electronic mobility cane designed to simultaneously detect multiple obstacles namely sideway and frontway obstacles by relating their distance from each other. It detects all level of obstacles that includes head, knee, waist and floor level obstacles. The main drawback is the cane need to be hold at 90⁰ with the floor plane for accurate results.

Position locator devices are designed to guide the user in an indoor and outdoor environment. Devices like Geotact[5] employs Global Positioning System (GPS) that helps in finding out the position of the person in an outdoor environment. It uses signals broadcasted from GPS satellites. At times the signals get blocked by construction materials. Recently android apps are developed to communicate between the device and smart phone that guides them with required route [16].

The wireless technology used for indoor localization employs RFID and WiFi technology. RFID [17] includes two components namely tag and reader that uses electromagnetic transmission to read the positional data. However it requires separate installation cost. WiFi or Wireless Local Area Network [18] follows standard IEEE 802.11 series and provides network coverage around its hotspot. It helps in indoor localisation system. This method has issues with fluctuating positional accuracy due to reflected signals.

III PROPOSED TECHNOLOGY

This paper focuses mainly on designing a cane that detects obstacle in all directional sides from head level to floor level using ultrasonic sensors and intimate the user about the floor status. The positional direction in an indoor environment is given by Li Fi technology. Light Fidelity (Li Fi) [19, 20] is the new technology that is faster and cheaper and it transfers data through illumination. The shopping malls and other indoor buildings switch over to LED lighting system for maximum energy management and thus Li Fi based localisation can be easily adopted. 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. If the LED is on, it emits binary one; otherwise it's binary zero.

This paper covers the design and development of a new mobility cane. Section II includes the details about the system architecture. Section III covers the methodology and design flow of the system. Section IV discusses about the hardware unit needed for the system. Section V discusses about the conceptual explanation using MATLAB simulink model. Section VI explains about the initial hardware prototype model Section VII discusses about the conclusion and future work to be carried out .

Highlights

- The Navigation system for visually impaired detects all level of obstacles that includes knee, waist, floor level obstacles and wet surfaces.
- Navigation system guides them through Voice based alert.
- Li-Fi technology detects the current position and assist them to reach the destination in an unfamiliar indoor environment Li-fi also serves the purpose of internet connectivity, LED illumination and can be easily adopted in shopping malls ,buildings

IV SYSTEM ARCHITECTURE

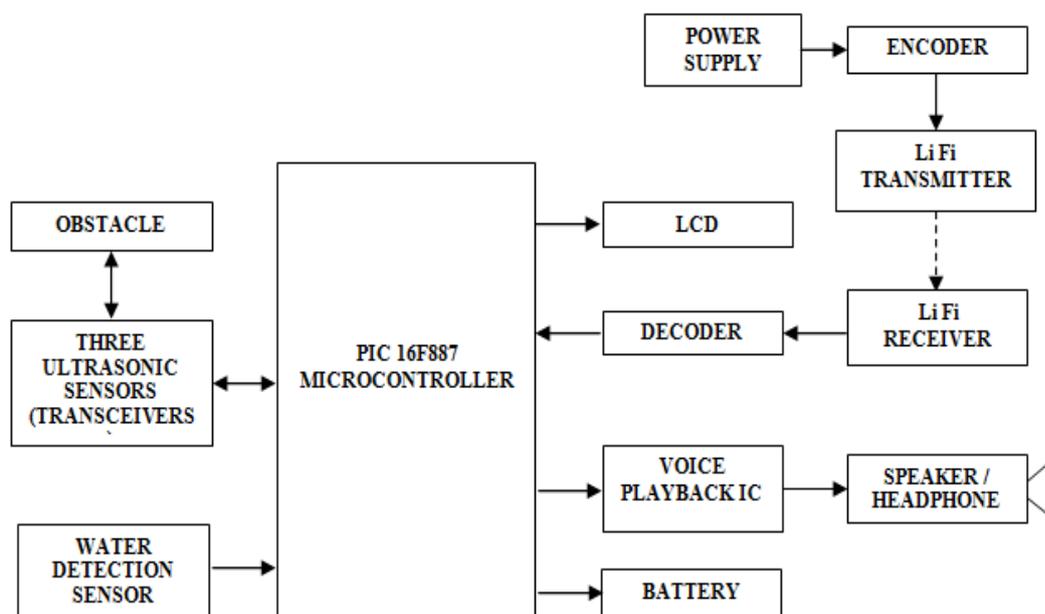


Fig 1. Block diagram of electronic cane for visually challenged people

The mobility cane is a real time embedded system that detects obstacles and guides the visually handicapped people in an indoor environment. It consists of two separate hardware units as shown in Fig 1. The first one is the cane that consists of three ultrasonic sensors, water detection sensor, microcontroller, Li Fi receiver, decoder, voice playback IC and a speaker or headphone. The second hardware set up need to be installed at different positions inside a building includes encoder, Li Fi transmitter and a power supply unit.

The cane is fitted with three wide beam width ultrasonic sensors pointing towards right, left and front direction. Water detection sensor is employed at the bottom of the cane to acquire information about the floor status (i.e. whether wet or dry floor). Li Fi receiver includes the silicon photodiode placed at the top of cane. Decoder circuit helps in decoding the correct positional data and provides it to the microcontroller. PIC 16F887 microcontroller controls the over circuitry function. The transmitter unit is installed along with the Light Emitting Diode (LED) lighting system in a building or shopping mall that includes encoder that transmits stored data through LED. Battery provides the needed power to the cane while power supply unit supplies the needed current for the LED to glow and transmit data.

V METHODOLOGY

The system design flow is explained in this section. The flow chart of the obstacle detection process is shown in Fig 2. When the system is made ON, the PIC 16F887 microcontroller regularly sends the triggering pulse signal to the three ultrasonic sensors. The ultrasonic sensors scan the three directional sides namely right, left and front, checking for the presence of any obstacle. The obstacle detection range can be programmed using microcontroller. The distance of the obstacle can be measured and the nearest obstacle can be prioritized first, so that pre recorded audio signal gives the alternate directional command.

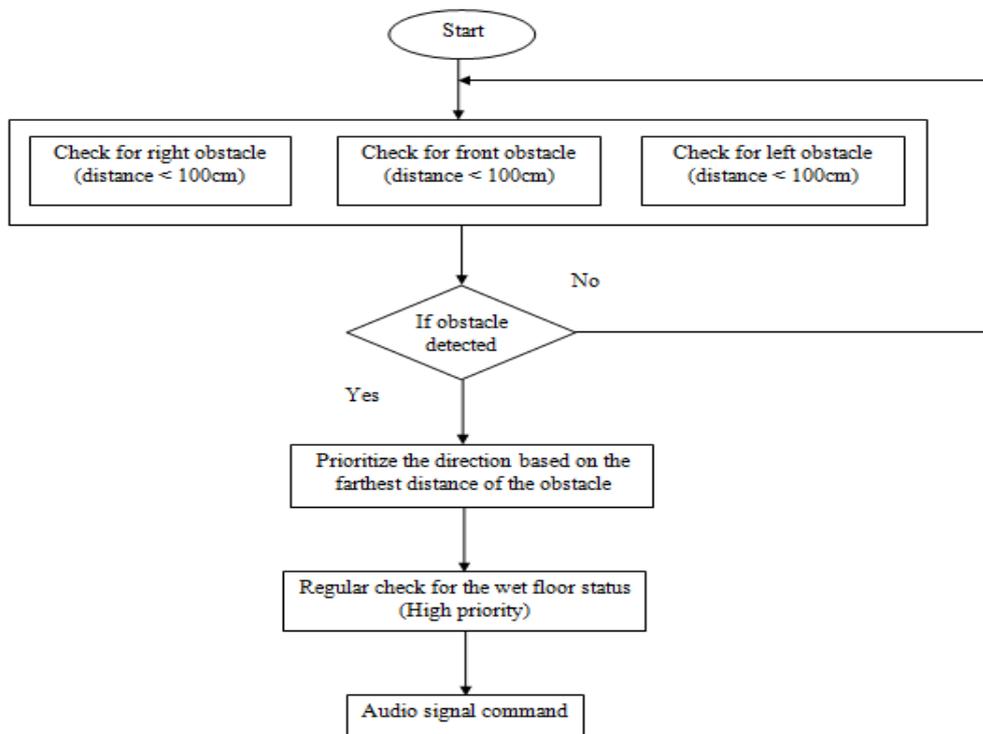


Fig 2.Flow chart of the obstacle detection process

Water sensory circuit is used to detect the slippery floors. It regularly checks the floor and when any liquid is found the circuit becomes complete producing high priority external interrupt to the PIC microcontroller.

When a button is pressed, the PIC microcontroller stop scanning the sensors and it switches the control over finding

out the current positional status. The cane consisting of Li Fi receiver receives the encoded positional data from the Li Fi transmitter (LED) through light.

The data is decoded and sent to the microcontroller that provides the respective command for reaching the desired destination.

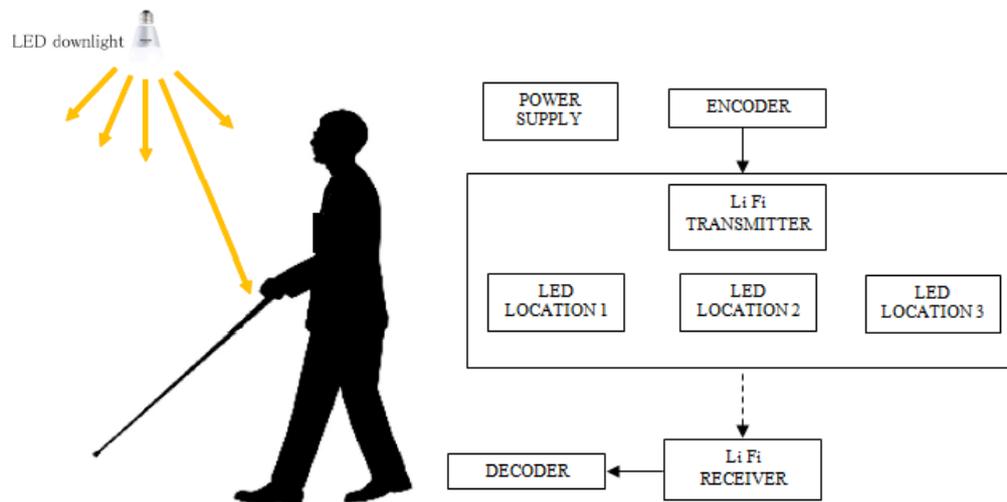


Fig 3. Block diagram of Light Fidelity positioning system

The block diagram of Light Fidelity positioning system is shown in Fig3. For example, if the transmitter unit placed in front of the hall, the encoded data is sent that decodes voice signal command as “In front of the hall”.

VI. HARDWARE INTERFACING UNIT

The hardware parts used for implementing the real time system is given below.

6.1 Ultrasonic sensor

HC-SR04 Ultrasonic distance sensor is a complete set of both transmitter and receiver module. It is a popular and low cost solution for non-contact distance measurement function. It is able to measure distances from 2cm to 400cm with an accuracy of about 3mm.

HC-SR04 module has 4 pins namely VCC, GND, TRIG and ECHO pins. TRIG and ECHO pins can be used to interface the module with a microcontroller unit that emits and receives back the signal on detecting out the obstacle. These are TTL (0 – 5V) input output pins.

6.2 Encoder and decoder

This setup requires three entities: (1) A Transmitter (2) A receiver (3) Address of the receiver. The role of address in electronics is played by address lines.

The encoding and decoding technique uses IC namely HT12E and HT12D. The ‘12’ in the name means 8-address lines and 4-data lines while E and D letters represents ‘Encoder and decoder’ respectively.

6.3 Light-Fidelity

In Li-Fi system, which is based on visible light communication, data is modulated on the light source using

modulation techniques like pulse position modulation or frequency shift keying. In the receiver end demodulation is performed to fetch the data back from the light. The receiver module has a photo-diode to detect the on and off states of the LEDs. The receiver module captures this sequence and generates the binary sequence of the received signal. It then sends the binary sequence to the decoder which converts the data to the original format. Voice playback IC module can record and provide voice playback using programming codes. With the master chip and plug-in SPI-FLASH, it has a great advantage in the duration time of recording and cost performance.

VII. SIMULATION RESULTS

The conceptual explanation is done using MATLAB Simulink model. The simulation for obstacle detection process is shown in Fig 4. Ultrasonic sensor and water sensor module is designed by setting different set of voltage values for a range of time interval. Presence and absence of obstacles in the blocks are indicated by setting different voltage values (i.e.) zero volts for absence of obstacle and voltage greater than zero for presence of obstacle.

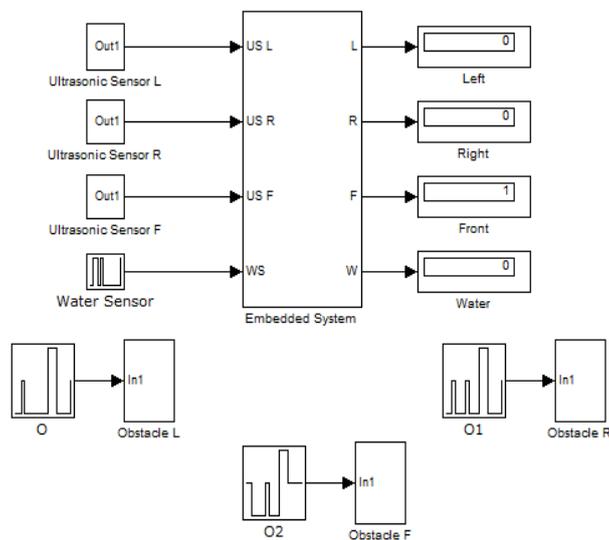


Fig 4. MATLAB Simulink model for obstacle detection

The sensor inputs are given to embedded system block. The embedded system block checks for presence of obstacles using voltage values given for each sensor. If the left ultrasonic sensor detects obstacle at an instant time period, then the output is set HIGH at that time. Similarly, the same logic happens for all other sensors. When water sensor is HIGH, then high priority is given to indicate the presence of water. The work of embedded system block is done using PIC 16F887 microcontroller when implemented in hardware. When an obstacle is detected in all directional sides, the farthest obstacle path is taken.

If the obstacles are of equal distance from the user then audio commands are given as per Table I.

Table –I Mapping of Obstacle Situations with Relevent Voice Messages

Direction of obstacle	Voice over speaker
Water indication (High priority)	Wet floor
Right	Right blocked
Left	Left blocked
Front	Front blocked
Front and right	Turn left
Front and left	Turn right
Left and right	Move straight
All sides blocked	Block

Similarly the indoor positioning data can be sent to the microcontroller by the process of modulation and demodulation through Li Fi transmitter and receiver. The positional data is decoded and respective voice command is given through voice playback IC.

7.1 Hardware Unit

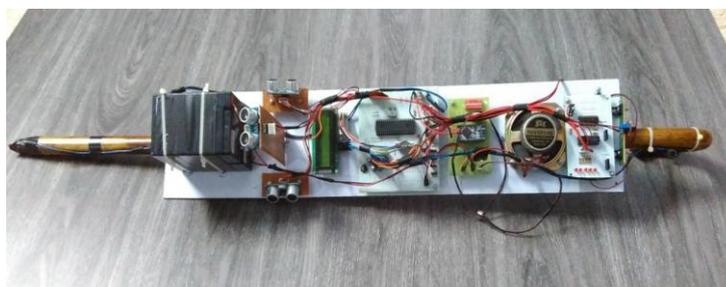


Fig4. Hardware set up of cane

The initial hardware set up shown in Fig 4 is designed only for the obstacle detection process. The ports are initialised for ultrasonic sensors. The sensors are placed towards left, right and front that regularly checks for obstacles in all directional sides and computes the distance which is shown in TABLE –II.

TABLE –II Theoretical Calculation Of Response Time For A Single Sensor Experiment:

Distance	Time(μs)
10 cm	580
23 cm	1334
35 cm	2030
55 cm	3190

The experiment was carried to classify the location in which the obstacle lies (<30cm or >30cm) as shown in fig

5 and 6.. Based on the location of the obstacle it is prioritized and the voice feedback is given as indicated in Table -III. The straight view includes the obstacles placed inside an angle of 15°, while side view obstacles includes the obstacles placed in an area >15° and <50°.

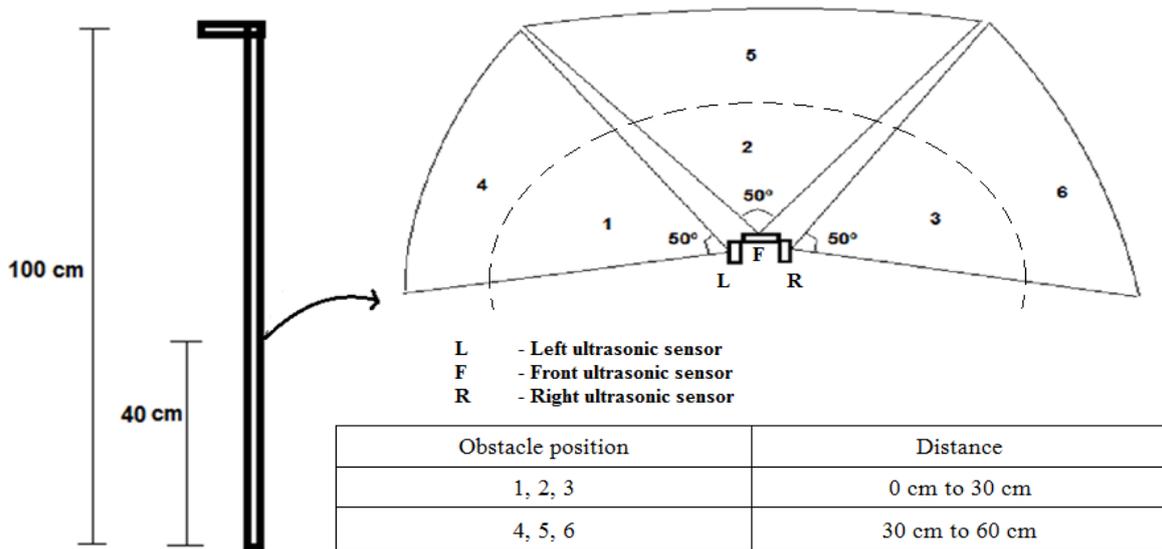


Fig5. Pictorial Representation of the experimental setup of objects placed

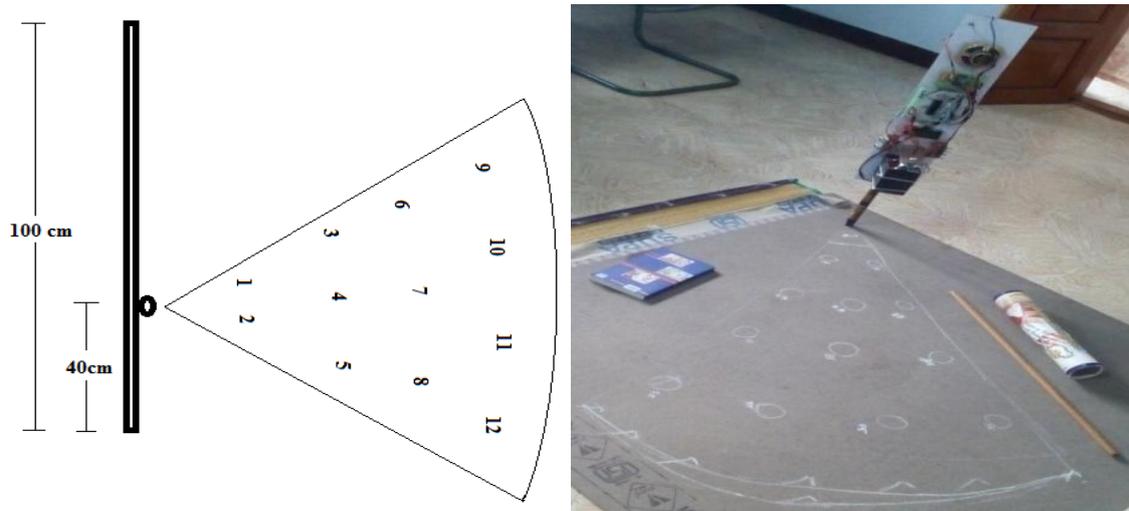


Fig 6. Positions of floor –level obstacles in front of the sensor at various distances and experimental setup

TABLE III. Mapping of Prioritised Obstacle Situations with Relevant Voice Feedbacks

1	2	3	4	5	6	Voice record
(< 30 cm)	(< 30 cm)	(< 30 cm)	(>30cm & <60 cm)	(>30cm & <60 cm)	(>30cm & <60 cm)	
1	0	0	X	0	0	Left side obstacle (Move right or front)
0	0	0	1	0	0	
0	1	0	0	x	0	Obstacle on front (Move right or left)
0	0	0	0	1	0	
0	0	1	0	0	x	Obstacle on right (Move front or left)
0	0	0	0	1	0	
1	0	0	X	1	1	Slightly move front or right
0	1	0	1	x	1	Slightly move left or right
0	0	1	1	1	x	Slightly move left or front
1	1	1	X	x	x	All sides blocked
0	0	0	1	1	1	
1	1	0	X	x	0	Move right
1	0	0	X	1	0	
0	1	0	1	x	0	

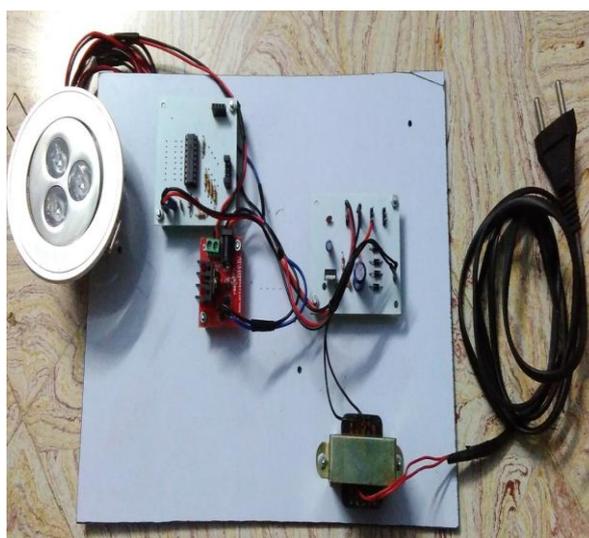


Fig 7. Li-fi Transmitter and Receiver

The prototype of Li-fi Transmitter and Receiver is shown in figure 7 and the distance covered during data transmission is about 1 feet. The data's transmitted and the corresponding positional data are shown in TABLE

–IV. The comparison of the proposed navigation system with the existing methods is shown in TABLE- V.

TABLE IV. MAPPING OF POSITIONAL DATA

Data transmitted	Voice over headphone
-	Position not found
0000 1110	Floor 1
0000 1101	Floor 2
0000 1011	Floor 3
0000 0111	Floor 4

TABLE V. Comparison with Existing Technologies

ETA	Author and year	Technology	Features
Teletact, Minitact	Farcy et al (2006) Villanueva et al(2012)	Laser sensor	High cost
Pouce	Scherlen et al (2007)	Infrared sensor	Limited only to obstacle detection system
Venitact	Bhatlawande (2012)	Ultra sonic sensors	Large in size, limited scanning area
Electronic bracelet	Mahadevappa et al(2013)	Ultrasonic Sensors	Needs regular positioning of hand for scanning of obstacles . No position guidance system
Proposed System	-	Ultrasonic sensors	Cost effective, Detects the obstacles Position and navigation assistance to destination using Li-fi Technology

VIII CONCLUSION

The cane for visually handicapped people is implemented and it had detected the floor level obstacles in front, right and left directional sides each covering an angle of 50° using three ultrasonic sensors positioned at right angles to each other. The indication about the wet surface floor was found to be detected with high priority. The positional information and guidance in an indoor multi floor environment is provided using Light Fidelity technology.

The hardware designed for obstacle detection process using PIC 16F887 microcontroller. The programming was done using Embedded C and simulated using MPLAB simulator. The angle coverage of the designed cane is more

when comparing with the other existing travel aids. Since, the indoor positioning system for multi floor environment employing LiFi technology needs a single installation cost that serves both lighting management system and positioning system.

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