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INDOOR NAVIGATION SYSTEM FOR VISUALLY IMPAIRED PEOPLE USING LI-FI AND DEEP LEARNING

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Abstract: *The system addresses the challenge of navigating complex indoor environments by leveraging visible light communication technology to provide a real-time navigation system. The proposed system comprises modeling selection, training, evaluation, and testing phases. The system achieves enhanced performance and usability through iterative improvement and user feedback. Integration into user-friendly applications enables seamless deployment in various indoor settings, empowering visually impaired individuals to navigate independently and safely. This system contributes to advancing assistive technologies and promoting accessibility for individual impairments. Throughout the process, factors such as robustness, adaptability to different indoor environments, real-time performance, and user interface design for accessibility. Additionally, ensuring privacy and security of user data is crucial when developing and deploying such systems. Indoor navigation poses significant challenges for visually impaired individuals, hindering their autonomy and mobility*

Key Words: (Light Fidelity (Li-Fi), Wi-Fi, Light Emitting Diode, Visible Light Communication (VLC), wireless, Navigation, Security.

I. INTRODUCTION

Usually, outdoor guidance for visually impaired people is much more efficient compared to the assistance they get indoors. To date, only traditional methods such as using guide dogs have been implemented. and that, advancements in technologies nowadays, the safety concern of impaired people should also increase. Recent technological progress opens up new possibilities for making life more comfortable for people with visual impairments. Indoor navigation systems are considered a vital innovation thathelps blind people be more independent in indoor areas, ensuring safety and normal navigation. The inability of GPS to act accurately enough indoors due to the signal's limitations has become a driving force for scientists to create indoor navigation systems using Li-Fi and deep learning algorithms. Li-Fi represents a technology of transmitting information using light signals that allow accurate indoor localization and navigation. Deep learning techniques are suitable for functioning in a limited space and processing different complex data patterns. As a result, these technologies combined represent the most optimal way to build indoor navigation systems specific to the blind's needs. In this article, we discussed the technique we have introduced to make indoor navigation systems easy for visually impaired people.

Section 2 indicates the components required to implement our indoor navigation system: Li-Fi technology, deep learning, and all the hardware components used in this project.

In section 3, we will discuss the development of the indoor navigation system. In the 4th and 5th sections, we will discuss future enhancements and conclude.

II. LITERATURE SURVEY

Many researchers have studied the importance of assistance for visually impaired people.

Naga Thulasi Vundelli, Dharahas_Venkat G, and Hima Bindu Valiveti proposed Two Ways of communicating between Blind-Deaf-Dumb Person and Normal People, where braille information is given through a display converted into text displayed on a liquid crystal display and gives voice output from the speaker.

Sheikh Abdullah, Eti Akter, Mohammed Shariful Islam, and Jargis Ahmed proposed a Cost-effective IoT-based smart stick for visually impaired people. This stick assists the visually impaired in moving outside the environment.

Yanbin Liu, Xiaowei Qin, Tianyi Zhang, Ting Zhu, Xiaohui Chen, and Guo Wei proposed a novel decoupled TCP extension protocol for a VLC hybrid network. Different from regular TCP protocol, decoupling operation to TCP transmission.

Agon Memedi, Hsin-Mu Tsai, Falko Dressler investigated the impact of realistic light radiation patterns on Vehicular VLC (V-VLC) based on an empirical study for typical car headlight and taillight modules.

Lalithanjani Udayagini; Siva Reddy Vanga; Lohitha Kukkala proposed using an ultrasonic sensor that detects obstacles, then the camera module starts detecting the object and gives the obstacle's name as audio output. The audio output or a microphone will help the blind person reach their destination. The camera module can also detect the faces of family members, and relatives through audio output giving the name of the person.

III. OUR APPROACH:

In this section, we described the Li-Fi technology and the working of the indoor navigation system.

3.1: Using Li-Fi Technology:

Li-Fi is an innovative technology that uses light waves instead of radio waves (used in WIFI) to transmit data. Developed initially by Harald Haas in 2011, Li-Fi provides wireless communication at high speeds, potentially exceeding those of traditional WIFI. The technology involves modulating light from LEDs at speeds imperceptible to the human eye to encode and transmit data. Li-Fi offers several advantages, including higher bandwidth, increased security due to light's inability to penetrate walls, and reduced interference with other devices. This makes it particularly useful in environments where radio frequency communication faces challenges, such as in hospitals or aboard aircraft. As it continues to develop, Li-Fi could complement or even replace traditional Wi-Fi in specific applications, offering a more efficient and secure way to access the internet.

Li-Fi substantially improves the performance of indoor navigation systems among the visually impaired by enabling accurate localization and real-time high-speed data transmission. Li-Fi enables LED light signals to determine users' precise location within indoor frameworks, eliminating GPS's inefficiency in such settings. The potential of Li-Fi is fully unlocked when combined with deep learning algorithms, which can efficiently analyze Li-Fi data in conjunction with other sensory information. Through merging, Li-Fi has revolutionized indoor navigation as it promotes indoor systems' accuracy, stability, and flexibility, allowing the visually impaired to maneuver indoor environments with enhanced freedom and safety.

Features	Li-Fi	Bluetooth
Frequency	Light does not require frequency	2.4GHZ
Range	Based on LED Light	10 meters
Availability	Where ever light is available	WPAN
Data transfer	>1 Gbps	800Kbps
Power consumption	Medium	Low
Cost	Low	Low
Security	Highly secure	Less secure
Usage	Anywhere where there is availability	It can be used anywhere in the
Operating band	Operates at visible light band	Operates at 2.5MHz
Development	Development started in 2011	Development started in 1998

Table 1: Features of Li-Fi

3.2 Using Deep Learning:

Python, a versatile programming language, proves to be indispensable in enhancing indoor navigation systems for visually impaired individuals through deep learning, especially when combined with Li-Fi technology. By utilizing Python's robust libraries and tools, developers can create complex deep-learning models that process and analyze data from Li-Fi signals, sensors, and other sources to provide accurate and real-time navigation assistance. The integration of Python with deep learning ensures that indoor navigation systems are efficient, responsive, and user-friendly, thereby improving the quality of life for visually impaired individuals. Deep learning algorithms analyze and interpret the data to make intelligent decisions regarding navigation routes, obstacle avoidance, and real-time adjustments. By leveraging Python for deep learning, indoor navigation systems become more adaptive, accurate, and user-friendly for visually impaired individuals, ensuring a safer and more efficient navigation experience.

We have used Deep learning for face recognition. Here we have combined deep learning using Python to our project for more effective results. The code is generated through Anaconda Navigator and combined with the hardware components.

An audio output that consists of the person next to you is given by the hardware component once the face recognition tool recognizes the person.

If the person is new, it gives a warning to the blind person that an intruder is present.

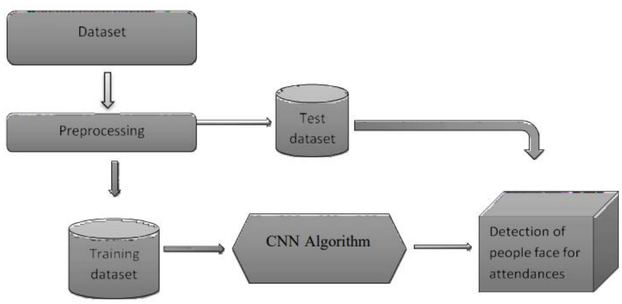

Figure 1: Sequential diagram of Deep learning

IV.DEVELOPMENT OF INDOOR NAVIGATION SYSTEM:

4.1: Indoor navigation system design:

In this indoor navigation system, we have combined hardware components along with Li-Fi technology and deep learning to form a system that promotes the safety of visually impaired people indoors.

We have used hardware components like STM32, IR Sensors, Li-Fi Receiver and Transmitter, Zigbee RX and TX,Ultrasonic sensor, DF Player, and other components like LCD, Buzzer, and Speaker.

At the transmitter side, the process begins with data generation, where information to be transmitted is created. This could include various types of data, such as sensor readings, commands, or multimedia content. Subsequently, the encoding protocol comes into play, converting thegenerated data into a format suitable for transmission overthe selected medium. Encoding protocols ensure efficient bandwidth use and enable error detection and correction mechanisms to maintain data integrity during transmission.Once encoded, the data is transmitted through the chosen transmission medium, which could be wired or wireless, depending on the application. Power control mechanisms regulate the transmission power to optimize signal strength while minimizing interference and energy consumption. Channel access protocols dictate how devices share the communication channel, managing access to prevent conflicts and ensure fair transmission opportunities. Finally, data integrity measures are employed to verify the accuracy and completeness of the transmitted data, enhancing reliability and trustworthiness.

On the receiver side, the transmitted signal is received through the STM32 RX and undergoes signal reception processes to capture the transmitted data. Following reception, the received data undergoes processing, where itis manipulated and analyzed to extract meaningful information. The IR sensor senses human movement. This ensures compatibility with the intended application and facilitates further analysis and interpretation. The receiver side acts as a test tool or stick for a blind person.

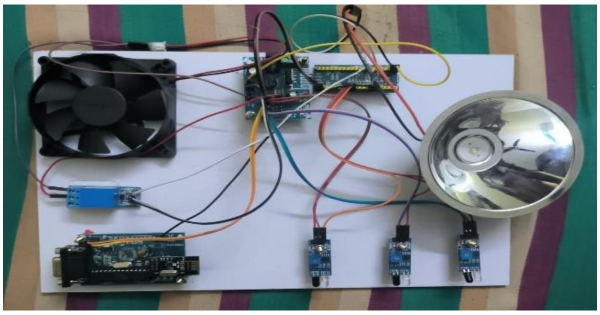

Figure 2:Transmitter circuit board

Sensor 1	Bedroom
Sensor 2	Hall
Sensor 3	Kitchen

Table 2: Sensors

V. VERIFICATION AND RESULT:

In this section, we present the verification test.

5.1 Verification Test:

The proposed indoor navigation system has been thoroughly evaluated through various experiments and pilot studies. The results have demonstrated the system's ability to provide highly accurate and reliable positioning, with centimeter-level accuracy in most tested scenarios. Compared to traditional GPS and Wi-Fi-based systems, the Li-Fi and deep learning-based approach has shown significantly improved performance in terms of localization precision, responsiveness, and ability to function in challenging indoor environments. The system has also been tested with visually impaired users, who have provided positive feedback on the ease of use and the enhanced mobility and independence it has enabled.

We have tested our prototype in a closed indoor area, with the help of a visually impaired person. Where he could easily navigate the rooms. In our project, the transmitter part is placed on the stick of the blind person and the receiver part is designed assuming it is different parts of the house.

The Deep learning concept is used where the people close to the blind person are scanned and can be recognized along with their names in an audio output form and any new person will be identified as an intruder, through this audio, the blind person can recognize who is potentially near them when needed.

5.2: Result:

This paper explains and shows the final results that have been obtained from this paper, we have created a stick prototype that can be carried by the visually impaired person (Receiver) around the indoor area. The ultrasonic sensor present in the stick intimates the person if any obstacle is near them and the Li-Fi Receiver indicates which destination they have reached on coming in contact with the Light source. Through our project, visually impaired people can be more safe and secure indoors without other people’s assistance. It can drastically decrease accidents and it is affordable compared to other prototypes used for blind assistance since we have used microcontrollers directly instead of other pricey hardware.

VI. CONCLUSION

Light Fidelity (Li-Fi) is a technology for wireless communication between devices using light to transmit data and position. In its present state, only light from light-emitting diodes (LEDs) lamps can be used for the transmission of visible light. The Hardware components used in this paper together form a prototype of a stick to prevent indoor accidents. We implemented an ARM processor as the central controller and integrated various sensors and modules, the system effectively assists users in navigating indoor environments. The use of IR sensors, light transmitters, and receiver units enables the system to detect room entry and announce room identities. Additionally, the ultrasonic sensor helps users avoid obstacles. The integration of Python deep learning with OpenCV further enhances the system by enabling the recognition of known individuals.

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