Indoor Assistive Technology for Blinds using Visible Light Communication (VLC) and Machine Vision

M. Jayashree[1], Duddela Sai Prashanth[2], Raghavendra G. Shetty[3]
[1]*PG Student, Dept. of Computer Science Engg., Sahyadri College of Engg. and Management, Mangalore, India*
[2]*Asst. Prof., Dept. of Computer Science Engg., Sahyadri College of Engg. and Management, Mangalore, India*
[3]*Managing Director and CEO, RDL Technologies Pvt. Ltd., Sahyadri Campus, Mangalore, India*

***Abstract*: An advanced research in the field of mobile device users those who are physically challenged people like blinds, through guidance and support with their position identification is "Indoor Assistive Technology for Blinds using Visible Light Communication (VLC) and Machine Vision". The technology used here are OpenCv and Android. It centers on automatic video capture, investigation and image processing the details of which are explained in the introduction. The system is useful mainly for blind people by assisting them to navigate from one place to another in Houses, Shopping Malls, Multiplex Theatres, Retail Stores, Departmental Stores, Factories and so on. A smart assisting approach dependent on man-made realization calculations is presented in an interior condition for relative situating for blind people, by guiding them and resolution construction via research and development procedure. In this system, relative location of mobile user (in this case, we refer to blind people) can be detected in the same mobile device so that it can guide them in a right direction. Moreover, in this project, we refer to the physically challenged people like blinds as android-based mobile users so as to offer a small contribution to the society.**

***Keywords*: Indoor Assistive Technology, Visible Light Communication (VLC), Machine Vision, Image Processing**

1. Introduction

Recently, positioning has become the emerging and challenging research to work with outdoor and indoor environments. The researchers have come up with innovative ideas for outdoor scenarios; for example, GPS. But there have been very few approaches for interior situating. However, interior situating is essential in number of applications such as self-governing machine auditing as well as regulation, interior exploration assistance, automatic security interests, smart as well as intelligent services and numerous other applications. The system is to assist blind people and physically challenged people with a voice message to navigate them in the right direction providing a way that will help them to reach their destination consuming a lesser amount of time. This system is mainly developed with a social concern. As we know time is precious for mankind and most of the time is spent in finding out a way to the destination especially for physically challenged people or blind people, ending up with a dilemma. So, this work gives a possible solution for them to find their way into their desired destination without depending upon anybody with very less time. The system uses LED illuminators as transmitters and smart-phones as the receiver. We do the auto capturing of video for few seconds using an android-based app called as IP App installed on the phone, dividing the captured video into image frames and then processing these image frames in the backend using Fringe Extraction and Peak Identification (FEPI) algorithm by giving a voice and textual message as an output. By this voice message the blind people will come to know that where they are standing or to find the relative location at that point of time. The innovation utilizes LED light units to correspond situating signals by means of amplitude modulation of light in a manner that doesn't affect the unit's essential capacity of giving brightening. A portable function that strengthens the underlying program structure can decode these Communication signals of Visible Light and use them to decide the relative location or the position of the cell phone device. The VLC signal transmitted by every LED light unit is captured by the mobile device. This procedure consists of different steps which are as follows: Firstly, the auto detection of the light unit is done. Then, auto capture of video is made. From the captured video we get the corresponding image frames loaded at the backend inside the tempLiFi folder which is created by the developer. Now, for these obtained image frames we generate the corresponding csv (comma separated value) files through image processing technique. Later, obtained data from the csv files are decoded completely. There by, assisting the blind people with a voice message that provides the relative position of the mobile device user via voice message for guidance.

In system design phase, all the conditions and specifications of the system are stated in detail. The solutions to the requirements mentioned by the user are focused on in this stage. Also emphasis is given to the system architecture. To represent the design in a client manner, Diagrams are used. The work in this paper is divided into two parts; the hardware part consisting of LED light set-up with a programmable PIC Microcontroller and MOSFET. In this case, the frequency of the LED light can be varied and controlled that acts as the transmitter and the android-based smart phone acts as the receiver, the beneficiary of the current set-up. The software part consists of computation of number of image frames captured per second for a given frequency, image processing, decoding and finally determining the relative location of the mobile device user by assisting them with a proper voice message. Figure 1, shows the Hardware Block Diagram.

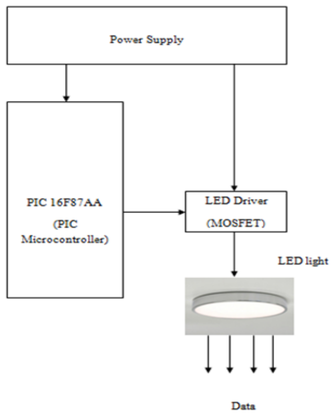


Fig. 1. Hardware block diagram

The theoretical model of the application is depicted by the architectural design. It comprises of the several constituents which exist in the system and also their behavioral patterns and their inter relationships. It displays the different features of the system. It gives a sense of direction towards the system and its functionality, as to how it can be developed. Figure 2, shows the System Architecture.

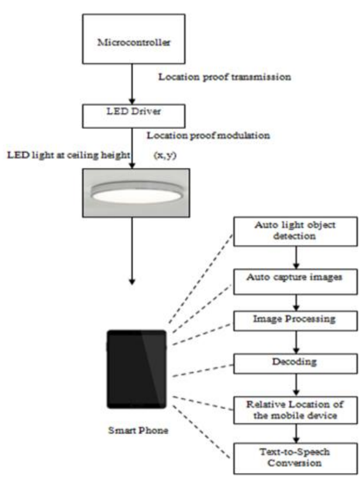


Fig. 2. System architecture

2. Related work

In the system, [1] it provides a VLP solution that gives precise and rapid indoor route by means of the plans of a detailed flash-less boundary classification strategy and an incompetent picture handling practice. Likewise, said arrangement includes upside of biased flash glimmer alleviation and darkening, which are essential for brightening. VLP indoor route arrangement which guarantees cost effectiveness and robustness as well as fast and high precision. [2] The innovation utilizes LED light components to communicate situating signals by means of amplitude modulation of light in a manner that does not affect the component's essential capacity of giving brightening. A portable application that consolidates this software framework can decode these Visible Light Communication signals and use them to decide the exact location or the position of the cell phone. In [3] the paper structures, actualizes, furthermore, assesses Rolling Light, an observable pathway light-to-camera correspondence framework that empowers a light to converse with assorted off-the-rack moving shade cameras. [4] In this paper, a correspondence plot that empowers inside surrounding LED lighting frameworks to send information to versatile gadgets utilizing either cameras or light sensors is presented. [5] The framework creates furthermore deploys this as an incompetent mobile transmission framework utilizing COTS LED illuminators as senders of the signals and cell phone cameras as collectors with the goal as such, it very well may be completely presented in a cell phone plus is practical for all possible interior situations. [6] Gives us an idea about how to design an indoor positioning scheme using Artificial Intelligence Algorithms such as ANN and Fuzzy Logic. [7] A Dynamic Visible Light Communication Link for Smart phones, a versatile observable pathway VLC framework for cell phones that powerfully modifies and augments its channel limit by evaluating the separation between the transmitter and the recipient. In this, we feature the requirement for an adaptable visible light communication interface that will powerfully alter its channels limit dependent on the separation between the transmitter and the recipient.

3. Indoor assistive technology

Inside structures, lights are common, have adequate access to control, and are regularly in a perfect world situated for detecting applications. In this project, a procedure is presented for transmitting information from strong state illuminators, utilized for inside encompassing brightness, to mobile gadgets related to smart phones in a way it's imaginary to tenants. Solitary convincing use of this methodology is the capacity to change brightness causes to milestone guides that will be able to be utilized for interior localization. In the event that each luminary could remarkably distinguish itself to adjacent cell phones, it is conceivable to effectively recognize rooms and zones inside areas those are enlightened by various bulbs.

The main goal of our system is to assist blind people with a voice message along with a text message and an image to accompany them which are helpful for them to navigate in an interior environment. This operation is done by our FEPI algorithm. The algorithm steps are summarized as follows:
Auto distinctive substantiation of the light unit is done simply by opening the IP App.

- Auto catch of video is made.
- The auto caught video is consequently changed over

into picture frames and grayscale pictures which will be set in the backend in the later stages.

- In addition, for these obtained picture frames we produce the relating csv reports through image processing approach in the background.
- Later, information that has been acquired from the csv records is decoded from one end to the other by detecting the peak values in the csv files.
- In this way, we find the relative position of the smart phone by assisting the smart phone user via voice message.

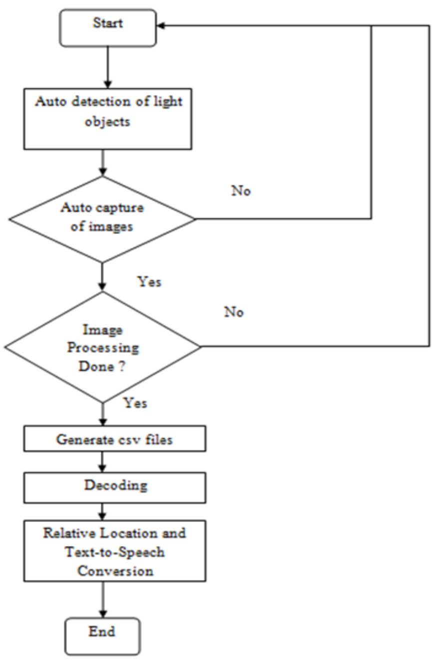


Fig. 3. Shows the flow diagram

Indoor Assistive Technology is a method used to guide blind people in a right direction with a voice message as an outcome of the system by helping them to reach their target area. In implementation, we actually combine our plans and design and set them into motion. The design is being implemented in reality. In this section, we particularly focus on elaborating how things actually operate in the different segments or modules of the system. Thus, we intend to emphasize on executing the actual idea or concept we had perceived all along early stages of our innovation. Efficient innovation utilized here are OpenCV and Android. And the implementation is done by OpenCV methods in Android. We use Android Studio as our implementation platform to run our code which includes OpenCV libraries imported into the latest version of Android Studio. OpenCV is the most regularly used processor vision library for picture handling and AI. OpenCV is a cross-arrange library using which we can develop progressing applications. It basically focuses on picture handling; video catch and examination including features like face recognition and article area. Android is a flexible working arrangement made by Google, in light of a replaced variation of the Linux kernel and other accessible basis for computation and organized fundamentally for contact screen PDAs, for instance, hand-held devices.

The implementation involves detecting the peak values of different frequencies of the processed image frames by using a Fringe Extraction and Peak Identification (FEPI) algorithm. It involves fringe extraction and identification of peak values through image processing and decoding technique. Image processing is done by comparing the image frames with fringes of different width for different frequencies. It also associates with finding out the total number of peak values in a csv file for a particular frequency of an image frame and then taking the decisions in the form of binary data values that is 0's and 1's which is corresponding to the frequency 800Hz and 1500Hz respectively. In this case, we have taken 800Hz representing a "0" and 1500Hz representing a "1".

4. Experimental results

We illustrate the proposed methodology particularly depends on:

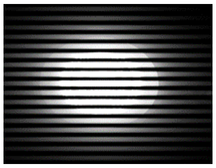
- The time required to capture and process one image frame: 33ms
- The number of images frames captured per second: 30 frames
- The total number of peaks for the frequency 800Hz (image frame type 1): 12
- Hence we infer, this particular frame is having a frequency 800Hz and we denote this frame with a binary "0".
- The total number of peaks for the frequency 1500Hz (image frame type 2): 23
- Hence we infer, this particular frame is having a frequency 1500Hz and we denote this frame with a binary "1".

This is because; we have hardcoded the two different frequencies within a particular range. Below are the figures that show the results of image processing.

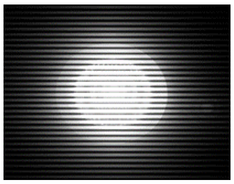
The following figures show the results of coloured images and their corresponding grayscale images for two different frequencies based on FEPI algorithm. Notice that the coloured images are the original images. Figure 4 (a), (b), (c), (d) shows the conversion of video into image frames.

(a)

(b)



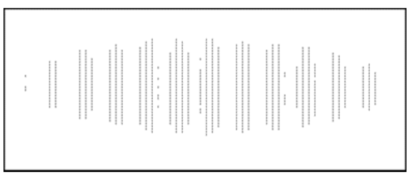
(c)



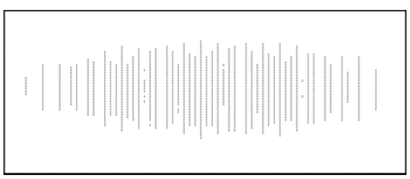
(d)

Fig. 4. Conversion of video into image frames (a) coloured image frame for frequency 800Hz (b) coloured image frame for frequency 1500Hz (c) grayscale image for the frequency 800Hz (d) grayscale image for the frequency 1500Hz

Figure 5 (a) shows Generated csv file for the image frame number 20 with frequency 800Hz. (b) shows Generated csv file for the image frame number 19 with frequency 1500Hz.



(a)



(b)

Fig. 5. Corresponding csv files generated after image processing with binary data (a) Generated csv file for the image frame number 20 with frequency 800Hz (b) Generated csv file for the image frame number 19 with frequency 1500Hz

Figure 6, shows Indoor Assistance for blind with a voice message and textual message with an image

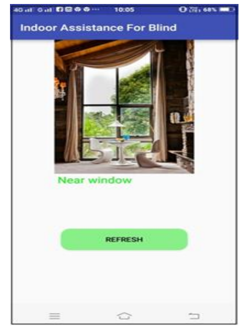


Fig. 6. Indoor Assistance for blind with a voice message

5. Conclusion

We have implemented an image processing technique using OpenCV and Android using FEPI algorithm. Our algorithm successfully decodes the VLC signals from the LED transmitters into situating signals at the receiver end that does not affect the primary effect of giving brightening. As a result, binary data is received at the receiver side in the form of a particular pattern in csv (comma separated values) files. There by finding the relative location of a blind android-based smart phone user by assisting him/her with a voice message to take proper decision for navigation. We have applied our algorithm on many image frames by research and development procedure, and found that it successfully decodes the captured image frames into situating signals.

References

[1] J. Fang et al., "High-Speed Indoor Navigation System based on Visible Light and Mobile Phone," in IEEE Photonics Journal, vol. 9, no. 2, pp. 1-11, April 2017, Art no. 8200711.
[2] Aleksandar Jovicic, Qualcomm Lumicas: A high accuracy indoor positioning system based on visible light communication, 2016.
[3] Hui-Yu Lee, Hao-Min Lin, Yu-LinWei, Hsin-IWu, Hsin-Mu Tsai and Kate Ching-Ju Lin, “RollingLight: Enabling Line-of-Sight Light-to-Camera Communications,” 2015.
[4] N. Rajagopal, P. Lazik and A. Rowe, "Visual light landmarks for mobile devices," *IPSN-14 Proceedings of the 13th International Symposium on Information Processing in Sensor Networks*, Berlin, 2014, pp. 249-260.
[5] Y. Yang, J. Hao and J. Luo, "CeilingTalk: Lightweight Indoor Broadcast Through LED-Camera Communication," in *IEEE Transactions on Mobile Computing*, vol. 16, no. 12, pp. 3308-3319, 1 Dec. 2017.
[6] A. Islam, M. T. Hossan, M. Z. Chowdhury and Y. M. Jang, "Design of an indoor positioning scheme using artificial intelligence algorithms," *2018 International Conference on Information Networking (ICOIN)*, Chiang Mai, 2018, pp. 953-956.
[7] Michail Vasilakis, “DynaLight: A Dynamic Visible Light Communication Link for Smartphones,” 2015.