Low Cost Smart Navigation System for the Blind

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2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS) | 978-1-6654-0521-8/20/$31.00 ©2021 IEEE | DOI: 10.1109/ICACCS51430.2021.9442056

Abstract* — *One of the major problems faced by visually impaired people is navigating from one place to another. Commercially available walking canes only serve as obstacledetectors for these people.The need for an economical guidance and navigation system for the blind is long overdue. Existing solutions are highly cost-ineffective, rendering them available only to people on the higher end of the economic strata. A cheap and affordable piece of technology can help the blind commute to their workplace instead of relying on help from random strangers to even commute walkable distances. In this paper, we propose a design for a walking stick to help the visually impaired commute to their livelihood. The proposed solution works on the Internet of Things realm wherein the blind can "communicate" with the environment. This prototype is equipped with an ESP8266, a power source for the development board and coin motors along with a smartphone application, thereby making it accessible for even the working class visually impaired.

Keywords* - *Visually challenged, mobility aid, assistive technology, internet of things, ESP8266, blind navigation

I. INTRODUCTION

In this fast-growing world, the number of people affected by vision loss is increasing [1]. According to a recent World Health Organization (WHO) report on blindness and visual impairment, globally, over 2.2 billion people suffer from vision impairment or blindness[2]. The total inability to see while impaired visually or with low vision is a severe reduction in vision that cannot be treated using standard glasses or contact lenses and reduces a person's ability to function at certain or all tasks. As per the data collected and observations made in [3], approximately 65% of the visually impaired travel five or more times a week, which is an unexpected result (shown in Fig.1). Most of these people belong to the working class of society. The frequency of head level accidents who are blind and legally blind (partially blind people who have vision 20/200 or less) as shown in Fig.2. These accidents happen since the visually challenged do not have proper guidance while walking on roads [4]. About 40% of these go outdoors daily and about 90% travel outdoors at least once a month [5]. These statistics provide a compelling reason for a navigation system to be designed for the visually challenged to help them navigate to their workplace or their place of choice without their visual impairment being a hindrance.

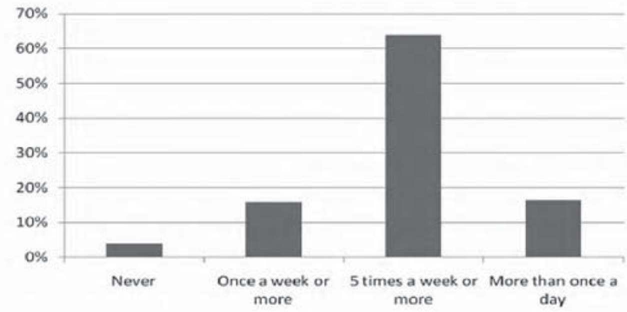

Fig. 1. Frequency of visually impaired people travels outside one's residence.

At present, a technology that can navigate blind costs around $600 - $3000 [6]. In rare situations, people have also adopted highly expensive path-retracing, AI-powered robots to aid them with their daily needs [7][8], but on broader demography, based on a survey in the United States of America, about 48% of visually impaired people are unemployed and full-time employees with a median salary of $35,000 [9]. These staggering numbers combined with the everyday struggles of the working blind play a huge factor in bringing into the picture a low-cost solution.

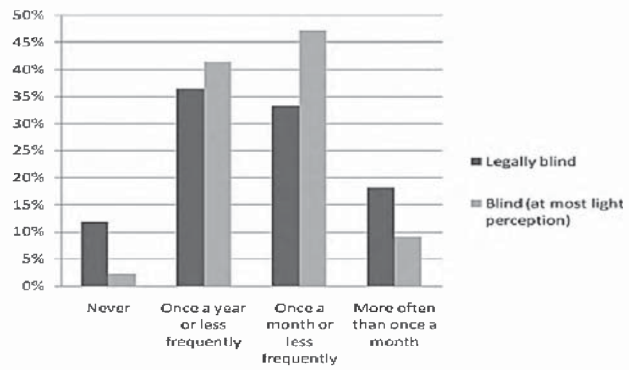

Fig. 2. Frequency of head level accidents who are blind and legally blind

To eradicate this issue, a solution has been proposed which can guide them to their destination at an affordable cost. The proposed module uses GPS to track roads, paths, and turn points when a destination is given as voice input through a

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mobile application. It indicates turns at a prior of 5 meters. This module can be remodelled by attaching it to a cane and the output is fed through two-coin motors (one each for left and right turns). These coin motors which are used for alerting an approaching turn can be attached to the subjects' hands using a glove or straps to attach the module to an existing walking stick. With this modified walking cane, the visually impaired have the freedom to step out at will. The organization of this paper is as follows: Section II describes the methodology of the proposed solution. Results are presented in section III followed by cost comparison in section IV, with possible technological expansions and conclusions are discussed in section VI.

II. METHODOLOGY

The proposed system consists of vibration motors, a development board (ESP8266), and a map service from which data have been read through a smartphone application. The block diagram of the system is as shown in Fig. 3. The intuition for vibration motors over a voice-assisted turn indication is that visually challenged people perceive tactile stimulus faster and better than the normal people who were blindfolded. [10] Vibrations proved to be the most viable solution and having two separate sources of vibration to indicate the direction of the turns makes it easy for the users to adapt to the system. Although vibration motors range from small coin motors to Haptic sensors [11], taking into consideration the cost of the modified walking stick [8] and how the majority of blind people are above the ages of 50 [1] should not be subject to intense vibrations, two small coin vibration motors were used to indicate the direction to be followed.

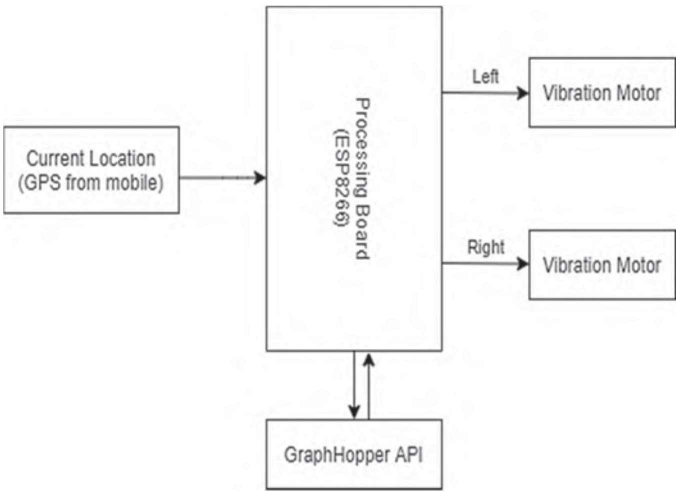


Fig. 3. Block Diagram of the proposed system

To supply the current to the coin vibration motor, a NodeMCU [12] is used. ESP-8266 being a low-cost device was the firstchoice for implementing sensor networks in an IoT scenario [13]. The NodeMCU communicates with an app that receives and sends messages to a map service (API) based on HTTP requests. Map APIs vary from paid map services like Google Maps API that offer a wide range of services, to free map APIs like Open Map Tiles and Open Street Maps. In this paper, GraphHopper API, based on the Open Street Maps API, which is a free map service, is used.

The application is built using MIT App Inventor which runs on Scratch, a block-based visual programming language. The application is voice-activated and powered via Google Assistant, making it easy to access. The application currently works only on the Android platform. The app collects the destination via voice command and starting location from GPS [14] of the mobile device and sends HTTP requests to GraphHopper API. The API sends back a JSON file through a server (Fig. 5). The JSON file is parsed by the application, the turn coordinates are extracted and stored. When a turn approaches, the app exchanges status with NodeMCU via a local HTTP server [15]. The whole system's working is as shown in the flowchart (Fig. 4.)

The distance (d_m) between two geographical locations is defined using the Minkowski Metric [16]. The Minkowski metric gives the flexibility in finding the Euclidean distance as well as city block distance. The roads are usually not straight but they are also not as random as city block points. The formula used to calculate the distance (d_m) is as in (1).

$$d_m = ((x_1 - x_2)^k + (y_1 - y_2)^k)^{1/k} \quad (1)$$

The optimum value of k to be used is 1.4 [16]. If the distance between the current location and the upcoming location gets below 5 meters, the device receives the upcoming turn from the JSON file extracted. If the turn direction is left, the current is passed through a one-coin vibration motor. If the direction is right, the other coin vibration motor is activated. The current from a GPIO pin from a NodeMCU is 12mA. The current required for the coin vibration motor to vibrate is 30mA. So, a current amplifier was used to supply enough current for the motors to work.

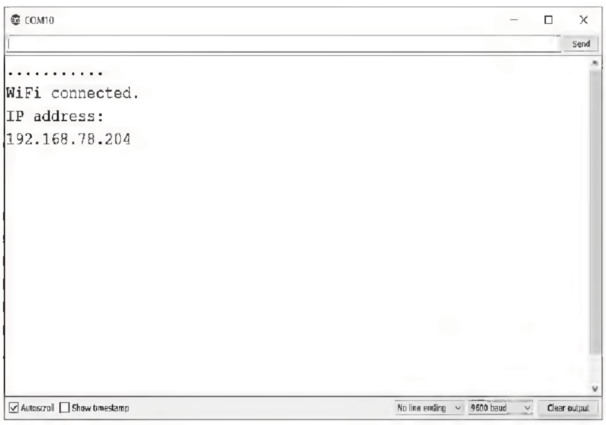
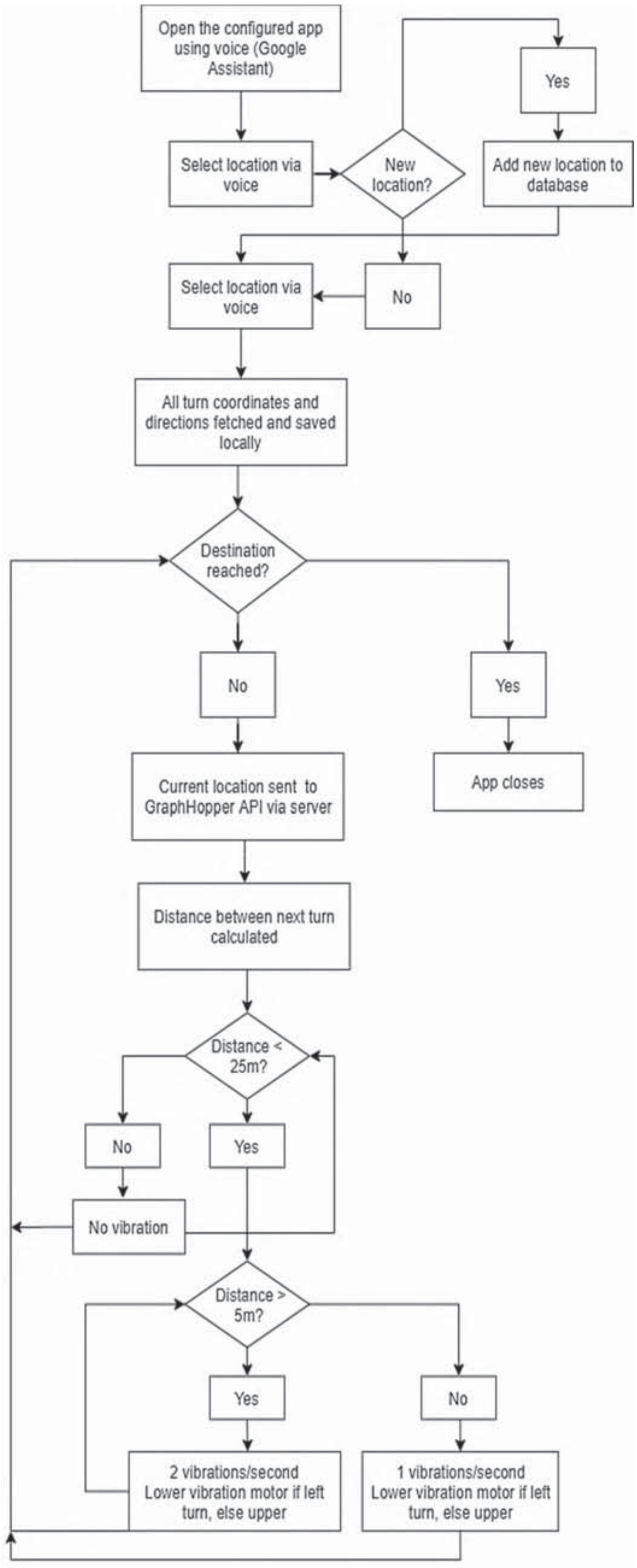


Fig.4. An active server setup with the WiFi module in ESP8266



`Fig. 5. Flowchart of the working mechanism

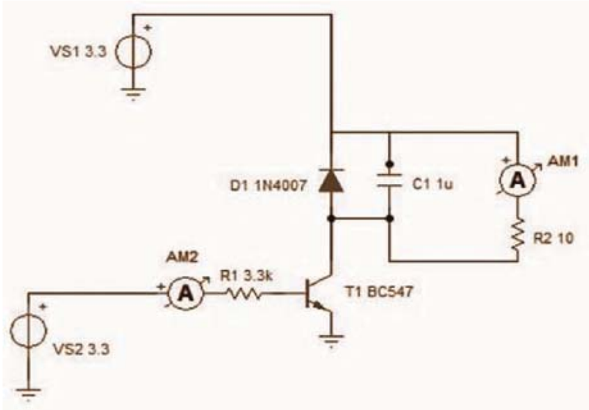


Fig.6. Simulations of a current amplifier used for the vibration motors

As shown in Fig. 6, ammeters AM1 and AM2 represent the coin vibration motors. Fig. 7. shows the physical connections of the proposed hardware.

III. RESULT

Before the app is made available to the user, it is configured to store all the possible locations the user has to commute to. After the initial setup, the application is made available to the user. The user's acquaintances can also use this application, who can then further add other locations post the initial configuration.

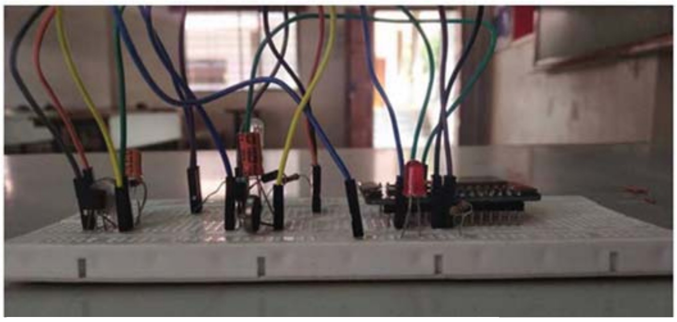


Fig.7. Implementation of the proposed circuit

With the help of Google Assistant, the user launches the application. After being read the set of stored locations, the user can choose his destination via voice. Fig. 8(a) shows the Google Assistant waiting for voice instructions and Fig. 8(b) shows the user selecting the 7th location of 10 locations preconfigured in the app.

Fig. 8. (a). The application waiting for a voice command

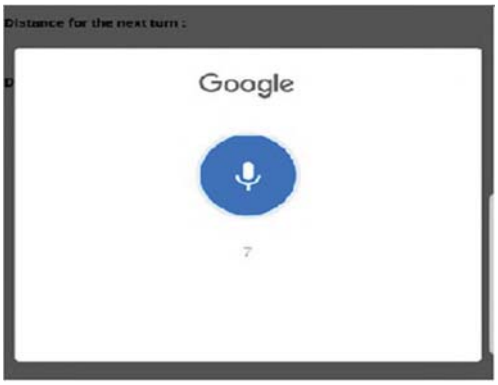


Fig. 8. (b) Choosing the 7th of the 10 locations from the app

Fig. 9. shows the basic UI of the app, which has details like the coordinates of the turn points and the physical directions, which will be read out to the user for further assistance.

In this work, the functioning of the coin vibration motor is shown by using LEDs. A left turn is denoted by the glowing of the blue LED and a right turn is denoted by the glowing of the red LED. When the coin vibration motor indicating right or left is supposed to vibrate motor M_R or M_L, the corresponding LED glows. In the event of a wrong turn taken or an approaching turn missed, the user is alerted by both. The same has been depicted in Fig. 10 through Fig. 12. Fig. 13 shows the final prototype fixed to a stick.

Fig. 9. The user interface (UI) of the developed app.

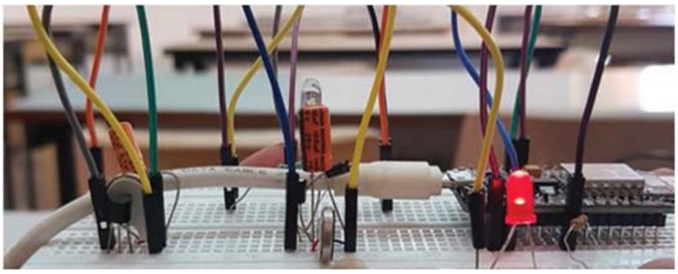


Fig. 10. Indication upon approaching a right turn

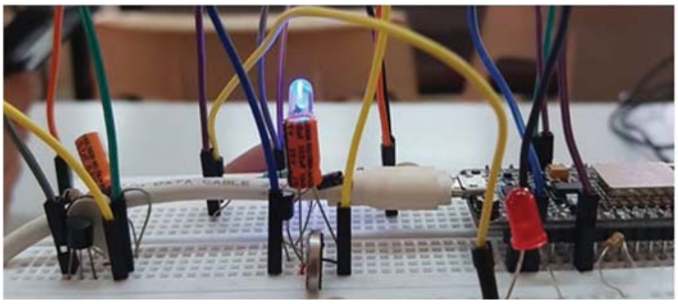


Fig. 11. Indication upon approaching a left turn

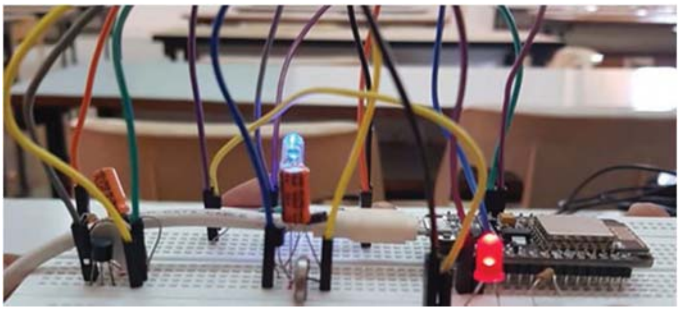


Fig. 12. Indication upon taking the wrong turn/ missing a turn

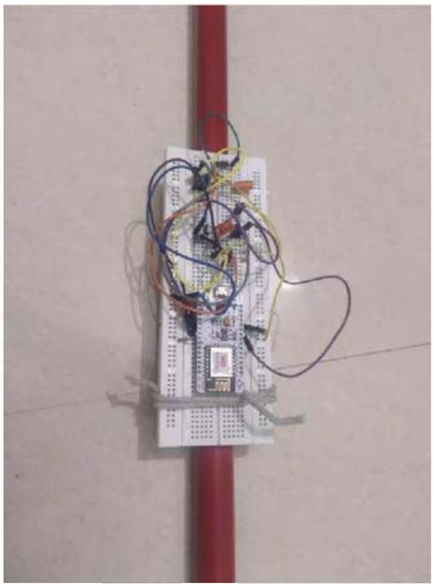


Fig. 13. A prototype of the stick with the circuit fixed

IV. INFERENCE

The main objective of the work is to build a low-cost walking stick for the blind and the same has been prototyped. Table. 1 shows the total cost incurred for building the prototype.

Table 1. Cost estimation of the proposed prototype

Component	Count	Cost (in dollars)
ESP8266	1	4.71
Coin Vibration Motors	2	1.35
Red LED	1	0.07
Blue LED	1	0.07
Power Source	1	0.34
Walking Cane	1	5.43
Jumper Wires	10	1
	Total Cost	12.97

As shown in the above table, an average walking cane with the proposed navigation system totals up to $12.97 (INR 952), compared to the currently available $600 cane. The cost can be brought down significantly upon commercial production of the model and a custom-fabricated chip. [17].

V. CONCLUSION

This work proposes a cost-efficient and easily accessible walking stick that can be used by the blind to help them get on with their lives. Mass production of the module would drive the cost further down, thereby making sure even the remotest would be able to access it and can help to get access to a more accurate map service like Google Maps.

VI. FUTURE SCOPE

The forthcoming work towards this paper would be to mount the processing onto a custom-fabricated chip to reduce the size of the hardware. To remember the paths which are frequently used, artificial intelligence can be used so that the use of GPS can be avoided. Additionally, the cane can also be mounted with existing obstacle detection technology to ensure a safer commute.

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