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Smart Tool Kit for the Visually Impaired - A Survey

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Abstract: People often do not realize the importance of all our sense organs and how if even one is lost, life becomes harder to live. Each sense organ is equally important and when it comes to vision, it takes a bigger importance as it affects our travel and daily routines more than others do. The aim of the research paper is to explain the working principles of various existing technologies in order to help the visually impaired. The paper also reviews the technologies used earlier based on various parameters such as accuracy, cost, precision, range of sensors used and their types. A comparison is drawn to arrive at the most suitable system, which satisfies the required demands.

Keywords: Arduino boards, IR sensors, mobility stick, Obstacle detection, Raspberry pi, Ultrasonic sensors, visually impaired.

I. Introduction

The challenges faced by the visually impaired aretoo many. The biggest problem arises when they have to travel in outside spaces such as roads, buses, unknown environments and other public places. In order to help such people we require a sophisticated user-friendly device. The main concern while building such a device is the device's efficiency and its cost effectiveness. The visually challenged human beings most commonly use the traditional white cane or a guide dog to make their way through in public spaces as they aid their mobility.

Today, technology is improving and growing every day in all aspects and so has the approach to the blind cane designed for the visually impaired. Various robots and sensor-based technologies have been applied to guide the blind to detect obstacles at ground level and help them overcome these uneasy situations in a better and smart way. The main objective of this survey paper is to provide a convenient and easy option for the blind to help them in their daily activities.

This paper provides the detailed information about the various methods of implementing the system regarding the types of sensors used and its benefits and keeping in mind its affordability. It provides a brief information about the on-board computer used, if any and other components made use. Electronic Travel Aids (ETAs) devices have been introduced recently to be a mobility aid for the blind people.

II. Requirement for the Visually Impaired

For a visually impaired individual, many parameters come into play for their ease of livelihood and transport. The following are the most required by them, when conducted a survey.

a. **Cheap mobility stick:** The visually impaired need a cane or a mobility stick for them to be mindful when they travel outside or indoors.
b. **User-friendly:** The stick should be light weighted and must not have complicated on-stick devices for their ease of use and to carry it around.
c. **Fast detection of obstacles:** The components embedded on the stick must be fast responsive so that the person using it can be warned a little beforehand and the necessary steps can be taken.
d. **Avoiding confusion:** It becomes very important to detect what exactly is the obstacle in order to face it or avoid it. Therefore, the device should contain different signals or notification for the better understanding to the person using it.
e. **Battery backup:** The device that contains the system should have a good battery backup as the visually impaired need to watch their step every time and proceed slowly. If the device runs out of battery and is not helpful for them in the time of need, the whole purpose is compromised

III. Description

White canes are normal stick usually carried out by the blind for walking in earth platform. These sticks do not contain any peripheral devices to detect or identify the objects as obstacles. These devices could not be able to communicate with the user and help them to avoid the obstacles. They are just used to detect simple obstacles on their way such as holes, steps, walls, uneven surfaces, downstairs etc. In addition, these are possible only up to the knee-level. They have limitation on the range of detection and it is mostly one to two feet

in height. Obstacles such as pitch, window, grass, stones, bars, road obstacles, water and others that are in contact with ground can easily be detected with the help of this normal cane.

The "smart cane" is a thing, which is normally carried out by the visually impaired people to detect obstacles. It uses Ultrasonic sensors to identify obstacles and inform the user with help of vibration .The vibration produced depends on the distance between the user and the object as obstacle. The system is removable and attachable. The cane is mounted on the top of the normal stick and it acts as a smart cane to detect obstacles. This device does not harm humans and user friendly. However, the major disadvantage of this is that it not fully developed and not known to common blind people.

Giva Andriana Mutiara et al [1] proposed and designed a prototype named Smart Guide Extension that can detect obstacles, holes and give information about eights wind direction using Arduino. The obstacles and holes module used the 2 PING Sensors, while the 8 direction of the wind information was given using CMP compass sensor 511. All the information in this system was conveyed to the person through sound.

The system can detect eight direction of the compass wind position with deviation angle position about +30. A small survey and questionnaire was conducted with the users and 77.38% of responder stated that these tools are user friendly and easy to use. The research conducted aims to make an UID design of extension module as smart guide extension, which can give information about the obstacle, hole, and the position of the user based-on the eight position of wind direction. The PING sensor is programmed to read the object, obstacle and hole from a distance 150 – 3 cm. The sensor is integrated with Arduino and produces the beep sound through the buzzer as information about the obstacle or holes detected. The closer the obstacle, the faster of the beep sound. Compass sensor 511 was designed to provide information about eight wind positions of the compass and Qibla direction to do a prayer.

Sharada Murali et al [2] proposed a device that could detect obstacles and terrain changes in the person's path. A traditional white cane is used as the base upon which the sensors and the other components are placed. Additionally, a feature to detect and notify the presence of puddles and slippery surfaces in the person's path has also been included in the device. The presence of these obstacles is notified to the person by the means of recorded voice played via earphones or through the haptic feedback module, provided using vibration motors placed on the hand support or the band on the hand as part of the stick. The smart walking cane also uses GPS and GSM modules, which can be used to send a distress signal to the user's mentioned caretaker or family along with the his/her location activated by a simple button. A depth sensor, step sensor and a water sensor fitted at the base of the walking cane indicate changes in terrain. Feedback for obstacle detection is haptic in nature, given through vibration motors, while terrain information is conveyed through audio recordings that can be heard through earphones. The device was found to be lightweight and was powered using a battery. The overall design gives moderate accuracy, energy efficiency and easy portability.

N. Sathya Mala et al [3] proposes a theoretical model and a detailed concept to provide an electronic aid for the visually impaired people. This work relies on developing a walking stick and a Bluetooth headset (wearable) that helps them to find their way in this world. The Internet of Things is an intercommunication between various systems where the communication is being carried by means of network or some of signals. The current situation of the humans can be found by using Global Positioning System (GPS), which is embedded in the stick. The headset and the proposed stick are paired using a Bluetooth Stick. In the proposed system, IOT helps blind people identify their way back home by the communication between the walking stick and the headset, which are Bluetooth paired and enable the communication between devices. Their current work detects only obstacles and does not help them to identify the type of obstacle they face. However, many mobile applications help them recognize objects, which is complex to understand and operate.

Rajesh Kannan Megalingam et al [4] proposes to modify an ordinary white cane into a pathfinding device with the use of an obstacle detection module and the addition of an Bluetooth module for notifying the user. The device is incorporated with a vibration module (Haptics Module) intended for detecting moving objects. As the obstacle approaches the user and reaches close proximity, the intensity of vibration increases. The use of a Haptics Module that works coordinated with the Ultrasonic Range Finder Sensor to give a notification of the obstacle ahead is introduced as a feature to help navigating. The team uses a SRF05 Ultrasonic sensor that produces an eight cycle sonic burst of 40 kHz upon reading the echo signal, the duration can easily be calculated and by which the distance can be calculated.

Once an Arduino board is connected with the Ultrasonic Range Finder, it detects the distance information and prints it on a serial monitor. In order to transfer this information onto an Android device a Bluetooth device Shield is used. The Bluetooth Shield enables pairing between Arduino Board and the Android phone. Once the distance information is obtained, it is sent to the Android device using a v2.2 shield. The Team also inculcates a LM-35 Heat sensor that detects hot objects in the range of -55 to 150 degree Celsius.

Ankit Agarwal et al [5] propose an Ultrasonic stick that uses an Ultrasonic sensor as the main obstacle-detecting device, which is used for navigation. The proposed system includes the use of three Ultrasonic sensors

that can scan an area of 180 degrees working together, and a buzzer and a vibration module that works coordinated with detection unit. The buzzers and vibrators are activated once an object is detected. GPS and GSM modules are included in the system to provide a distress mechanism. The sensors send out pulses covering a wide area and once the obstacle is detected, it activates the vibrating module to provide an indication of its proximity. The GSM module when activated interacts with the Microcontroller to obtain from the GPS module the location of the user, and this information is sent to a pre-recorded number via an SMS.Hence, the Microcontroller works at the heart of the system to control the functioning of the other modules. Thus, the team aims to provide a navigation system with a distress mechanism.

Ashraf Anwar et al [6] proposed the following system. The developed prototype gives good results in detecting obstacles placed at a distance in front of the user; it will be real boon for the blind. At the same time global positioning system (GPS) can be linked with the voice stick for navigation, so that person can know his current position and distance from the destination, which will be informed to users through voice instructions.

D. Munteanu et al [7] proposed the smart assistive system, which can be used by the visually impaired or blind people, which is implemented using a Multi-point control unit. This device can be controlled by a smartphone using predefined voice commands and a Bluetooth connection. The distance between the person and the obstacles are made by ultrasonic echolocation and the microcontroller processes the sensor data, it also controls the feedback part. The switching on and off the device is also controlled by the predefined by the voice commands and the type of feedback can be selected by the voice commands. The proposed system is a vision substitution method in which the output is non-visual, tactile or acoustic or both based on the users choice of selection. The proposed device is a guiding mechanism that helps the visually impaired or blind people to avoid collisions with obstacles present on the walking path using tactile or audio or both as the feedback.

In today's world, a visually impaired person worries about the difficulties he has to face while moving from one place to another. Melvin Varghese et al [8] proposes with an idea of "The Smart Guide Cane" which aims at a world in which the visually challenged can walk without worrying about these difficulties. The aim was to provide a cost effective device for the people and was specially designed for the Indian scenario, which is different from the rest of the world. There are many guidance systems that were available for example like Guide Dogs, the C-5 laser cane (using 3 laser diodes), Mowat sensor (ultrasonic device), Binaural sonic guide, Navbelt but most of them were not cost effective and non-reliable, so Melvin Varghese and team came up with The Smart Guide Cane, a system which integrates the regular cane and an interface which consists of an on board computer like the Arduino microcontroller and ultrasonic sensors. The system is based on the echo received after the ultrasonic signal was reflected from the obstacle. The output or the alert to the user is through the haptic or tactile feedback, a vibrator was used which would vibrate to indicate the presence of obstacles the speed or intensity of vibration depends on the distance between the obstacle and the user.

The conceptualization of the entire system is that it is a reliable device to navigate by detecting obstacles at ground level and overhead, and avoid unnecessary obstacles. The output is reliable and helps for the navigation of the visually challenged in a great way. This system is versatile and economic as designed for the masses and for Indian scenario it is very much suitable as it makes an alternative to the traditional white cane.

Ayat A Nada et al [9] have proposed a reliable system which is light in weight, economic, user friendly, with a fast response time and which consumes low power, a smart stick based on infrared technology. A pair of infrared sensors can detect staircases and other obstacles presence in the user path, within a range of two meters. A pair of infrared sensor, the horizontal one to detect obstacles in front of the blind in the range of 2m, the inclined infrared sensor to detect obstacles on floor, upward and downward stairs. When the infrared signal is received at the microcontroller, it begins to compare between transmitted and received signals to identify obstacles standing in the way of the blind. If the microcontroller finds a difference in the form and amplitude of transmitted and received signals, it invokes the appropriate speech-warning message. In this paper a solution is proposed for the blind to move safely by detecting obstacles in their path using a foldable stick and a pair of IR sensors mounted on a stick, an earphone is connected which alerts the blind person if an obstacle is detected. It can also detect the stairs and differentiate between them (upstairs and downstairs) and this is informed through an alert to the blind person-using earphone.

Shashank Chaurasia et al [10] propose to build on the traditional white cane to help the blind navigate better, this is performed with the use of Ultrasonic and Infrared Sensors. Ultrasonic sensors having a better range are mounted on top of the cane to aid in obstacle detection, and Infrared sensors are mounted at the bottom of the cane to help detect low lying obstacles at a more nearer range. The system is also provided with a GSM module so that user can send a message to a pre-registered phone number, the message could be recorded and simple like "help I am in trouble". The proposed system also makes room for future improvement with the addition of GPS System.

E.cardillo et al [11] proposes to mount microwave radar on top of the traditional white cane to aid the user by making him aware of the objects ahead of him in a wider and a safer range. The proposed radar system

adopts the use of a BGT24MTR11 integrated circuit as the leading block and SiGe transceiver. The working of the system is as follows, a balanced transmitter and an unbalanced receiver have to be connected in accordance with the datasheet, the signal is transmitted and upon receiving the echo signal it is processed and based on these inputs the target distance is calculated, the system helps in detecting obstacles and hence helps prevent collisions. However, the use of a radar provides better detection the cost of the system increases and thereby making it uneconomical.

Gita Hapsari et al [12] have worked to improve the traditional white cane and thereby benefit the blind by the usage of a GPS module, which is integrated with Raspberry pi board. The proposed system uses the GPS module to provide the location of the user which is processed in the raspberry pi board to convert this information to audio and thereby making the user know his location and to navigate thereon.

The proposed system also leaves a scope for future improvement with the connection of the device into a map system to aid the user in real time navigation.

Muhammad Hunan et al [13] propose an intelligent cane system to replace the traditional white cane. The system consists of three Ultrasonic Sensor modules each with different range; the interface is completed with the use of an Arduino Uno board that helps in processing the information obtained with the use of the sensors. The output or the indication of the objects is provided with the use of motors, based on the sensor that is activated the concerned motor starts rotating hence the user has an indication of the object in front of him and also the distance of it from him. The system also includes a GPS module that is used for navigation purposes.

A smart stick having the capability to detect the obstacle and communicate the person smartly through speaker or by vibration rhythm through vibrator motor and help the blind help their way was proposed by Kunja Bihari Swain et al [14]. The designed blind stick working efficiently with low power rechargeable battery. It can help the visually impaired person appreciably in guiding in their way. The model can further improved by employing the small comparable solar cell so the user has not bother for recharging of the battery. As it has GSM module, an earphone piece can be attached so that the impaired person can speak to the programmed number along with sending SMS. One demerit found in this model when the GPS module not getting the satellite signal or the person is in indoor region the SMS can give wrong information.

When the stick is powered with battery supply depending on the types of obstacle it gives a particular rhythm through vibrator based on the type of the obstacle detected. The classification of obstacle is done based on the sensor output. The values are calculated based on the inclination of the stick while walking and here we have considered an average inclination is 45° the range of ‘D ‘is calculated based on the trial distance of test obstacles. The actuation rhythmic signal is generated from Arduino in pulse format differently for different type of obstacle face by the blind.

Akhilesh Krishnan et al [15] propose the use echolocation to detect objects in front of the blind person, for a purpose they use Ultrasonic sensor that transmit waves and based on the reception of these waves the object is detected. The team also use an Image sensor to identify the object in front of it by using the hue and saturation model and for the purpose of navigation a GPS model is used which is synced to a smartphone app through a microcontroller that lies in the heart of the system, using this app the user can navigate and reach the desired destination.

A different kind of prototype proposed by M. Maiti et al [16] and others aims to provide simulated vision to these people. Electronic eye carries a concept of complex human eye. A helmet is specially designed to mount all necessary hardware in it. A stepper motor controlled small rotating camera mounted on the helmet gives the 360-degree visual information to a microcontroller. The controller processes the image and generates a continuous audio instruction to the person about the closed views. The generated useful audio command is conveyed to the person through a headphone. The power required for the entire unit is generated through different renewable sources. These are small solar module on the helmet, piezoelectric generator fixed with shoes and electric generation unit from body heat. In addition to the camera, four obstacle detectors have also been mounted on the helmet to provide additional object distance detection. These are flexible solar module mounted on the helmet, Piezo module fixed in the shoe and body heat to electricity generating module mounted on the body. A lithium ion battery has also been used to store generated power required for idle situation. The unique factor of this prototype is the way it is powered. The entire model is placed in a helmet, which is a light in weight.

Visually impaired people walk with a normal cane they try to remember the path by counting the footsteps by learning the places they visit and the path they walk. But this is not a suitable method for navigation for the blind, hence R. Sherline Jesie et al.[17] “Advanced Talking Navigation Cane for Visually Impaired using Capacitive Touch Keypad” has come up with a reliable tool for the visually impaired to walk with, wherein an audio and tactile feedback will be used to inform the user where they are, and which route they have to follow thus trying to improve their mobility.

Visually impaired or blind people are familiar with braille dots hence in this system a capacitive touch keypad is used which is named as Braille capacitive touch keypad. The capacitive touch keypad will provide the information to the user in a form that is necessary i.e. audio, the user can know if he's walking in the right path, if there is any obstacles that lies ahead of him, it also informs him about the timings. The system has outputs in both audio and tactile form. Using the recent advancements in the technology the Braille form has been converted into electronic form. The information that is received by the sensing action is converted to audio messages using headphones. The system contains a GPS module, which will give location in latitude and longitude form, two vibration motors are used one for indicating presence of a person and other for quick tactile feedback to indicate the path followed by the user. This information can be stored or recorded using a memory recorder that may be useful if the blind man chooses to traverse the same path again.

The capacitive touch keypad is much easier for the blind person to recognize in and when the blind person feels the capacitive touch, keypad it will be easier than the Braille manual keypad.

This advance technique of Braille electronic navigation uses modern equipment has to guide directions such as GPS sound navigation and ranging which uses sound techniques to detect any moving objects. This system is easier flexible and efficient and is going to change their way of life. It also allows them to control the operation of the device via the braille touch keypad.

Di Mattia et al [18] proposes the use of a radar that transmits a short pulse and analyses the echo coming from the surroundings, this method was helpful in detecting objects their shapes and sizes as well as locating them at different heights i.e. chest level and foot level, the device that is used is a k band slot antenna which is to be integrated on a small circuit board to be attached on a white cane.

IV. Conclusion

The use of various embedded electronic components to benefit people is a growing trend today. In order to particularly assist the visually impaired, we make use of such components too.

The smart stick systems that have been proposed are mainly validated by their economic value in the market.

The use of Compass 511 sensors, radar systems and image processing systems though make the systems more reliable are difficult to calibrate and also the increase the processing time, with the added disadvantage of making the model costlier.

Thus the systems using Ultrasonic and IR sensors have become a mainstay, they are cheaper and also get the necessary work of detecting objects done. Some systems also incorporate the GPS and GSM modules to aid in distress message transmission.

Though there are various available systems which can be made use in this field, there are certain restrictions and guidelines which must be followed such that the resulting efficiency is high. The main aspects, which must be kept in mind, are:

a. Power consumption must be less.
b. Must be easy to carry from place to another.
c. Cost effective, and
d. Must be easy to use.

An efficient system can be designed only when the above conditions are satisfied before developing the final product.

V. Future Works

The future work could include integrating more features onto the existing modules. The obstacle detection can be improved by detecting what type of obstacle is being faced, by detecting solid and moving obstacles or water and puddles. It can further be improved by adding IR sensors for obstacle detection instead of ultrasonic sensors as they use lesser area and it can be compact. Active RF transceivers can be used for providing information about their daily commute or the source and destination of the arriving public transport.

Moreover, Piezo sensors can also be used for fall detection and the panic button can be integrated to go on when the user is in any distressed situations. The system should be made compact and user friendly, lightweight and long lasting.

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