IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Smart Cane for Blind and Visually Impaired Persons

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Abstract: Blindness is a state of lack of visual perception, which leads to the inability to see anything, including light. Complete blindness is the total absence of light, but partial blindness represents the lack of integration in the growth of the optic nerve or visual center of the eye. In some cases lens, occupied glasses will help to improve partial blindness. Low vision cannot be corrected by visual aids such as glasses and contacts. In those situations, it is too difficult to find or detect obstacles in front of them, which makes it dangerous. They need some aid to feel safe while navigating. Conventional Blind canes are widely used for assistance, but it has too many limitations. Thus the current scenario needs a technologically developed cane. Thus, Smart cane comes as a proposed solution for visually impaired people. In this experimental work, we implanted a simple, economical, and user-friendly smart blind guidance system. This system is designed to improve the mobility of both visually impaired and blind people, and to remove the curse of blindness, to make them self-dependent to do their daily routines.

The proposed work includes the design of a lightweight adaptable cane with multiple sensors connected to an Arduino board, along with a handle head and sticks elongator. A conventional white cane forms the main base frame of the device, ultrasonic and infrared sensors are mounted at appropriate locations to detect obstacles and it can scan a predetermined area, both known and unknown locations around blind by emitting-reflecting waves with the help of that blind stick. The equipped sensors send signals to an Arduino programmed board, which communicates with the alarm unit that comprises a buzzer and vibrator and gives some recorded audio clips to navigate the blind people safely. An audio jack is also available in the blind cane whose presence is not found in other conventional canes. The system can also control the peripheral components that alert the user about the obstacle's shape, material, and direction. The device is lightweight and is been powered by a battery. Thus the system is easy to use and is an innovative reasonably priced solution to blind and visually impaired people. The power consumption is too low, and the stick is economic over the conventional one.

Index Terms **- smart cane, Ultrasonic, Infrared, sensors, Arduino board, GPS, visually impaired persons**

I. INTRODUCTION

Visual impairment is considered as a major global health issue. According to World Health Organization and National Federation of the Blind, the visual impairment and causes have been estimated in the year 2010. There are more than 250 million people who are visually impaired and out of which 36 million people are blind [1]. Among them, 82% of the total blindness is for people with 50 years and older. The interesting fact is, India is the home ground to the world's largest number of blind people [2]. In the present world, it is estimated to be almost more than 2 billion people have a vision impairment or blindness. Among 1 billion people includes those with moderate or severe distance vision impairment or blindness due to unaddressed refractive error, cataract, glaucoma, corneal opacities, diabetic retinopathy, trachoma and age-related macular degeneration are more common [3, 4]. It is due to physiological or neurological factors. In terms of regional differences, the prevalence of distance vision impairment in low and middle income regions is estimated to be four times higher than that of the high income regions. With regards to near vision, 80% of unaddressed near vision impairment is addressed in low income regions. While comparative rates in high-income regions, are reported to be lower than 10% [5]. In their daily life, they are trying to face and overcome some of their challenges, when living life [14]. This paper reviews the challenges and finding the solution to the one of the most important problems face by them.

Vision impairment or vision loss, is a decreased ability to see the environment and objects to a low variant of degree. This can be overcome by using different variants of contact lenses. The term blindness is used for complete or nearly complete vision loss. Those persons who finds very difficult to leave independently such as not able to move freely. Normally, visually impaired persons use white canes or dogs for their assistance. The guide dogs which are trained specifically to help the visually impaired persons on their movement by navigating. However, this method has some limitations such as difficulty to understand the complex direction by these dogs, and the person will struggle to follow them during some critical situations. Also, they are only suitable for about almost less than five years. The cost of these trained dogs are very expensive, so most of the crowd suggest to use canes [7]. Nowadays, different types of such canes have been used such as white cane, the smart cane [8], and the laser cane [9]. The white cane is a long cane that helps navigate and avoid obstacles on the road. It is their visual aid that helps identify dents, platform edges, steps, uneven surfaces. Some of them choose to use a cane to move around while others use it to let people know about their visual impairment. It is important to understand that not all of them are entirely blind or have the same eye condition. There are different types of canes are available in our market, based on their needs, like

mushroom tip, roller tip or straight tip, used for different purposes. Guide cane and Long cane are some of the type of cane are widely used by them. Guide cane is used to identify a step or dent on any surface. It is also used to notify people about their visual impairment, and long cane is used to avoid obstacles on the road and some use it for long journeys. In some cases, based on their situation, they even change their canes, like if a person is deaf and blind, then he/she use Red and White cane, which symbolically indicates the person's problem [6].

Most of them ease to use White canes in their daily life routines, because of its availability and low cost. But, it will not perform efficiently. Sensing through simple white cane is cost efficient, but time consuming and less efficient, which results in reducing the confidence of visually impaired persons, to do something or go outside from the house. Based on the available validations and analysis reports, the number of visually impaired persons will increase. Mostly, these deficiency is commonly seems to IT professionals, due to continuous work in-front of the computer screen, which also reduces the efficiency of the eye in the future, after a particular age. Many people suffer from serious visual impairments reasons. Sometimes, we can cure the problem through proper analysis and treatment. Some people are born as blind, those issues cannot be cured through surgery.

In this scenario, the future generation needs some more technically developed equipments to move and achieve. They need a wide range of tools and techniques to make their mobility make easy, at that time we need a cost effective method or device for the persons to walk independently. Most recently, many techniques have been developed to boost the mobility of blind and visual impaired persons, which to be dependent on signal processing and sensor technology. These are widely called Electronic Travel Aid. Based on their aspects, they are, mainly of two types: sonar [10, 11] and camera input systems [12, 13]. These equipments are used to identify the direction, height and speed of the objects. Also, the distance between the obstacles. However, all prevailing systems notify the persons, the presence of an object at a specific distance in front of or near to him, through vibrations. Information about the object characteristics can create additional knowledge.

To overcome the above-mentioned margins, this experimental work offers a simple, efficient, configurable guidance system for both the blind and visually impaired persons to help them in their mobility, while they are indoor or outdoor. The ingenuity of the proposed system is that, it make the most of an embedded vision system of two simple IR sensors, one ultrasonic sensor and a proximity senor, which brings all-together to provide reflective signals in order to classify an obstacle through Arduino board. Hence, in addition to distance, the suggested guidance system enables to determine the two main characteristics of the obstacles, which are material and shape. Furthermore, the user can carry the cane, after the purpose, and reduce to desired length, using motors. Also, it consist of LDR, which helps to lighten the stick, as reflector, and it is very suitable for real-time applications. So, this Paper proposes the design of A Basic Smart Blind cane which can be made by anyone with very minimal cost, which can be made applicable for people with different range.

II. MATERIALS AND METHODOLOGY

1. System Configuration Design

The smart blind cane, is basically an embedded system incorporating the following components, which includes: a pair of ultrasonic sensor to detect obstacles in front of the visually impaired person from the ground level height to head level height of the cane in the range of 325-400 cm ahead, infrared sensor is used to detect the upward and downward stairs, water sensor and heat sensor for detecting puddles. Fig. 1 and 2 shows a schematic representation and 3D design of the electronic smart blind cane. A switch, which is placed on the handle bar of the cane, that can be operated with the thumb in worst condition, that allows the user to send a message 'I am in trouble, help me' on to the preferred mobile number for help. Vibrating sensors along with a buzzer used for beep and vibration if stick is about to hit any obstacle. The range of the vibration is controlled by the user with the help of a button. The sensors will collect the real-time data and send it to the Arduino board for processing. After processing, the Arduino appeals the right speech warning message through an earphone. The system is powered by a rechargeable battery. For choosing a wrong length for visually impaired smart cane can make walking a painful and mind-numbing process, while take small unsure steps. This may results in either not being able to walk as fast as you want or walking faster than your cane allows and it may disturbs or risk bumping into people or objects. Thus, choosing a cane, that is too short can be uncomfortable and can make movement unnecessarily hard. So, based on the height of the person, we need to adjust the height of the cane. Otherwise, it may affect the visually impaired person through so many ways, as mentioned above.

When it comes to choosing the right and proper length for visually impaired smart cane, there is no single rule to be followed but care must be taken to try out a few lengths and determine which length is the most effortless comfortable and feels most natural to you personally. So, based on the following guidelines, the height of the cane is placed or can be adjusted. One of the more common methods of measurement is to pick a smart cane that goes from the ground up to your sternum or your chest area when you are standing in an upright position. Some people prefer a cane or stick that one end comes up to their chin when both you and the stick are upright and its other end is touching the ground and finally a cane that is approximately 4 inches shorter than your height and will come up to your nose if stood vertically upright. The representation of height is shown in Fig. 3.

Another most embarrassing technology is also placed in the system, for the better enhancement of the user. GPS is been placed on the blind smart cane device with user input interfacing alerting the blind person when he reaches his destination by voice. This consists of microcontroller (Arduino) module, GPS Unit and a voice module to generate voice output, through headset with the help of head jack. It stores the data of the current location, which it receives from the GPS system, so that it can make use of the data stored to compare with the destination location of the user. By this it can trace out the distance from destination and produce an alarm to alert the user in advance. Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, then they are reflected back as echo signals to the sensor which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo.

The co-operation between the Ultrasonic and IR sensors are utilized to create a complementary system that is able to give reliable distance measurement.

The features are:

- Different types of vibrations for different obstacles and voice clips.
- Automatic (during night time i.e. LDR dependent high intensity (Red colour) LEDs.
- A small LED strip on the top.
- More efficient and economical than other devices.
- Easy to access for blinds.

The system is featured by its small size and low cost when it is compared with other systems that use separate microprocessor, input/output devices, and memory. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems.

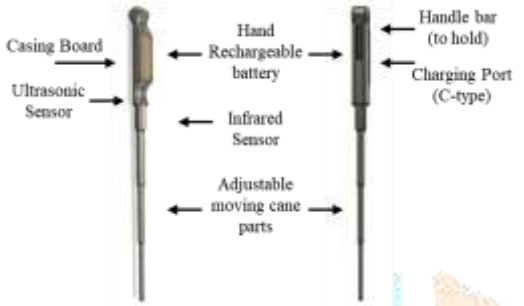
Fig. 2 Side view of 3D Model

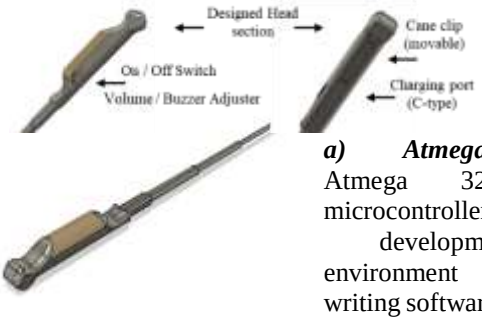
Fig. 1 Schematic representation and design of the electronic smart blind cane

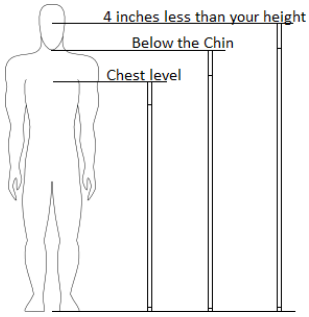
Fig. 3 Cane length Guidelines

2. System architecture

The proposed system design of the smart blind cane shown in the below fig. 4 has the following units.







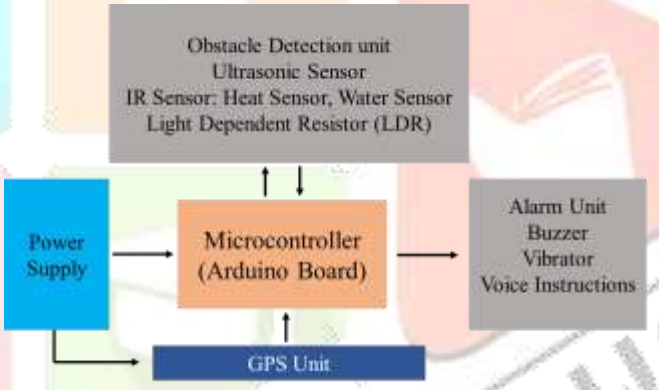
a) Atmega 328

Atmega 328, a microcontroller is a development environment for writing software for the board. It consist of 20 digital input/output pins, out of which 6 are PWM (pulse width modulation) pins and 6 are analog pins. It also consist of a 16MHz resonator, a USB connection port, a power jack and a programming header. It may be used for the development of interactive objects, taking inputs from a variety of switches or sensors and controlling other physical outputs.

Fig. 4 Block Diagram of the electronic smart blind cane

b) Ultrasonic sensor:

Ultrasonic sensor is used to measure the distance between the obstacles and itself. Since it mounted on to the stick, it finds the distance



between the stick and the obstacles ahead. This sensor consists of two circular projections, trigger and echo which act as transmitter and receiver respectively. The sensor transmits ultrasonic signals of high frequency with a speed of 344m/s, this signal gets bounced back after reaching the obstacles ahead and the signal is been collected by the Echo, the inbuilt timer in the sensor, calculates the time taken by the wave transmission and receiving. This is then applied in simple equation (speed/time = distance), to find the distance between the stick and obstacle. In this case module HC-SR04 is used. HC - SR04 provides 2 - 400cms, non-contact measurement function, the ranging accuracy of the system can reach to 3mm. The modules of the system includes ultrasonic transmitters, receiver and control circuit, as shown in Fig. 5.

The basic principle of work:

- Using IO trigger for at least 10us high level signal,
- The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
- If the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.

c) Light Dependent Resistor (LDR)

LDR (Light Dependent Resistor) is also called as Photo resistor or Photoconductor. Simple working principle of LDR is that when the light intensity increases around the sensor, the resistance decreases ranging in few ohms and when the light intensity decreases around the sensor, the resistance increases ranges to mega ohms. During night time, the LDR will have high resistance and the current will not pass through it, but through a LED connected system, parallel to it which illuminates and acts as a Flashlight, which can be easily noticed by others. It alerts people about the presence of blind person to let him to pass the way, as shown in fig. 6.

d) Infrared (IR) Sensor

An infrared (IR) sensor is an electronic device that measures and detects infrared radiation in its surrounding environment. While measuring the temperature of each color of light (separated by a prism), he noticed that the temperature just beyond the red light was highest. IR is invisible to the human eye, as its wavelength is longer than that of visible light (though it is still on the same electromagnetic spectrum), as shown in fig. 7. There are two types of infrared sensors: active and passive. Active infrared sensors both emit and detect infrared radiation. Active IR sensors have two parts: a light emitting diode (LED) and a receiver. When an object comes close to the sensor, the infrared light from the LED reflects off of the object and is detected by the receiver. Active IR sensors act as proximity sensors, and they are commonly used in obstacle detection systems (such as in robots).

Heat sensor: It is very sensitive to the heat and can detect heat from long a distance. If the sensor detects the heat radiation, it will send an electrical signal to the controller and thus voice instruction will be sent to the person and also the vibrator and buzzer starts alarming.

Water sensor: A water sensor is located at the base of the stick to have precaution against the wet surface which can causing slipping on the floor and thus can hurt the blind man. When the water sensor comes in contact of the wet surface, it produces an electrical signal, which triggers the Arduino controller. A voice instruction for wet surface is produced and also a buzzer is enabled for alarming against a wet floor.

e) Alarm unit

The person is informed through a vibrator and a beep sound. It consists of the following parts:

Buzzer: A transducer (converts electrical energy into mechanical energy) that typically operates a buzzer is in the lower portion of the audible frequency range of 20 Hz to 20 kHz. This is accomplished by converting an electric, oscillating signal in the audible range, into mechanical energy, in the form of audible waves. Buzzer is used in this research to warn the blind person against obstacle by generating sound proportional to distance from obstacle.

Vibrator: A vibrator motor is included so that the blind person can be warned about the obstacles in front of him along the beep raised by the buzzer.

f) Global Positioning System (GPS) unit

A radio navigation system which is used mainly for determining location and for emergency crews to locate people in need of assistance. The GPS based blind device with user input interfacing get alert the blind person when reaches his destination by voice.

The candidate type to use: Skylab UART GPS Module (For Microcontroller and Arduino)

g) Switches

The function of switches in this system is to control the range of the sensor. When switches are open (off), sensors operate at their half range, and when it is closed (ON), sensors operate at their full range.

h) Audio jack

An audio jack or a headphone jack is typically used for analog signals. In this system the audio jack of 2.5mm is been connected to the smart blind cane so that the blind man can perceive the voice instructions via the headphone. Voice instructions also include instructions from the various sensors when they are been activated.

i) Battery system

The most integral part of the design is its low cost and compact size. For both the constraints to be fulfilled we have used a cost efficient battery which also helped in reducing the size of the cane. The battery used here is LiPo (Lithium polymer) battery with 1500mAh which is of less cost hence reducing the overall cost of the blind cane.

Fig. 5 Ultrasonic Sensor Fig. 6 LDR Fig. 7 Infrared Sensor



Fig. 8 Arduino Board

3. Working

The stick can be switched on and off by using the switch button on the cane. On switching ON the cane starts getting initiated. The cane can be adjusted according to the height or comfort of the user. Once the cane gets initiated, the various sensors gets activated. When the user is walking independently on the streets, the ultrasonic sensor continuously transmits ultrasonic wave with high frequency in speed of 344 m/s. When this signal finds an obstacle, it gets bounced back, the range up to which sensor can sense is 4 m. Then the signals get received by the receiver and the time of the transmission from the transmitter to the receiver is noted by the inbuilt timing system of the sensor. By using the time information and putting it into simple equation (distance = speed/ time), where the speed of the signal and time is known, thus finding the distance between the stick and the obstacle. If the distance between them is less 4m the Arduino code runs and triggers beep of pin alarm, if not the ultrasonic sensor continues running.

If the distance is found to be less than 2 m the vibrator is set on else the buzzer is on. In all cases the voice instructions are been made and sent to the user via headphones. On giving a particular location to which the user needs to travel can be sought out with the help of GPS. With the help of GPS the user can find his way to his determined location.

III. CONCLUSION

With the proposed design, a simple, cheap, configurable electronic blind smart cane system is constructed, with at most accuracy, the blind people will able to move from one place to another without others help, which helps to improve the constructive assistant and support for blind and visually impaired persons for children and aged peoples, also it leads to increase autonomy for the blind. The developed smart stick that is amalgamated with different types of multiple sensors will help in navigating the way while walking and keep alarming the person if any sign of danger or inconvenience is detected. The entire system is designed and implemented using Autodesk Fusion 360, with the help of standards. The whole system is indicates that the system is more efficient and irreplaceable in its capability in specifying the source and distance of the objects that may encounter. The IR sensor has been fully utilized in the system, in order to advance the mobility of the blind and visual impaired persons in safe and independent way. This system does not require a huge device to hold, also does not require any special training. The developed prototype gives good results in detecting obstacles paced at 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.

The smart blind stick prototype has successfully designed and analyzed this paper. The newly designed stick complies with the human ergonomics because it is developed for adult users. The blind stick prototype is tested for different heights of obstacles. Therefore this novel blind stick is capable to assist a blind person to move independently.

IV. FUTURE WORK

Future work will be focused on improving the performance of the system and reducing the load on the user by replacing the speaker's tune by real human sound to guide the blind exactly. Moreover, shape detection test for objects that move at different rotational speeds across several distances will further be considered. Currently we are using rechargeable batteries, with the help of charging ports. For higher proportions, to fix compatible solar panels, for charging purpose, in order to avoid continues charging at instants.

The future scope of the existing smart stick, guides the visually impaired person in his navigation independently in an efficient manner ensuring the person's safety.

a. The Braille input device gives the blind person an uncomplicated method to provide the destination address for navigation system.

b. The programmable wheels would steer the stick away from the obstacles and also leading the blind person towards the destination.

c. In order to run this integrated set of hardware we can use solar panels as an alternative to the battery. The use of solar panel occurs to be more advantageous as it uses sunlight, easily available renewable resource of energy, to get recharged.

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