Smart Assistive Device for Visually Impaired People

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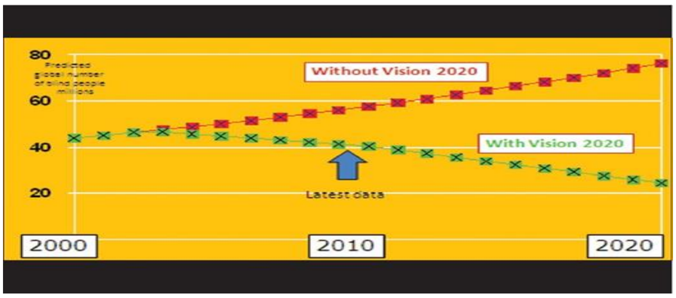
***Abstract*— This paper aims to address the development of a device that shall help and serve as an effective solution for visually impaired. Blind people face constraints in independent mobility and navigation. Daily activities are hampered by their inability to conceive to their surroundings. The developed model aims to guide the blind person and prevent them from unwanted collisions with the obstacles through pre-recorded voice commands hence providing an active feedback. The model consists of two modules- cane and shoe unit. Both are integrated together, working as a single unit facilitated by "Bluetooth" connectivity and offers solution for orientation through digital compass. The IR ranging sensors used in the shoe and cane units together provide information to the user. It also incorporates a pressure switch to alert the user if he/she loses hold of the cane. LED lighting system on the cane helps to alert the crowd about the presence of the blind person. All of these measures altogether alleviate the risk of injury to the blind person.**

***Keywords*— Bluetooth, Cane module, Digital compass, IR ranging sensor, PIC microcontroller, Shoe module, Voice chip.**

I. Introduction

The ever increasing number of blind persons attracts the development of many assistive devices around the world with the hope that these will help visually impaired in leading normal lives. One in every 179 people is blind. As per the current statistics, India contributes to 21% of the total blind population all over the world. In India itself, around 8 million people out of around 39 million people are blind. And in a million, 53 thousand people are visually impaired, 46 thousand people have Low Vision and 6800



people have complete vision loss i.e. they are blind. And unfortunately, as per the current statistics only 5% of them have access to any kind of assistive technology.

Given the fast-paced life now-a-days one faces many difficulties due to the congestion of obstacles in the environment, it would be even worse for the visually impaired people. They usually rely on either external assistance which can be provided by humans, trained dogs or other electronic support systems for decision making. Existing systems are able to detect obstacles at the ground level or at the waist level or above but not together. Hence we were motivated to develop a device which intends to guide the human through the obstacles at both ground and waist level. We implemented two modules, one is the Shoe Unit and the other one is Cane Unit. The shoe unit is integrated with three IR ranging sensors- Front, Left and Right. While the white cane is used usually by the blind people as an assistive device by tapping it on the ground or by making it collide with the approaching obstacle. However, it is not as efficient as it is supposed to be. So we wanted to provide an additional feedback to the user before he runs into the obstacle. We have accomplished the goal by adding an IR Ranging sensor to the white cane to detect obstacles above the ground level. The main feature of the developed model is that Bluetooth technology has been used to make both the modules work as a single unit and a voice playback/ recording chip to alert the user through voice commands. Depending on where the obstacle is located, audio feedback gives a message to the user accordingly. We have used a simple small speaker and a buzzer for alerting the user as use of earphones or any such dedicated device may cancel the noise in the environment which may otherwise be helpful for the blind and not hamper with his/ her natural sense of hearing.

II. Literature Survey

A. Paper I

The cane has an ergonomic design and an embedded electronic system. The electronic system uses haptic sensing

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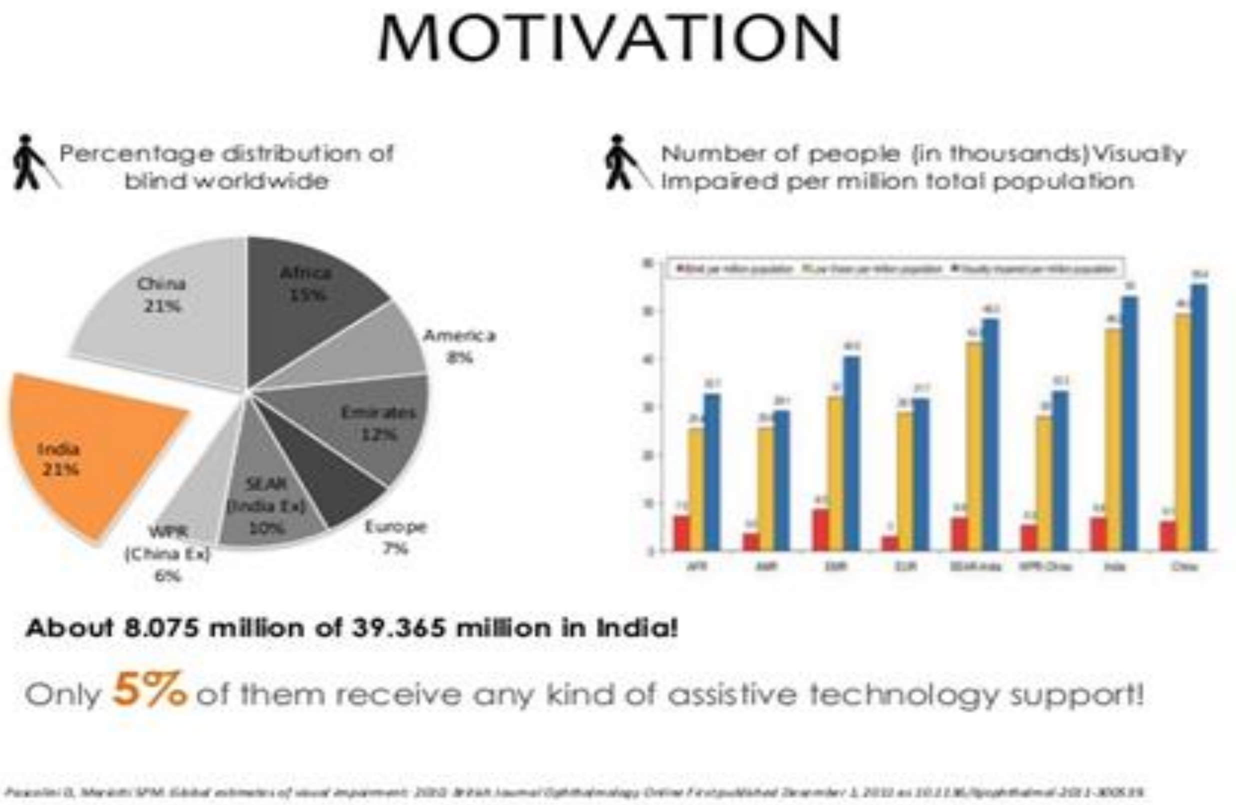

to detect obstacles above the waistline. When an obstacle is detected, the cane vibrates or makes a sound. The device was designed to detect physical barriers above the waistline based on echo detection and to give tactile feedback in the form of vibration (or sound) inside the cane to warn about potential collisions. The haptic sensor and controller are embedded in the cane. Battery life was ten hours. The delay time was obtained when the echo signal arrived, and the distance to the obstacle was computed. Finally, the haptic feedback, which relies on the measured distance, was triggered.

B. Paper II

White cane can only be used to detect obstacles up to knee-level within a range of only 2-3 feet. Cane mounted knee-above obstacle detection and warning system using ultrasound beam to enhance the horizontal and vertical detection range. A detachable unit comprising of an ultrasonic ranger, vibrator and a microcontroller was developed which can detect obstacles above knee level. Distance information is conveyed to the user though a vibrator. Vibration frequency increases as the obstacle comes closer. Enables the person to effectively scan the area in front and detect obstacles on the ground such as uneven surfaces, holes, steps, walls etc. The user keeps the cane at a convenient inclination. As a result the ultrasonic detection cone is directed upwards and allows detection of knee-above obstacles. Device consists of an 8051 microcontroller SRF04 ultrasonic ranger, and a vibrator. Runs on a standard Li-ion rechargeable battery. For charging the user connects an AC or USB adapter fully charged battery lasts about 10 hours of constant usage before recharging.

C. Paper III

Shoes were used to guide the blind person, fitted with an array of ultrasonic sensors around the sole. The sensors are supported by the proprietary circuit located inside the shoe of the user. The concept used in this prototype is that the obstacles will be detected by these sensors and the information about it will be given to the user in real time as physical notice. For the physical feedback, the shoe has made use of some vibrating boxes that the user can put in his/her pockets. Arduino controller keeps polling the ultrasonic sensors and provides feedback via the boxes. This information is processed and fed to the user via one of his other working senses – here it has used the sense of touch. They've used the Arduino Mega 2560 for processing.
Advantage: keeps the user's hands free for doing other tasks.

D. Paper IV

The main features are that Blind Shoes are equipped with vibration sensors can indicate a number of obstacles. Sensors will vibrate when they encounter a number of obstacles, such as holes, vehicles, walls, and even be able to show the road markings. The sensor will vibrate when comrades blind encounter resistance at a distance of 80 cm to 1 meter and a height of 15 cm as well as on the hole or limiting the sidewalk. Blind Shoes are also equipped with a single chip microcomputer that acts as the brain that controls all of the features and data storage. Smart shoes can charge the battery automatically. Blind Shoes can charge the battery by itself through kinetic generator pinned under the soles of shoes. The battery will be charged automatically when the user step.

E. Paper V

As a battery-operated walking stick, the prototypical smart cane is equipped with ultrasonic sensors that are efficient enough to detect obstacles in an extended range, as compared to a white cane. This smart cane detects obstacles through the transmission of ultrasonic waves and the decoding of the received reflections to sense the presence of physical objects. These ultrasonic sensors make it possible to measure and detect the distances to moving and still objects. The cane is simple to operate and provides distance information directly. The detection range, including the length of the cane's tip, may be adjusted based on the user's preferences. The smart cane produces vibrotactile feedback on the handle bar. The prototypical cane had a vibrotactile actuator to generate alerts on the handle when detecting obstacles within a range of 2 m and above knee-level.

F. Existing Technology Vs Our proposed technology

S.No.	Existing Technology	OUR PROJECT
1.	detachable unit comprising of an ultrasonic ranger, vibrator and a microcontroller to detect obstacles above knee level	Everything integrated into a two separate units, two modules one for shoe and cane each, providing increased efficiency to the user
2.	Distance information is conveyed to the user though a vibrator	Distance information is conveyed to the user by voice commands
3.	Projected cost of user modules is under 50 USD	Cost is around Rs.7000
4.	Core of the device consists of an 8051 microcontroller and ultrasonic ranger	Core consists of PIC Controller and Long range Infrared sensor which are highly accurate
5.	module runs on a standard Li-ion rechargeable battery	12V rechargeable battery
6.	Fully charged Battery lasts for about 10hours straight	Lasts for about 20hours straight when fully charged

III. ARCHITECTURE

A. Block diagram of the system

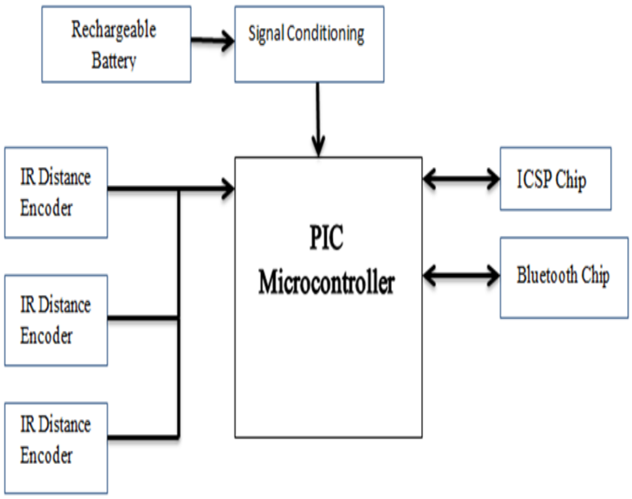

Fig.1: Block diagram of shoe module

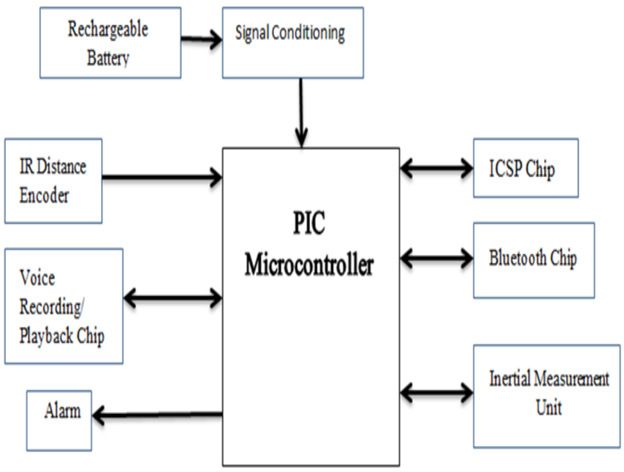

Fig.2: Block Diagram of Cane Module

IV. HARDWARE REQUIREMENT:

The major components used in both the modules are:
1. PIC Microcontroller- PIC18F45K22
2. 3-terminal positive voltage regulator- LM78M05CDT
3. Voice Chip Playback/ Recorder- ISD1700 Multi-Message Single Chip Voice Record & Playback Devices
4. Rechargeable Battery- FG20121
5. Standard Bluetooth chip
6. Digital Compass Multi Sensor Board- GY-80 3 Axis Gyro -
3Axis Accelerometer

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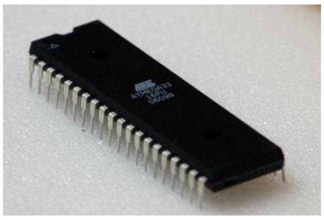
V. SALIENT FEATURES OF THE COMPONENTS

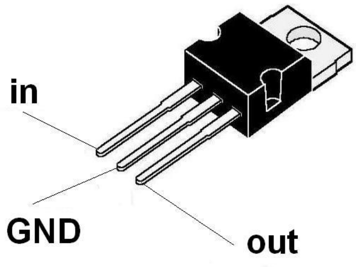
- *PIC Microcontroller-*

1. High performance RISC CPU,
2. C Compiler Optimized Architecture,
3. Up to 1024 Bytes Data EEPROM storage,
4. 40 pin, low power, high performance,
5. 2.3V to 5.5V supply voltage,
6. 35 I/O pins, plus 1 Input-Only Pin,
7. Analog-to-Digital Converter (ADC) module, 10-bit resolution, up to 30 external channels,
8. In-Circuit Serial Programming (ICSP) requiring single supply 3V
9. In-Circuit Debug (ICD),
10. High-Current Sink/Source 25 mA/25 mA,
11. Two Master Synchronous Serial Port (MSSP) Modules,
12. Two Enhanced Universal Synchronous Asynchronous Receiver Transmitter (EUSART) modules.



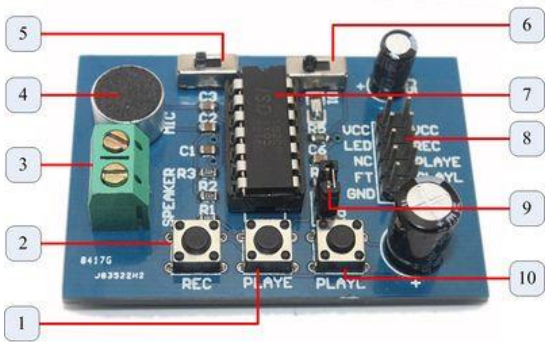
- *Voltage Regulator-*

1. Employs built-in current limiting,
2. Thermal shutdown, and safe-operating area protection,
3. Adequate heat sinking,
4. Eliminates the noise,
5. Output voltages of 5V, 12V, and 15V possible
6. Line Regulation 7.2V <= VIN <= 25V



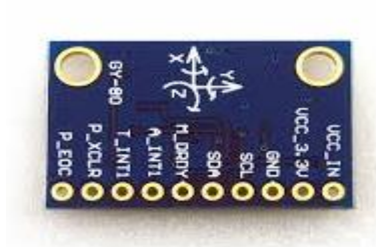
- *Voice Chip Playback/ Recorder-*

1. Message duration is user selectable in ranges from 26 seconds to 120 seconds,
2. Operating voltage spans a range from 2.4 V to 5.5 V,
3. Designed for operation in either standalone or microcontroller (SPI) mode,
4. Chip self-manages the address locations for multiple messages.
5. Multi-Level Storage (MLS) array,
6. Simple push-button interface, includes five push-buttons ‘PLAY’, ‘REVERSE’, ‘FORWARD’, ‘ERASE’, ‘VOICE’, ‘GLOBAL ERASE’,
7. Zero power message storage.



- *Digital Compass Multi Sensor Board-*

1. Board combines sensors into a single tiny package used together as an inertial management unit,
2. consists of 3 Axis Gyro, 3 Axis Accelerometer,
3. only needs 4 wires to get started
4. GND- GROUND
5. Supply voltage-GY80 is 5v and 3.3v compatible
6. SCL - I2C Clock
7. SDA - I2C Data
8. 3 Axis Accelerometer - Measures acceleration. Can be used to sense linear motion, vibration, and infer orientation and force.
9. 3 Axis Gyroscope - Measures angular rotation which can be used to infer orientation.



- *Rechargeable Battery-*

1. Nominal Voltage 12 Volt
2. Nominal Capacity 1.2 Ah, 20 hours rate
3. Maximum charging current 0.3 A,
4. Weight 0.60 kg,
5. Operative temperature range -20 °C to 50 °C

- *Bluetooth-*

1. Typical -80dBm sensitivity
2. Fully qualified Bluetooth v2.0+EDR 3Mbps modulation
3. Operating voltage 3.3V
4. Built-in antenna
5. Selectable baud rate (here used is 9600)
6. Weight-4g, low power operating voltage -1.8V

VI. HARDWARE DESCRIPTION

Hardware connection:

The power supply from the rechargeable battery is rectified and filtered and supplied to the circuit. For the suppression of high frequency noise a 1uF capacitor has been used. The voltage regulator typically supplies 5V and can supply an excess current of 0.5A. In the Cane module, PIC microcontroller is used which uses 3.3V supply. The ICSP (In-Circuit Serial Programming) chip eases the process of programming of the PIC controller. Its pin1 is connected to the MCLR/Vpp/RE3 pin of the controller. Vpp is the programming voltage of PIC because when PIC is supplied with approximately 13V, it enters into the programming mode. Pin4 and pin5 of ICSP chip are ground and power supply pins respectively. Pin2 and pin3 are connected to RB6 and RB7 respectively which are PGC/PGD pins. PGC/PGD pins are for programmable data and clock pins which are used to read/write the PIC controller. A pressure switch is connected to pin RB5 which works as a normally closed switch because when the user loses a hold of the stick the buzzer goes off hence alerting the user about its position. A global reset pushbutton is also provided on the circuit to reset the microcontroller. For the Bluetooth chip, pins4 and 1 are ground and power supply pins respectively. Pins 2 and 3 are connected to RD6 and RD7 of PIC. RD6 and RD7 are the EUSART (Enhanced universal synchronous asynchronous receiver transmitter) pins. The Bluetooth collects the data from the auxiliary board (shoe unit) and transmits it to the main board (cane unit). The receiver chip is integrated into cane module while transmitter chip is fitted onto the auxiliary board.

For the IMU, pins 1 and 2 are power supply and ground pins. Pins 2 and 3 are connected to the RC6 and RC7 EUSART pins of the PIC. It has been used to guide the person if for some reason the person loses his direction of path or gets confused on which direction he/she was on. There is a provision to store the current location by using a pushbutton. And another pushbutton helps to find out the correct direction. When the user will press it, the buzzer will go off and it will keep on ringing until the user returns to his/her original direction. The IR Ranging sensor has pins1 and 3 as the power supply and ground pin respectively. Pin2 is connected to the RA0 (analog input) pin of PIC.

(PRINCIPLE)-The Sharp IR Range Finder works by the process of triangulation. A pulse of light (wavelength range of 850nm +/-70nm) is emitted and then reflected back (or not reflected at all). When the light returns it comes back at an angle that is dependent on the distance of the reflecting object. Triangulation works by detecting this reflected beam angle - by knowing the angle, distance can then be determined and in turn the output voltage.

For the voice playback/ recording chip, pin 4 is connected to the RA5 of PIC, which is digital input/output pin working as the chip select signal for the voice chip. Pin 3 is connected to the RC3 pin which is the MSSP (master synchronous serial clock) pin. Pins 2 and 3 of voice chip are connected to RC4 and RC5 which are SPI (Serial peripheral Interface) pins for input and output respectively.

The Bluetooth transfers the data from the auxiliary module and sends it to the PIC controller of the main board. PIC processes the data of the three IR sensors on the shoe as well as of that of the cane sensor and outputs the required command to the voice chip to playback the pre-recorded message.

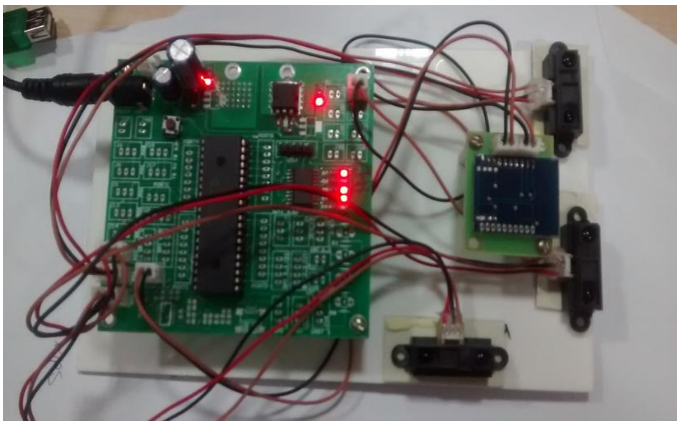
Whenever the user encounters n obstacle in the front, the voice chip plays out “Front Obstacle” through the speaker. And when the obstacle is out of the way or the path becomes clear, the voice chip plays out “front clear”. Similarly, for the other sensors at the top (on the cane), on the left and right side of the shoe. For the Shoe module, the connection is almost the same except for that three IR Ranging sensors have been used instead of one. One for right, one for left and the remaining one for the front. The transmitter chip for Bluetooth is connected in the same fashion as is connected in the main board (RC6 and RC7 EUSART pins are used).

VII. SOFTWARE USED

1. EAGLE software for PCB designing
2. MPLAB for PIC Controller programming.
3. Arduino for sensor testing

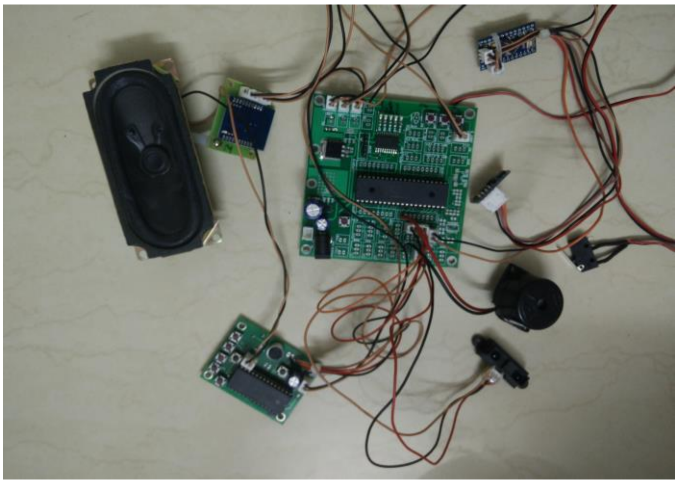
VIII. HARDWARE IMPLEMENTATION

We have tried our level best to make the system look as compact as possible. On the shoe, the shoe unit is mounted on the exposed surface of feet, while the sensors are fabricated into the shoe as required. While for the cane unit, we have tried to fit the entire circuitry into a compact box and minimum exposed wiring so that it doesn't hamper with the user's movement. The sensor has been fitted at an optimum position on the cane so as to detect the obstacle before it touches the stick, keeping in mind that typically blind people hold the cane at an inclination of about 55to 60 degrees. (According to the preliminary data collected from users at the National Association for the Blind (NAB), Delhi)



IX. CONCLUSION

It has been observed that developed support system- is accurate in detecting the obstacle and alerting the visually impaired person find their way bypassing every obstacle that comes on their way to the destination.



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