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SMART WEARABLE PROTOTYPE FOR VISUALLY IMPAIRED

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ABSTRACT

Visually impaired individuals have relied on a variety of techniques to actively participate in society. There are many available technologies both wearable and non-wearable to assist them. These either provide them assistance in walking, or some help them to recognize things by audio or touch feedback. Our approach is to provide a low-cost wearable assistive system which can not only help blinds to navigate freely, but also tells them the time. The system will also enable a distant mobile user to monitor body vitals of the blind person and in case of any emergency the blind can call him with just one press of a button. So overall, the system provides not only aids to the blind, but also to his/her family members.

Keywords: visually impaired, wearable, ultrasound, haptic feedback, audio feedback, time information, monitoring, emergency calling.

1. INTRODUCTION

To navigate safely through an environment, the individual must continuously identify the positions of obstacles around him/her, in order to develop a mental map of the surroundings, in which a safe route can be planned and followed. Therefore the first goal of an assistive system for navigation is the detection of obstacles, which must be followed by the non-visual communication of the detected layout of the surroundings, to the user. The system prototype developed employs a device that the user wears on the head, belt and wrist which measures the distance to the obstacles around, with the use of ultrasound and then provides appropriate feedback, auditory or sensory.

For providing time information, the user can either receive auditory messages through ear phones, or he/she can have them sensed through haptic (touch) feedback. The temperature, sweat and pulse sensors mounted to the kit will continuously send body vitals to a server via Bluetooth or wireless connection. In case of any emergency or assistance required, the blind can have the ability of pressing just one button which will send an emergency alert to the concerned mobile user/caretaker.

2. RELATED WORK

Existing work and research in this biomedical domain is being pursued

1) A Head-mounted-device connected to a pocket PC with 3D Sound Rendering Engine is already developed but not yet made commercially viable in the market. This model had certain drawbacks: Cross-talk may exist between adjacent ultrasonic beams when the angle between the sensors is near or less than 30° and latency issues between the elements.

2) Another study hypothesizes of a Smart Cane that alerts visually-impaired people over obstacles in front helping them in walking with less accident. The cane could communicate through voice alert and vibration, using ultrasound sensors for detection. Smart Cane is far heavier than the ordinary white cane and also it is hard to keep because it cannot be folded. Besides that, cost is also a weakness in this project as it uses ultrasonic sensors and a number of servo motors.

3) Over the years, the Sonic Guide has undergone continuous improvements and its latest version is the system called KASPA. KASPA is worn as a headband and creates an auditory representation of the objects ahead of the user. With sufficient training, allows users to distinguish different objects and even different surfaces in the environment

4) Another additional feature being deployed for assistance to the blind is the development of Tactical Watches in which finding out the current time is as simple as pressing a button, or feeling tactile markings viz. Braille Watches.

The area of wearable devices is currently a “hot” research topic in assisting people with disabilities such as the blind. As this area is still very much young and experimental, there are not many mature commercial products with a wide user base.

3. DESIGN

The overall design flowchart of the proposed system is depicted below.

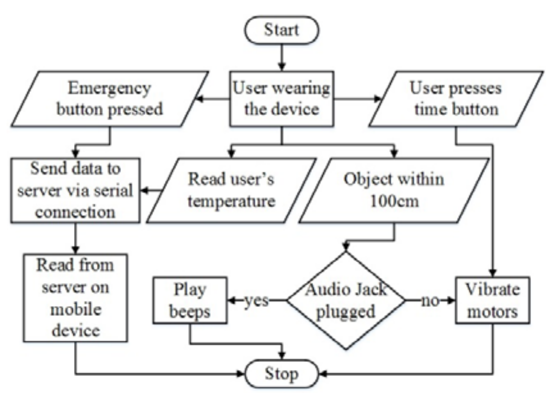

Figure-1. Overall design flowchart.

We use an Atmega328 micro-processor for developing the basic prototype.

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4. IMPLEMENTATION

a. Navigation with haptic feedback

To design a module that can assist the blind in free navigation we have used ultrasounds mounted at various parts of the body. The ultrasound uses sound waves to detect distance of objects by calculating time difference between sending and receiving signals. There are 3 ultrasound attached to belt for scanning obstacles in front, left and right direction. Then there is a head mounted ultrasound to detect head collisions along with a wrist module for directional scan as per will of user.

At each ultrasound location, a vibrational motor is also attached which vibrates at intensities inversely proportional to the distance sensed by the corresponding ultrasound.

The schematic diagram one ultrasound along with its vibrational part is shown below.

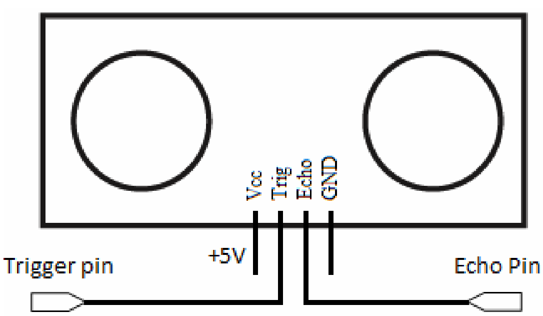

Figure-2. Ultrasound for measuring distance.

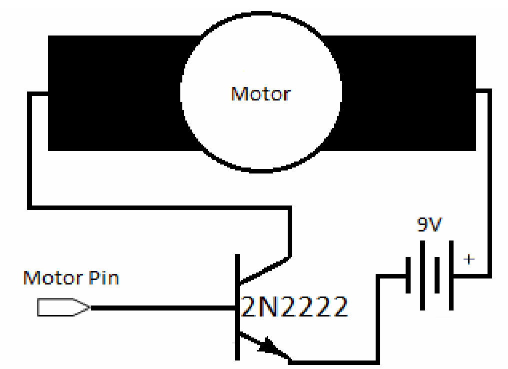

Figure-3. Motor for Haptic feedback.

The trigger pin is used to send the sound waves and the echo pin to sense when they return. The motor pin is used to provide variable voltages to control the intensity of motor.

The algorithm is designed to sense objects within 100cm range but ultrasound offers a capability up to 400cm. The algorithm is given below:

a) Trig ← HIGH
b) delay(1)
c) Trig ← LOW
d) duration ← pulseIN(Echo,HIGH)
e) distance ← (duration/2) / 29.1
f) motor ← 200 - distance*2
g) delay(500)
h) motor ← 0

As per algorithm the value given to motor increases proportionally to the decreasing distance.

b. Navigation with audio feedback

To provide blind user his own choice of getting feedbacks, we provide an Audio Feedback mechanism which gets activated when a normal 3.5 mm jack is plugged into the device. When the audio jack is plugged in the haptic feedback part gets turned off automatically. The schematic diagram is given as below.

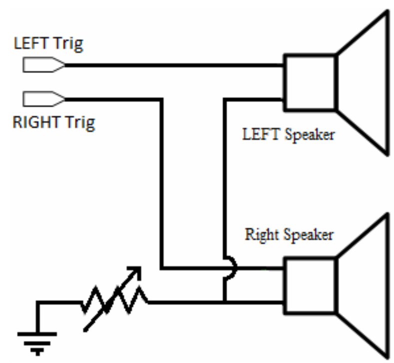

Figure-4. Audio feedback mechanism.

We use different intensities of beeps with different time delays to warn user of approaching obstacles. The volume can be controlled using the potentiometer. The algorithm for left sided audio feedback is given below:

a) get ‘distance’ using ultrasound
b) left_audio ← distance*2
c) delay(distance*3)
d) left_audio ← 0

As per algorithm the frequency of vibrations as well as tones increases with decreasing distances. The delay () function gives small counts for smaller distance values.

c. Time information

The 3 motors provided in belt can be used to indicate time to the user. A push button is dedicated for this purpose. The mechanism for a push button is shown in the diagram below.

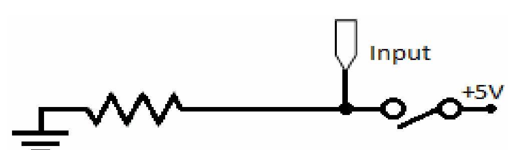

Figure-5. Switch mechanism.

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As the button is pressed the current time is converted into more suitable form so that it can be communicated via 3 motors.

The motors assigned to time are as shown in diagram below.

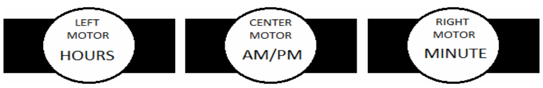

Figure-6. Time information mechanism.

Now the algorithm for time information is given below:

a) hr ← hour()
b) mi ← minute()
c) if mi between 8 and 22
   flag1 ← 2
d) if mi between 23 and 37
   flag1 ← 3
e) if mi between 38 and 52
   flag1 ← 4
f) if mi between 53 and 59
   flag1 ← 1
   hr ← hr+1
g) else
   flag ← 1
h) if hr> 12
   hr ← hr - 12
   flag ← 2
i) do i ← 1 to hr // hours count
   left_motor ← 200
   delay (100)
   left_motor ← 0
   delay (500)
j) do i ← 1 to flag // AM/PM
   mid_motor ← 200
   delay (100)
   mid_motor ← 0
   delay (500)
k) do i ← 1 to flag1 // minutes count
   right_motor ← 200
   delay (100)
   right_motor ← 0
   delay (500)

As per algorithm it's clearly observed that the left motor vibrates for count equivalent to the hours count. The center motors ticks 1 for AM and twice for PM. The right motor gives information of quarter of an hour as per below Table.

Table-1. Table for clicks of motor to show minutes.

Time range	Right motor clicks
8min to 22 min	2
23min to 37 min	3
38min to 52 min	4
53min to 7min	1

When time is greater than 53 min the hour is incremented by one, i.e. if time is 10:45AM then it will be considered as 11:00AM, so the left motor ticks 11, the center ticks 1 (for AM) and the right motor once indicating 0 min.

d. Remote patient monitoring

Blind people are often helpless when special care is needed.

The advancement in health facilities have introduced the concept of RPM (Remote Patient Monitoring) to enable monitoring of patients outside of conventional clinical settings and improve independence of older adults. Remote Patient Monitoring (RPM) refers to a wide variety of technologies designed to manage and monitor a range of health conditions. Point-of-care monitoring devices, such as weight scales, glucometers, implantable cardioverter-defibrillators, and blood pressure monitors, may individually collect and report health data.

In our proposed prototype, to monitor the temperature of patient we use a temperature sensor which touches the skin of blind to constantly read temp and sends the readings to the serial connection.

For developing the prototype we used a PC connected to the hardware via serial board. We then used a PHP file to scan the connected port and retrieve the temperature values. We then save these values in a local database and using local network we project these values using another PHP file. Any mobile device connected to this network can be used to view these temperature readings.

In real case scenario a Bluetooth shield can be used to send values to a Bluetooth enabled mobile phone with internet connection. The phone with proper application can be used to write these values to a server which can be retrieved anywhere.

The connections of Temperature sensor are depicted below.

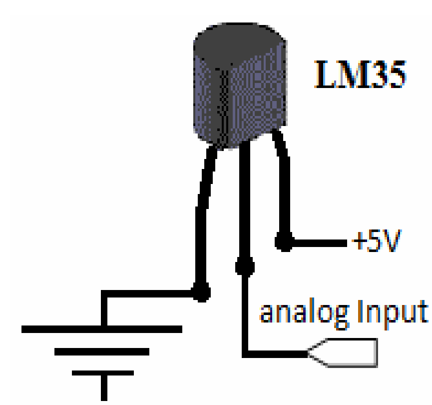

Figure-7. Temperature sensing.

The center pin gives the value of temperature read by LM35 sensor.

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e. Emergency calling

A blind person often finds himself stuck in critical situations. Asking for help sometimes becomes very difficult. RPM- integrated systems provide alerts when health conditions decline, allowing patients, caregivers, and clinicians to intervene and modify treatment plans as needed.

As a solution, we provide an additional switch in our proposed prototype for emergency calling. The system continuously sends the status of switch on the serial line which is scanned by PHP file. When switch is open the system writes 'N' on serial line which when read by PHP is completely ignored.

When the switch is closed the system writes 'W' on serial line. When PHP file receives this 'W' character it sets the emergency signal ON in the database. The user monitoring the blind receives an immediate notification about emergency which he/she can turn off just by clicking on mobile phone.

5. TESTCASES

The following table depicts some of the test cases along with expected and actual results.

Table-2. Test cases.

S. No.	Test case	Expected outcome	Actual outcome
1	Object between 90cm to 100cm	Object sided motor vibrates slowly	Object sided motor vibrates slowly
2	Object between 0 to 10cm	Object sided motor vibrates vigorously	Object sided motor vibrates vigorously
3	Object between 90cm to 100cm with headphones plugged in	Slow beeps in headphones according to direction.	Slow beeps in headphones according to direction.
4	Object between 0cm to 10cm with headphones plugged in	Fast beeps in headphones according to direction.	Fast beeps in headphones according to direction.
5	Time button pressed at 10:25AM	Left motor with 10 spins, Center with 1 spin and right with 3 spins	Left motor with 10 spins, Center with 1 spin and right with 3 spins
6	Time button pressed at 2:55PM	Left motor with 3 spins, Center motor with 2 spins and right motor with 1 spin.	Left motor with 3 spins, Center motor with 2 spins and right motor with 1 spin.
7	Mobile user checks for temperature	Current body temperature on mobile device	Current body temperature on mobile device
8	User presses emergency button	Emergency alert on mobile device	Emergency alert on mobile device

6. RESULTS

The Haptic feedback mechanisms helped in easy navigation of blind person. The head mounted unit helped in avoiding collisions such as low door entrance etc. The hand unit can be used as directional scan.

A prototype with three side distance monitoring is depicted as below.

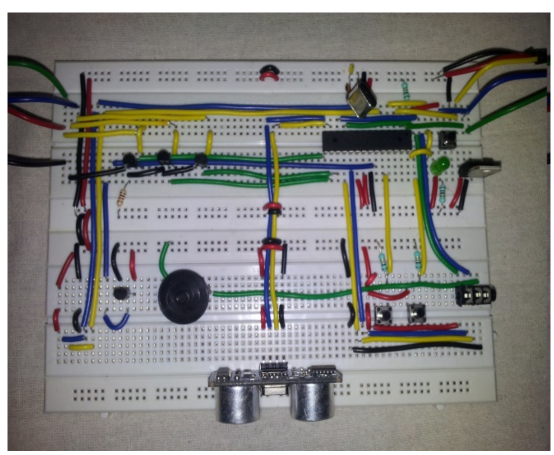

Figure-8. Processing unit and Ultrasound connections.

The ultrasound is attached only to the central part. It can be placed on left and right sides also.

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The haptic feedback mechanism is shown in figure below. It contains 3 motors, each for providing left, center and right side vibrations.

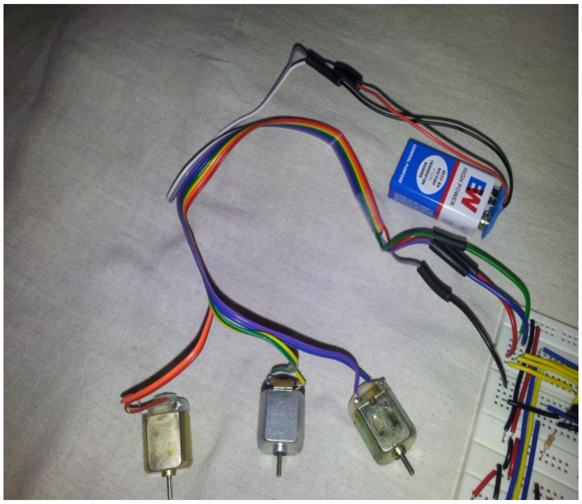

Figure-9. Vibration feedback mechanism.

These motors are driven by separate 9V batteries for more intense vibrations.

The audio feedback mechanism can be used just by connecting a standard 3.5mm jack into the socket provided on the board. Once the audio jack is plugged in the vibration part goes OFF. The working of audio part is similar to vibrations; it's just that the intensity of sound varies with distances. The audio jack can be plugged in as shown below.

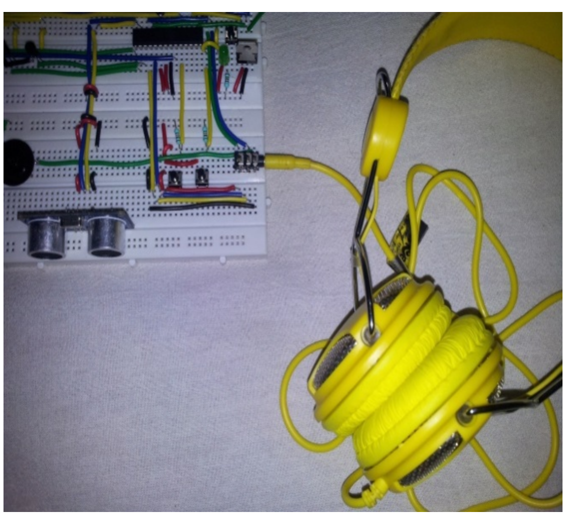

Figure-10. Audio feedback mechanism.

The black circled unit is a potentiometer that can be used to turn down the volume of the headsets.

The Serial communication can be achieved with the help of serial board connected to a PC via USB. The prototype connections are as shown below.

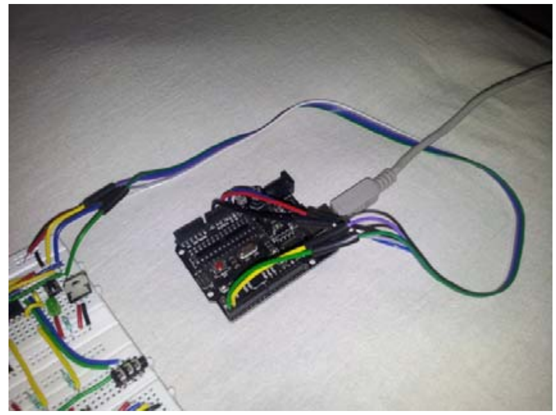

Figure-11. Serial communication unit.

There are two switches one for each time information and another for sending emergency signals.

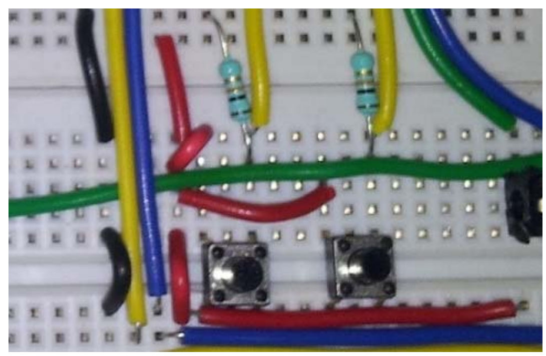

Figure-12. Switches for emergency and time.

The right switch is for time-telling and the left one is for making emergency calls.

Finally, the patient monitoring system consists of temperature sensor.

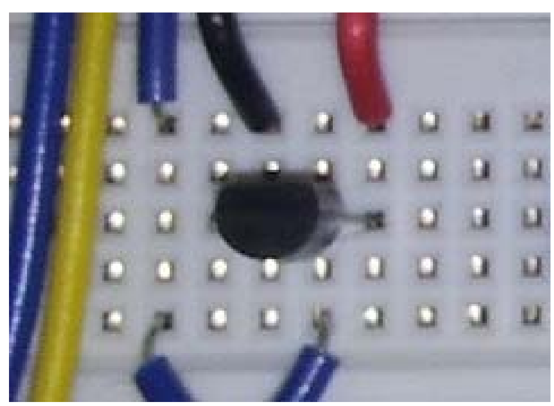

Figure-13. Temperature sensing LM35.

Once the system is live and a mobile phone is connected to the network, the temperature of the sensor can be seen on the mobile as depicted in the following screenshot of mobile.

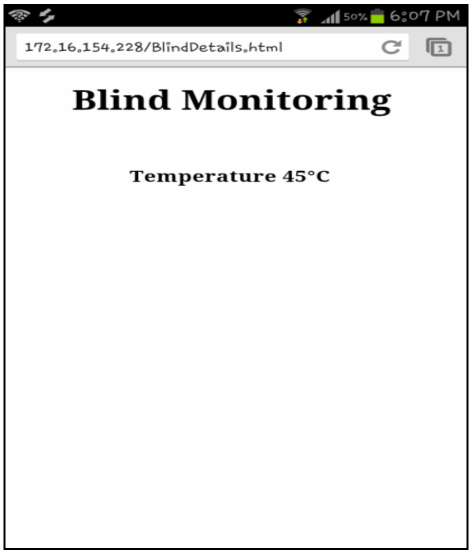

Figure-14. Temperature on mobile device.

The mobile at this time does not show any emergency notification. Once the left button is pressed by the user, the state of mobile page changes as shown below signaling for emergency:

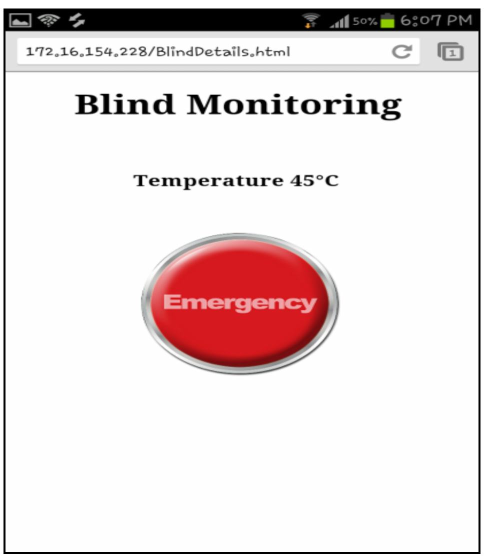

Figure-15. Emergency signal being displayed.

7. CONCLUSIONS

For the blind, hearing and touch become the first and second major senses, respectively. This paper presents a wearable prototype solution to the problems in mobility and spatial navigation by providing auditory and tactile feedback to compensate for visual information. Users were able to detect obstacles much before coming in contact with them. Also, certain Patient monitoring features like time-telling, temperature sensing and Emergency button were introduced for the ease of visually impaired person.

8. FUTURE WORK

Future work will concentrate on improving the performance of the prototype model. Main issues of concern would be: Sensory overload, long learning/training time in mastering the system and to reduce the interference of auditory feedback with the blind person's ability to pick up environmental cues.

Major technical advancements will be introducing natural voice for telling time on the connected headphones, as well as providing collision objects description. The emergency calling can include GPS system so that current location of the person wearing the unit is also received by the mobile tracker. With the current system much additional functionality such as electronic gadget's controlling can also be introduced.

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