Human bodysuit with color sensing for the Visually Impaired

Md. Khwaja Muinuddin Chisti, R. Koteswararao naik, B. Suribabu Naick, Sunanda Veganti, Lanke Pream Chandu

Abstract*: *In this paper, a navigational aid for blind people is developed as a suite with the handwear module, which makes use of ARM LPC 2148 microcontroller board with ultrasonic serial ASCII sensors and tappers for collision avoidance and a provision for primary-colored objects detection. The user is alerted with tapping mechanism and synthetic voice feedback to guide the navigation. The user is also provided with buttons for switching on the Left and Right-hand wear sensors and sensing primary colors. The user can also turn on and off the GPS and GSM modules, which gives the location of the user through a message to any preloaded number for assisting. Thus the proposed handware module helps the blind people to navigate outdoor and can differentiate primary colored objects that helps user in segregating daily household objects, appliance, clothes, etc. The paper also gives an idea of possible additional provisions to the jacket are explored.

***Keywords*: Navigation, Tappers, Ultrasonic sensor, GSM and GPS modules.**

I. INTRODUCTION

The provision of navigational aids to the visually impaired is increasingly becoming a major priority. Much technological research has been focused on giving the impaired population sufficient and reliable aids in helping them to navigate. The modern landscape, both urban and rural, is filled with a cluster of buildings and obstacles, with myriad pathways, that throw challenges even to those with a good sight. The navigation of the visually impaired would, therefore, require such technology, which combines both obstacle detection and location sensing. This can be achieved by using ultrasonic sensors positioned at different locations over the body wear, and by using them along with navigational devices like GPS, a reliable method for the visually impaired can be devised. The developed system can easily plug with additional interfacing devices.

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* Correspondence Author
Md Khwaja Muinuddin Chisti*, EECE Dept, GITAM University(GU), Vishakhapatnam, India. Email: chisti@ieee.org
R. Koteswararao naik, EECE Department, GU, Visakhapatnam, India. Email: koteswararao.ramavathu@gitam.edu
B. Suribabu naick, EECE Department, GU, Vishakhapatnam, India. Email:suribabunaik.bhukya@gitam.edu
Sunanda Veganti, EECE Dept, GU, Vishakhapatnam, Email: sunandaveganti999@gmail.com
Lanke Pream Chandu, EECE Department, GU, India. Email: preamchandulanke@gitam.edu

II. RELATED WORKS

This paper explores the project to assist such visually impaired people. The proposed equipment made of a microcontroller with voice output. There is a number of researchers working to help visually inspired people in different ways. The best way is that it should be user-friendly and portable. The few related works that published. White Canes [1] are the most popular aids used for navigation by the blind. But the disadvantage is that the stick has to be constantly moved to and fro, to get an idea about the terrain of the land being navigated. Another disadvantage is that there is no possibility to identify the objects at ground level like ditches, thereby causing unwanted accidents.

Other solutions are portable wear to the user for decision making[2][3]. In an emergency, integrating GPS technology, users can be located with their relatives[4]. By using software like MATLAB and aurdino tools for guidance, the visually impaired can easily detect the obstacles[5]. The detection of an object using a normal stick is a little difficult. So, by using an ultrasonic sensor implemented with raspberry pi 3 models [6] or an Arduino-Nano single-chip microcomputer with ultrasonic sensor, Bluetooth & speaker modules for obstacle detection and alarm[7]. Ultrasonic sensors present in the jacket will warn the person with a buzzer and vibrators[8]. Not only detecting the obstacles, clothes and their colours can be detected by a camera with the help of the CCNY Clothing Pattern dataset [9]. An intelligent electronic navigational aid to assist the user is proposed by Barbu[10] et al., An indoor navigational aid for visually impaired users to navigate in a given environment [11] and other related works[12][13].

The disadvantage of these systems is the use of vibrators as an alerting mechanism. These vibrators placed on the body parts can cause side effects like leading to heart attack, interruption to the normal blood circulation, damage to the neural system, …etc. Having a camera and carrying it along with the system is difficult for the user.

A safe and vibrations free, color sensing sensors with a portable system are developed which makes use of the serial ASCII output ultrasonic sensors, tappers & voice feedback, GPS and GSM modules and LPC board. By using the system the user can move through the obstacles without any collisions, independently. The functionality of the developed system is discussed in section III.

III. PROPOSED HUMAN BODYSUIT

The human bodysuit consists of two independent modules namely Jacket and hand-wear. The developed navigational system is placed across this suit. The components used for the construction of the suit are as shown in Fig. 1. This section describes the importance of each module that is used for the implementation of the proposed system.

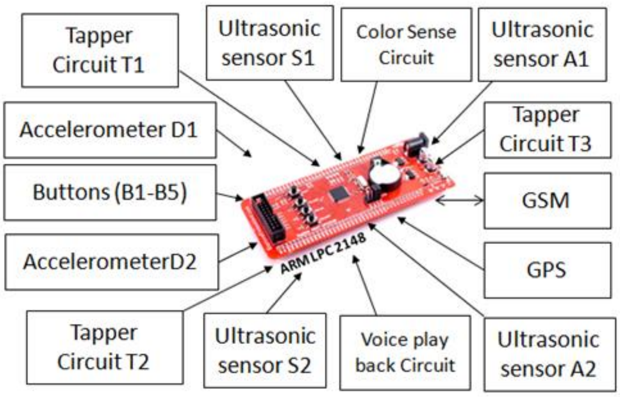

Fig. 1. Block diagram of the proposed suit and its components used

A. Jacket module

The Jacket module consists of the entire component assembly that would be worn by the user with the jacket part of the suit. The details of the components involved are given below:

- *Ultrasonic Sensors*:

There would be two ultrasonic serial ASCII sensors, which would be placed on the shoulders of the user. The device is good for short-range obstacle detection. This can measure the accurate distance of 0.02-4m. The data output of the sensor is from RXD which is serial ASCII [14]. The ASCII value so returned would be used to activate the appropriate vibrators, and also to synthesize a voice output, so that the user can hear the details of the obstacles.

- *Tappers:*

The suit employs the use of a tapping mechanism, which is much more advantageous over vibrator usage. Scientific research has shown that long term exposure to vibrations in a particular region would lead to a possible permanent dysfunction of the neural system present in that part of the body [15]. To counter this, tapping mechanism has opted for the Suit.

The proposed system is designed with the tapping mechanism as shown in Fig. 2. This PCB would have the necessary circuitry to drive the tapping motor, according to the output of the ultrasonic ASCII serial sensors connected to the microcontroller circuit board. This circuit alters the supply to the motor according to the ASCII feed given. The variation in supply to the motor would cause for different frequencies of tapping. A slower tap would need lesser supply, and so on. This is done by driving the tapper with appropriate PWM waveforms [16].

Fig. 2. Proposed bar tapper to alert the user

This paper proposes three different tapping speeds so that the user can be alerted accordingly. The distances considered for tapping the user associated with the suit are given in Table I.

Table- I: Distance considerations for Tapping

Speed	The distance of the obstacle
Slow-Tap	60 cm
Medium-Tap	45 cm
Fast-Tap	30 cm

The tapping mechanism used in this project is a 4 bar mechanism, a modification of [17], which consists of 4 bars, with the central control as a motor. The 4 bar mechanism is a very popular method employed in many devices that require tapping as a primary function.

- *Jacket Microcontroller circuit:*

This circuit consists of ARM LPC2148 microcontroller interfaced with ultrasonic sensor, tappers, voice module, GPS and GSM modules [18] for necessary functioning as shown in Figure 1.

- *GPS and GSM modules:*

Both modules work hand in hand. The GPS is a pretty well-established mechanism, which is being regularly implemented in many day to day applications [19]. The GPS module used in the Jacket crucial in locating the user, thereby giving the person a sense of security, as there can be someone who always knows the location of the user. Module outputs an SMS via GSM as location measures to the pre-programmed number, which could belong to the person who assists the user in case of an emergency [20]. In this case, it is the only transmission of a text message. The user is provided with a single touch button to make or receive voice calls as and when required. The component used for this project is SIM900 and GPS modem.

- *Voice module:*

The Ultrasonic module gives the distance of the obstacle. By using the microcontroller we will get the signals and computes the signal and gets the and appropriate voice signal is triggered as an output which is conveyed to the user Voice module is used to alert the user. It receives the commands from the controller and the same is conveyed to the user to make him alert. The voice module in Fig. 3 is used in the system is ISD1760.

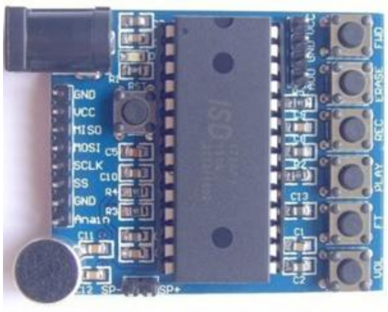

Fig. 3. Voice module with voice feedback

B. Handwear module

The Handwear module mainly consists color sensing and obstacle detecting circuit to aid navigation. The fore fingertip of the right-hand glove is fabricated with color sensing circuit as shown in Fig. 4. This enables the users to sense the primary-colored objects, clothes, and other articles. The obstacle detecting circuit consists of ultrasonic sensors with the accelerometer ADXL345. This enables the user to detect obstacles in all four directions. These hand ware modules are integrated via wires to the central microcontroller board.

In crossing the roads and/or walking, it's the inner sense that makes the users take these steps behind. This handwear module ensures a fearless walk by the user having known the digs and obstacles in this way.

The user activates the detecting circuit using the push button attached to hand gloves. Then the distance of the obstacle is read and depending on it appropriate tapping is done. The accelerometer/gyro helps to detect the direction in which the user wants to detect the obstacle. In the downward direction, if the distance from the ultrasonic sensor (d2) is greater than the preconfigured distance (d1) than appropriate tapping is done depending on the differences in distance.

(a) (b)

Fig. 4. Top view of Hand gloves modules

(a) Right-hand wear module with Color sensing
(b) Left-Hand wear Module

IV. PSEUDO ALGORITHM AND FLOW CHART OF THE PROPOSED SYSTEM

A flowchart depicting the proposed method is shown in Fig. 8. The user is provided with an array of options, to communicate during distress with a phone number that is preprogrammed in the Jacket microcontroller circuit. A suitable user interface is provided to select options. This interface consists of buttons, which are used for sending the location coordinates via the GSM module [21]. An additional button can allow making calls.

Initially, the user is given requisite training to use the jacket with sufficient ease. Also, a provision to change pre-programmed number with additional keypad.

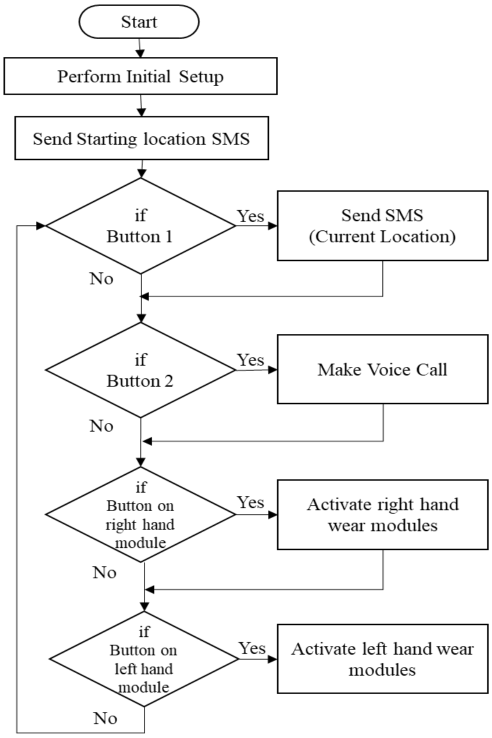

Fig. 8. Flowchart of proposed system software design

After the user is ready to move out independently, the setup can be switched ON, using the power buttons provided. This would trigger an SMS to the predefined number, which contains the details of the starting location. Therefore, another person can know when the user left the place.

The user is provided with a keypad that facilitates the storing of numbers and giving commands to the interface. There would be number keys from 0 to 9, which the user can use to store the contact details in the memory.

This keyboard also contains two buttons, one to allow the user to send an SMS, and another button to make a voice call. Either can be done to a number that is predefined. This feature can help the user to immediately call for any help if required. The designed Jacket is shown in Figure 9.

Some of the possible extensions to this interface have been proposed in section VI of the paper.

This process is quite fast, and it happens within the time frame of a few milliseconds, thereby giving the user full leverage in safely navigating through a labyrinth of obstacles.

Fig. 9: Bar tapper Ultrasonic sensors on both shoulders of the jacket.

A. Pseudo Algorithm:

Step1: Initial setup on power on. Check for user input for setup changes if yes go to step 2 not continue to step3.
Step2: Read the input from the keypad and update the user assistant number, d1, d2, and d3 distances.
Step 3: Send the starting location as SMS to the predefined number set in step 1.
Step 4: Check the button inputs user interface.
if button1 ON send the current location to predefine number
if button2 ON make a call for an assistant.
if button3 ON activates right-hand glove ad detect the obstacle and send voice feedback in case of obstacle and turn on PWM tapping.
if button4 ON activates left-hand glove ad detect the obstacle and send voice feedback in case of obstacle and turn on PWM tapping.
Step 5: Repeat the process

B. Low-cost color Sensor

A color Sensor is developed in the laboratory with cost-effective components like resistors, LDRs, RGB LED's and tested. This sensor is an accurate and low-cost circuit than the commercially available color sensor available in the market.

V. RESULT ANALYSIS

The design of the custom color sensor, its circuitry, and various case studies are presented in this section. For easy understanding, pictorial representation of the case studies is used.

The schematic diagram of the color sensor is shown in Fig. 10. Its working is very simple, firstly using the program blink each of the RGB LEDs. Record the amount of light is reflected on the LDR and voltage drop against the LDR is noted down, the experiment is repeated by changing resistor values to have the distinguished voltage drop against the each of the color. Results show that 330 ohms resistor for red led, 150 ohms resistor for blue led and 220 ohms resistor for green led shows the distinguished voltage drop which can be used to detect the RGB colors.

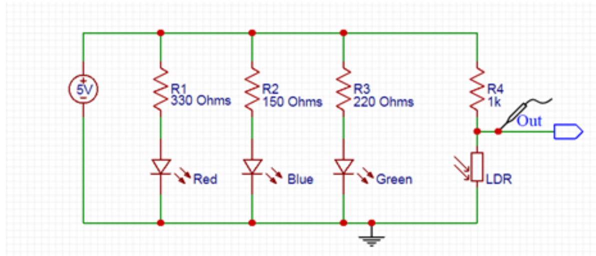

Fig. 10. Circuit diagram of color sensor Investigation

Table- II: Results of LDR output for color detection

Color Detection	LDR output Potential
RED	0V to 1.8V
BLUE	2.0V to 2.6V
GREEN	3.5V and above

With the specified resistor values the volage variation observed and programmed for the color detection is shown in Table II.

The human body suit system is tested against a person of 5ft 4 inches who is shown in figures picture. For dig detection, distance d1 representing the distance between the hand glove and the normal dig free ground surface is fixed to 65 cm and from there on any distance more than 8cm is considered as dig that jerks the human body i.e d2 = 65+8 =73 cm and the same way any obstacle whos distance less than 60cm is considered as for bulge/speed-breakers/ abnormal.

Table- III: Output readings of accelerometer/gyro for finding the direction of the glove.

Gloves Direction	X-axis_angle	Y-axis_angle	Z-axis _angle
Front	<0.1	>0.5	>0.2
Right	>0.5	<0.1	>0.2
Down	>0.2	>0.2	<0.1
Left	<0.2	>0.1	<0.5

Fig. 5, Fig. 6, and Fig. 7 shows the positions of sensors and the direction of obstacle detection. Table III shows the output values of the accelerometer used for the user to identify the direction of the inclination of the glove which helps in giving voice feedback.

Case I: As shown in Fig. 5 the hand gloves are used to detect the obstacle on the left side and right side with the use of the respective glove button ON. Audio feedback is sent to the user with the direction of the obstacle using the gyro sensor.

Case II: As shown in Fig. 6 the hand glove is used to detect the step as well a dig with the specified d1, d2 and d3 distances for the user.

Case III: hand gloves are used to detect speed breakers, bulges on his road.

Case IV: As shown in Fig. 7 the hand glove to detect an obstacle in the forward direction.

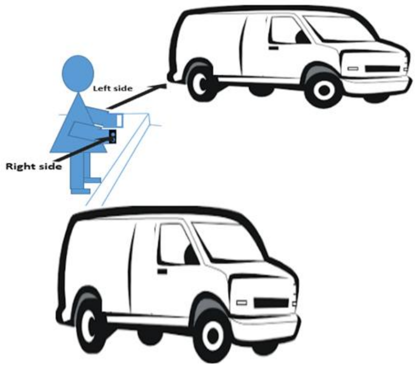

Fig. 5. Sensor detection to detect obstacles in left and right directions

Fig. 6. Sensor detection to detect digs/holes in downward direction (d2>d1)

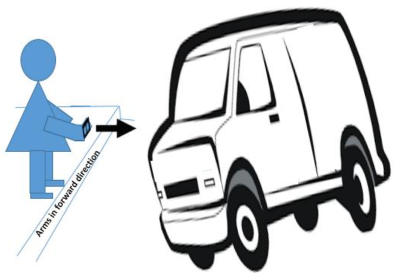

Fig. 7. Sensor detection to detect obstacles in front direction (d2>d1).

Fig. 8 Shows the logged data of the ultrasonic sensor that alerted the user in his path for about 100 meters walk where the user is let to go through different case studies with digs and bulges. Reading is displayed by taking the moving average. The discontinuity in the distance shows that there is no obstacle in the user way.

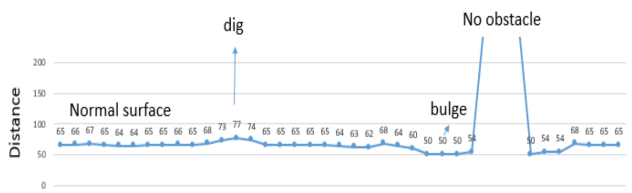

Fig. 8. Ultrasonic sensor output indicating different cases like dig, bulge, normal and abnormal surfaces.

VI. POSSIBLE EXTENSIONS

Before the aforementioned navigational jacket is equipped well enough as it is, to let the user go completely independent of any external aid. Though it has not been included in the current project, a few possible extensions are proposed herewith, to enhance the aid received.

- Instead of using a keypad we can include tactile touch mechanism so as to make the process of typing numbers completely independent. The tactile touch circuitry can be easily fabricated onto a piece of foldable plastic, which is attached to the tip of the fingers. This, combined with the synthetic voice feedback mechanism can help the user to identify the number he is pressing, therefore enabling him to do it without hesitation.
- Instead of buttons to make or receive calls, if a voice recognition software drive is included with the jacket, he can send a message or call someone just with a single voice command. Another advantage of this can be that the use of a keypad can be minimized, to a great extent, if sufficient training is given to the user, in dealing with voice commands.

In effect, the above extensions can be effectively used so that there would be no trouble faced by the user in handling the jacket. But in the end, all that matters is sufficient training to the user, to make efficient use of the jacket.

VII. CONCLUSION

A safe and portable bodysuit is designed and implemented to detect obstacles and give warnings or indications. To make a bio-safe, a tapping mechanism with voice alert wear helped the blind to navigate in a closed environment and in the outdoor. Color sensor circuit is designed to give different output voltages to the primary colors that helps in segregating objects. In the results section, it is clearly shown that ultrasonic senor output for various cases like dig, bulge, normal and abnormal is different and helps in detecting obstacles. The feedback from the user is that the device is handy and good for him/her to carry it as primitive wear, which helped him/her to feel the presence and absence of the obstacles in his way.

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AUTHORS PROFILE

Md. Khwaja Muinuddin Chisti, presently working as Assistant Professor in EECE, GU Vishakhapatnam. He is pursuing his Ph.D. in the area of Digital Image processing and Embedded Systems from JNTU Kakinada. He studied his Masters from Andhra University, Visakhapatnam. His research areas are Image processing, Embedded Systems, and Signal Processing, ML, Deep Learning.

Koteswararao naik R. presently working as Asst. Prof. in EECE, GU, Vishakhapatnam. He is pursuing his Ph.D. in the area of Radar Signal Processing GITAM. He studied his Masters from Andhra University, Visakhapatnam. His research areas are Signal processing, Digital System Design.

B. Suribabu naick presently working as Asst. Prof. in EECE, GU, Vishakhapatnam. He is received his Ph.D. in the area of Signal Processing, Andhra University. He studied his Masters from Andhra University, Visakhapatnam. His research areas are Signal processing and AI.

Veganti Sunanda, studying BTech final year, Electronics and Communication department. Her interested areas are embedded systems, and image processing.

Prem Chandhu Lanke, studying B.Tech final year, Electronics and Communication. His interested areas are embedded systems, and image processing