Smart Guidance System for Blind with Wireless Voice Playback

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Abstract. The visually impaired/blind people face many challenges and seeks help from the other people even for their daily routine life due to various complications. Also, they could not go independently outside, even for their basic needs and mentally depressed due to their current inability. A wearable navigation system/device is proposed and developed to help the blind people as well as the partially blind people or challenged people. The devised unit/prototype consists of the displacement measuring sensor for the detection of the obstacles and depth. The data received from the IR and Ultrasonic sensor is feed into the Arduino UNO Microcontroller and it is processed. The output from the controller is given to the impaired people through the wireless voice playback modem, to alert them when they found obstacle or collision. The receiver end receives the corresponding current position values through the navigation systems and the static, dynamic condition of the impaired people is measured using mems accelerometer and the same information (latitude, longitude) is shared as SMS to their family members or guardian to monitor them, during any emergency. The proposed guidance cane is a cheap, simple, user friendly and smart device.

Keywords: Visually impaired - Arduino - accelerometer- voice playback – latitude-longitude.

1. Introduction
All people are equal before nature and world but due to various reasons like birth disabilities, accidents, poor nutrition some people lost their eyesight or partially blind. The percentage of vision blindness is more in developing countries and under development countries when compared to developed countries. Also, childhood blindness is crucial, and those children should be given their basic rights and claims to live in the world. So, considering the overall difficulties and social movement of these people, the researchers tried out many research ideas and model to help them with the most priority of findings. Visually impaired people are those who cannot be able to identify the things which is near to them. In this case they seek help from the family members, and they need special care. Family members need to spend more time with them to do their daily activities and for family members to do the personal work, is an additional burden. The blind people hesitate to come out, but they have lot of talents when compared to others. As part of our society, responsibilities should be given to normal people, to help them to explore their knowledge. In olden days, the dogs were used to guide them while travelling. Now the technology has grown, and lot of instruments have
been invented for guidance purpose. It is a low-cost instrument, and it is user friendly for both visually challenged people and for family members.

Visually impaired people need some aiding devices related to the blindness disorders. Out of 100 people, 10 people are having poor eyesight and eye related complications. They are also finding hard to walk on their own safely, to do their own needy works, without others help [9]. To solve such kind of issues, the smart devices are designed. The visually impaired people are facing many difficulties while comparing to others and the family members also facing difficulties to monitor them. Now-a-days the visually impaired people are proving their talents in various fields. The impaired people are also a part of our society so, we have some responsibility and contribution to make their life happy in this world. By the contribution of many peoples, the following devices are found namely Sound based or Sonar instruments[10]. Walking cane which smart decisions and reporting [11]. Intelligent observation/ vision systems [12], walking/governing stick [13], These devices use the displacement findings technique for detecting the hurdles and barriers around their surroundings by considering all the distance parameters. Most of the situations, the depth of the position of particular location on their pathway is used by sending and receiving the ultrasonic waves Thus location could be precisely measured and the same can be transferred to their attendees when they are in needy circumstances. Systems like VOICE [14], Sound View [15], SVETA [16] and CASBLIP [10] are also developed due to research advancement in this area. The basic operation of above units is explained below. The images are captured by the single camera and it is processed and converted into audio message and it is transferred to impaired people. This audio messages will really help these to find out their whereabouts.

There are many challenges and difficulties faced by the impaired people and all cannot be listed here. But the research findings and models are trying to fulfil the needy people at least for their basic support to do their work independently without others help. There are some difficulties in detecting the obstacles such as downward stairs, holes are hidden but they are dangerous to the blind people. Usually vibration or sound signals are coming out as the feedback information. Many devices are invented using the principle of sound, frequency, and vibration and those are gaining importance in recent years. Any accidents or hit can be sensed by the particular sensors attached to their smart devices or cane with the help of the change in frequency or disturbances/vibrations. So, the Smart Guidance System is proposed to overcome the disadvantages. The format of the paper is as follows with the following contents. First division of the contents is introduction and second one is literature survey which explained the various contributions related to Smart Guidance System for Blind, third division dealt with the presented methodology which consists of all basic to important components. In fourth division outputs and explanation are narrated and finally future works and conclusion are explained.

2. Literature Survey
In [1], the authors proposed a blind stick for visually impaired people for navigation. They designed the system and implemented the same in the smart pole for proper hurdles identification and path finding purposes. The ultrasonic sensor is used for detection of obstacle and the buzzer is used for alert. The system is used for limited distance and the visually challenged person can locate only with that limited area. Also, the stick provides the personal independence to the impaired people. In [2], they developed a cheap, user friendly smart blind guidance system and used for the mobility of visually challenged people in the limited distance. Infrared sensing element is utilized to measure the reflected range by the barrier. The reflected range and overall system are controlled with the microcontroller. Effective smart stick for Blind people [3], is developed using infrared sensor to detect the up and down movement in the stairs. Sensing element using ultrasonics is meant for obstacle detection and the overall system is controlled by microcontroller. The entire integrated system is wired, and the future scope may be extended for wireless.

Ultrasonic Blind walking Stick [4], is developed using Ultrasonic sensor. The main aim of this instrument is to overcome the disadvantages of traditional stick. The ultrasonic sensing element is
utilized to sense the obstacle present in sight of visually impaired individual. This device can sense accurately the slopes, up and down places. This blind stick can detect the hindrances and hurdles especially when the impaired people walking alone in the higher sloppy regions by their own. Mishra and Koley [5] developed a very low-cost equipment to find the location and whereabouts of the sight affected or blind person. The aim is to completely minimize the use of the guide for path finding of the location for the vision weaken person in remote area and to develop the low-cost equipment. GPS tracking system is used for location information and the ultrasonic sensor for the obstacle detection. The system also incorporated a voice-based system communication protocols for transmission and reception of data.

In [6], the authors developed an electronic traveller aid for visually blind people. The above system consist of single board processing system. In this kit the author capture the image which is in front of blind and it is processed by the Fuzzy clustering algorithms as real time images and it is transferred to blind people with help of stereo earphones the image processed and result is given as stereo sounds. The system is based on the various image processing steps which automatically locate the position and location which is based on the intelligent decision-making techniques namely fuzzy logic systems. Smart Stick for Blind People [7], is proposed and the same is used to change the lifestyle of sight affected population. In this system the ultrasonic sensing element is utilized to identify the barrier and Arduino uno is used as microcontroller. The location tracking is implemented in the system to track the visually impaired people by the family members it is particularly useful to monitor them.

Many methods and devices are proposed and implemented by the researchers in helping the visually challenged people, still it is open for more findings and developments due to the latest technological developments. A day today survey is really required from those people to find their difficulties, pain and struggles to march further in this findings and developments. One of the recent and notable development in this smart guidance system is Indriya meaning an organ, which is a handheld small device or companion for the blind people. AI technologies are also incorporated in recent development of products for visually impaired. One important product may be considered is the AI glasses which incorporates intelligent techniques for location finding and hindrance identification and it is a real aid or friend to the blind people. A small attempt is made to fulfil the basic needs and requirements of the visually challenged people is reported in the presented method.

3. Proposed System
In the proposed methodology, the Smart guidance system is designed using the Arduino uno microcontroller to process the input data. The MEMS accelerometer gives its output in all three coordinates for any roll off or of normal motion of the people under investigation. This accelerometer collects the data in three axes and combined with obstacle detection parameter values, decision is taken based on the optimum values. A predefined roll off or normal motion of the people is fed as the reference values. When these optimum values are exceeded both in the case of accelerometer or vibration sensor, or due to the combined effect of both, the controller will transmit the necessary instruction and information. The ultrasonic sensor detects the obstacle and the depth of the route or pathway and it is given as an input to the Arduino uno microcontroller and the given data are processed and the output is given to the impaired people through the wireless voice playback modem. The wireless voice playback is used for the internal communication between the device and the impaired people. The GPRS identify the position and the location of the people by longitude and latitudinal basis. A proper internal power supply unit is also built upon in the device to energise the same. Safety precautions and limit of power supply is optimized for biomedical applications. The overall working flow of the presented methodology is manifested in Figure 1.

The proposed methodology is followed by hardware and software descriptions. The following section explains about the hardware components and their specifications involved in the proposed system. The most important components are MEMs accelerometer, Ultrasonic sensor, GSM module, Arduino Controller etc.
3.1. MEMS Accelerometer
The structural representation namely the functional blocks of MEMS accelerometer is manifested in Figure 2. In the proposed system the MEMS accelerometer is used to find the static and dynamic position of the impaired people.

The MEMS accelerometer is electromechanical component, which is used to find the motion. The input of the MEMS accelerometer is mechanical moving, and the corresponding output is in the form of 3D graphical representation. The output of the MEMS accelerometer is sent to their family members via the GSM modem whether the impaired people in the static or dynamic position. MEMS accelerometer used is the 3-axis sensor because it measures the motion of the object in all the three co-ordinates and shows the output in only one axis. MEMS accelerometer is electromechanical component it is also used as vibration sensor. The MEMS accelerometer is used to measure both static
and the dynamic motion of the person. If the person is moving, the corresponding movement is shown in the X-axis as variation. The accuracy rate of accelerometer is remarkably high.

3.2. Ultrasonic Sensing Element
The operation of ultrasonic sensing element is shown in the Figure 3. The ultrasonic sensing element is utilized to recognize the obstacle, disturbances, holes, and cavities on the road while making the movements. The sensor has better accuracy with respects to obstacle detection.

![Figure 3. Ultrasonic Sensor](image)

The short and high frequency sound waves is emitted by the ultrasonic sensor and it fall on the obstacle and it reflect as the echo signals to the receiver end sensor. The distance is calculated based on the time duration between the emitting and receiving of the echo signal. The ultrasonic sensor detects the cavity in the road and the distance range of the obstacle, and it is transmitted to the microcontroller. The output is processed, and the information is sent to the visually impaired person through wireless communication. The distance covered is between 2 cm to 4 m for finding the obstacles. This ultrasonic sensor basic principle is utilized in many smart guidance systems because of its simplicity in operation and able to detect the obstacles and hurdles well in advance to avoid the collision or fall off during movements.

3.3. Standard Mobile communications System part
Standard global mobile communication system shortly called as GSM part projects and works with a standard range of frequency extending from 850 MHz to 1900 MHz. Via GPS module the GSM module send the location information as message to the family members or to the guardian. This module part is very small and able to accommodate with in a small space in the user application devices like smart mobile sets, tablets, smart watches etc.

3.4 ZIGBEE
Zigbee is used to transfer the data from MP3 module to the visually impaired people. The high-level protocols communication used by ZIGBEE is formulated from IEEE802.1 which is the IEEE standard for WPAN. It is the abbreviation for Wireless Personal Area Networks. For the device which requires the wireless network, ZIGBEE is easily designed and used for short personal distance. ZIGBEE supports the transfer of data coming from the sensor at the rate of 250 kbps. ZIGBEE can operate at various frequencies such as 868MHz, 902-968MHz and 2.4MHz. The battery life is significantly
improved due to it consume extremely low power. It is used to transmit the instruction via wireless voice playback to the visually impaired people. It is used to share the instruction to the visually impaired people for short distance communication.

3.5 ARDUINO UNO

Arduino uno (Figure 4) is used in the proposed system as a micro controller to control the process. It is an open source microcontroller based on the microchip AT-mega 328P microcontroller and developed by Arduino cc. It is an 8-bit microcontroller and has both analog and digital inputs and outputs. Various expansion boards and circuits can interface with this board. This board contains 14 input and output lines which is in digital form and 6 lines of it are pulse width modulated lines, six analog input lines are also available and has programmable IDE. The Arduino uno collects the data from the sensor and GPRS, GSM and it is processed, and the processed data is transmitted through the transmitting device to alert the impaired people.

![Arduino Uno](image)

**Figure 4. ARDUINO UNO**

3.6 Programming in Embedded C

Programming in Embedded C is one of the important software module part and it is widely applied in many real time applications. It is beneficial to utilize the high-level programming and optimization of this embedded language. The signals are generated in the trigger pin of the pulse sensor and the trigger pulse falls on the object and it will return through the air medium. The pulse which return is known as the Echo pulse. The echo will reach the receiver the distance of the echo pulse is calculated by the received signal. The distance of the obstacle is conveyed via voice playback. The loop is continued till the person reach the destination.

3.7 Flow Chart

In Figure 5, the flowchart of the proposed system is shown. The trigger pulse is generated from ultrasonic sensor which is giving a high frequency sound waves and is focussed to fall on the object and received back as echo signal. There are two methods available one is based on time transit method and other is based on the frequency method. In time transit method, the difference between the transmission and reception of data is used. The frequency-based signals are transmitted and received if any obstacle is found. Based on the distance between transmitted and received signal, the output is generated. The output can be generated as a voltage in terms of milli volts. Depends on the output the
voice play back message is sent. The output values along with three axes accelerometer values a decision is taken and sent as an alert message for any deviations from optimum values.

![Flow chart of the Proposed System](image)

**Figure 5.** Flow chart of the Proposed System

### 4 Outputs and Explanation

The output from all the sensors, controller is verified separately, and cumulative value is tested and verified. The ultrasonic sensor is working based on the echo/reflection principle, so more consideration is given to study about the back scattering and receiving of waves for different objects. The measurement is starts with the microcontroller and the microcontroller send the triggering pulse to the ultrasonic sensor, the sensor will send out the signal with 40KHz and it is received back as reflected wave after falling upon the obstacle if there is no obstacle the emitted wave does not reflect back. The simulation test is done, and the analog value is calculated for different distance and the theoretical value is also calculated. The visually impaired people can use this smart guidance system to the maximum coverage area of 4 m.

The output from the ultrasonic sensor called as displacement measurement sensor is tabulated as below. (Table No 1). The output is the variation of displacement as a functional value of voltage. The error value is noted between the output voltage between measurement of calculated and measure value. The output from the ultrasonic sensor gave the correct when compared with the calculated value. As a result, the output accuracy is strengthened. Also, the output is a linear value.
Table 1. Results of Displacement Measurement Sensor

| Displacement (cm) | Output voltage Theoretical (mV) | Output voltage Actual (mV) | Difference |
|-------------------|---------------------------------|---------------------------|------------|
| 5                 | 24                              | 23                        | 1mV        |
| 10                | 48                              | 46                        | 2.7mV      |
| 20                | 98                              | 95.3                      | 2.7mV      |
| 30                | 147                             | 143.8                     | 3.2mV      |
| 40                | 195                             | 190.5                     | 4.5mV      |
| 50                | 247                             | 241                       | 6mV        |
| 75                | 355                             | 348                       | 7mV        |
| 100               | 500                             | 489                       | 11mV       |
| 150               | 745                             | 730                       | 15mV       |
| 200               | 950                             | 926                       | 24mV       |
| 250               | 1250                            | 1220.7                    | 29.3mV     |
| 300               | 1450                            | 1410.6                    | 39.4mV     |
| 350               | 1735                            | 1691                      | 44mV       |
| 400               | 2000                            | 1953.2                    | 46.8mV     |

The below graph shown in the Figure 6, shows the variation difference between the actual and calculated value for various distances, for samples (X-axis). Y-axis indicates the measured and calculated value as an integrated output.

![Graph showing displacement measurement sensor results](image)

**Figure 6.** Ultrasonic sensor output (calculated and measured value)

The graph below shown in the Figure 7, shows the increase in the analog value of output from the sensor. A standard linear function is maintained throughout the measurement for respective distance.
MEMS accelerometer is used to find the static or dynamic position of impaired people with its 3-axis sensor. The accelerometer senses the position values in all the three quadrants X, Y, Z. If the accelerometer output is a constant value/static position of the impaired people for prolonged time, automatically it will send the message to the guardian and family members for their respective registered mobile number via GSM modem. Location data will be conveyed through their relative and people of close contact as lengthwise and breadthwise values (Latitude, Longitude values). The family members will be receiving an alert message and depends on the distance and traffic, the person could be safeguarded immediately, with continuous monitoring. Also, the device is a user-friendly device for both educated and uneducated peoples and for various age group peoples. The output as location data and alert message to emergency contact 1 and contact 2 is shown in the Figure 8, and Figure 9. Also, the alert message as a guidance is sent as a audio playback to the impaired people also.

Figure 7. Analog Measured output voltage

Figure 8. MEMS Accelerometer sample output- Contact-1
Finally, if the visually impaired person is in static position, for a predetermined period of time and also any collision/any emergency situations, the current latitude and longitudinal data of the current whereabouts of the blind person is conveyed through the registered mobile number for their guardian. Latitude and longitude have specific value, and it does not merge with any other location values. Also, it is quite easy to access by local authorities.

5 Conclusion and Future works
The main objective of devising the blind and visually impaired people safety navigation system is proposed and the same is implemented and explained in this paper. The small and light weighted device is quite easy to carry with them while they travel alone and it will completely guide them during the entire travel or independently do their own work, without others help. Also, their family members feel free while they travel alone because it gives information/alert to their family in case of emergency. The MEMS accelerometer will respond even for a small shock, so that difference output or error could not be easily predicted. As, a future work, the same system could be extended for avoidance of small external disturbances as a function of output. As an extendable work, in case of any accidents/emergency, the same information could be integrated to the nearest hospital/health centres to immediately act for life saving of the people concerned. Also, along with the latitude and longitude values, the correct address will also be included in the future works.

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