Design of Smart Guiding System for Visually Disabled People Using Infrared Microcontroller

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Abstract: Blindness is a state of lacking the visual perception due to physiological or neurological factors. The partial blindness represents the lack of integration in the growth of the optic nerve or visual centre of the eye, and total blindness is the full absence of the visual light perception. In this work, a simple, cheap, friendly user, smart blind guidance system is designed and implemented to improve the mobility of both blind and visually impaired people in a specific area. The proposed work includes a wearable equipment consists of head hat and mini hand stick to help the blind person to navigate alone safely and to avoid any obstacles that may be encountered, whether fixed or mobile, to prevent any possible accident. The main component of this system is the infrared sensor which is used to scan a predetermined area around blind by emitting-reflecting waves. The reflected signals received from the barrier objects are used as inputs to PIC microcontroller. The microcontroller is then used to determine the direction and distance of the objects around the blind. It also controls the peripheral components that alert the user about obstacle's shape, material, and direction. The implemented system is cheap, fast, and easy to use and an innovative affordable solution to blind and visually impaired people in third world countries.

Keywords- Blind walking stick, Distance measuring sensor, Microcontroller, Servomotor.

I. INTRODUCTION

Many people suffer from serious visual impairments preventing them from travelling independently. Accordingly, they need to use a wide range of tools and techniques to help them in their mobility. One of these techniques is orientation and mobility specialist who helps the visually impaired and blind people and trains them to move on their own independently and safely depending on their other remaining senses. Another method is the guide dogs which are trained specially to help the blind people on their movement by navigating around the obstacles to alert the person to change his/her way. However, this method has some limitations such as difficulty to understand the complex direction by these dogs, and they are only suitable for about five years. The cost of these trained dogs is very expensive, also it is difficult for many of blind and visually impaired persons to provide the necessary care for another living being. There is an international symbol tool of blind and visually impaired people just like the white cane with a red tip which is used to enhance the blind movement. Nowadays, different types of these canes have been used such as the white cane, the smart cane, and the laser cane. However, this tool has several constraints: long length of the cane, limitations in recognizing obstacles, and also difficulty to keep it in public places. Recently, many techniques have been developed to enhance the mobility of blind people that rely on signal processing and sensor technology. These called electronic travel aid (ETA) devices help the blind to move freely in an environment regardless of its dynamic changes. According to the literature, ETAs are mainly classified into two major aspects: sonar input (laser signal, infrared signals, or ultrasonic signals) and camera input systems (consists mainly of a mini CCD camera). Their details are shown in Table 1. The way these devices operate just like the radar system that uses ultrasonic fascicle or laser to identify height, the direction, and speed of fixed and moving objects. The distance between the person and the obstacles is measured by the time of the wave travel. However, all existing systems inform the blind of the presence of an object at a specific distance in front of or near to him. These details permit the user to change his or her way. Information about the object characteristics can create additional knowledge to enhance space manifestation and memory of the blind. To overcome the above-mentioned limitations, this work offers a simple, efficient, configurable electronic guidance system for the blind and visually impaired persons to help them in their mobility regardless of where they are, outdoor or indoor. The originality of the proposed system is that it utilizes an embedded vision system of three simple IR sensors and brings together all reflective signals in order to codify an obstacle through PIC microcontroller. Hence, in addition to distance the proposed guidance system enables the determination of two main characteristics of the obstacle which are material and shape. Furthermore, the user of the system does not need to carry a cane or other marked tool. He/she can just wear a hat and hand mini stick (size of a pen) just like others. It has high immunity to ambient light and colour of object. It has typical response time about 39 ms, and it is very suitable for real-time applications.

The main objective of this project is to develop an application for blind people to detect the objects in various directions, detecting pits and manholes on the ground to make free to walk.

II. MODELLING AND ASSEMBLY

Modeling is done using Pro/E cero 5.0. Software. PTC Cero formerly known as PRO/ENGINEER is a parametric, integrated 3D CAD/CAM/CAE solution created by Parametric Technology Corporation (PTC). It is the world's leading CAD/CAM /CAE software, gives a broad range of integrated solutions to cover all aspects of product design and manufacturing. It was the first to market with parametric, feature based associative solid modeling software. The application runs on Microsoft windows platform, and provides solid modeling, assembly modeling and drafting, finite element analysis, direct and parametric modeling and NC and tooling functionality for mechanical engineers.

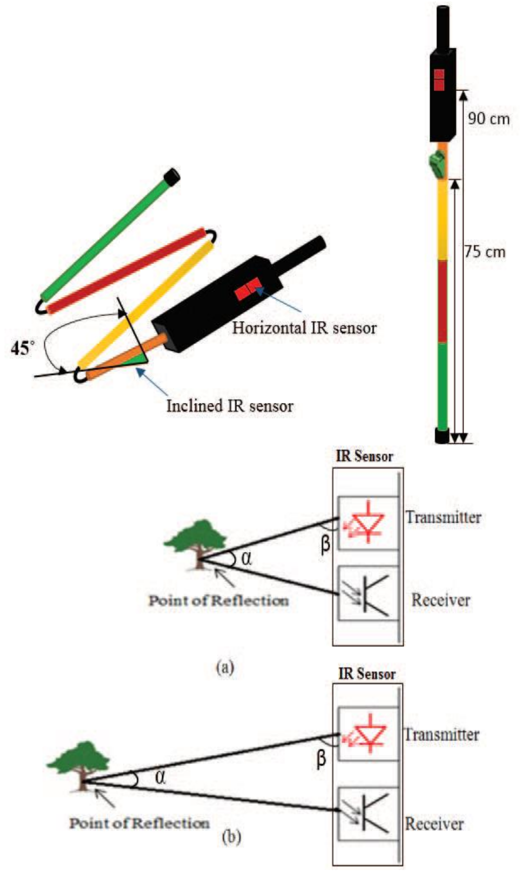

Figure 1: Modeling and Assembly of walking cane

III. BASIC COMPONENTS

The main basic components presented in this project are:

HARDWARE:

- Microcontroller
- Sensor
- Power
- 4. Servo Motor
- 5. Buzzer
- 6. Voice record and Play back device

SOFTWARE:

- Keil Compiler
- Pro/E cero 5.0
- Embedded C Code
- ucFlash

3.1. Block Diagram of the Design of Smart Guidance System for Visually Disabled People Using Infrared

Microcontroller Proposed

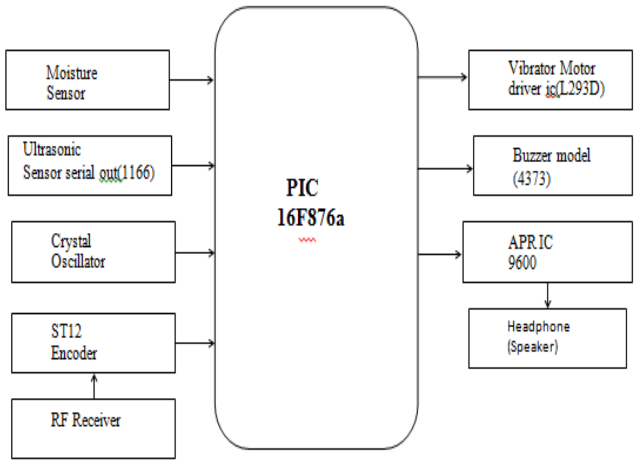

Figure 2: Block diagram of stick

Proteus is software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design. Proteus-VSM (Virtual System Modeling) permits the co simulation of the embedded software for popular microcontrollers alongside with the hardware design. The software Proteus was used to design and analyze both preliminary and final results for each part of the system. Proteus enabled the system to be tested and modified until accurate and expected results were obtained prior to the circuit installation in practice. Figure 1 shows the design and the implementation of the proposed smart blind guidance system. The block diagram of the system is illustrated in. It shows three reflective signals that were produced as follow: from front IR sensor, right IR sensor, and from left IR sensor. All signals are inputs for ADC on a PIC microcontroller. These signals are digitized and used as inputs to a specific program implemented in real time within PIC microcontroller. As a result of these signals the microcontroller according to some internal instructions will produce an output which will be transferred from the PIC to the buzzer and motor driver IC to aware the blind about the barriers blocking his/her way.

3.1.1. PIC Microcontroller 16F877A

To make wearable obstacle detection system for visually impaired people respond faster, it should be equipped with advanced microcontroller to decrease computational complexity. PIC 16F877A was chosen to detect any switch triggered and generate the audio sounds and vibrations. The PIC does not have an operating system and simply runs the program in its memory when it is turned on. PIC microcontroller is a small computer on a single integrated circuit which stores a set of instructions. It consists of a processor core, memory, and programmable input/output peripherals. PIC is an important component in the proposed system which deals with a Micro C programming code which was installed in it. 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 no digital electronic systems. PIC microcontroller operates at +5 V which can be regulated using the voltage regulator (L7805) which conserves voltage at +5 V if the input voltage for it exceeds +5 V. Also PIC cannot run without using its crystal oscillator which is used to execute the programming code. The PIC is used as a real-time processing element; therefore, a high frequency oscillator is used.

3.1.2. IR Sensors

Three IR sensors are employed to acquire particular details relative to the obstacle categorization. In this paper, the suggested guidance system principle is shown by introducing the main sensors and their ability to detect and identify typical objects. The IR sensors are the main electronic components in the proposed system because it acts as the new eyes for the blind. One IR sensor is located on the hand mini stick to scan the front side, and the other two sensors are located on the hat at both right and left sides. IR sensors will scan all area in there range of IR beam. Any obstacle lies in the scanning range of the IR beam will be reflected and picked back by the receiver unit in the sensor. The distance and angle detection depend on the body that caused beam reflection. Figure 3 shows the block diagram of IR sensor. The range of distance to be scanned is controlled by a switch. Three switches are used to control the range of sensors in the three directions (i.e., when switches are on, the sensors will work at full range; otherwise they will work at their half range). The IR sensors are used to detect an obstacle besides (right and left) and in front of the blind at a distance between 10 and 150 cm. The basic tools in electronic IR guide are mini hand stick and head hat. These tools have IR sensors on it. These sensors represent the blind eyes so its position is very important to give right decision that depends on their output. Mini hand stick contains IR sensor with a distance range from 10to 150 cm. This range can be controlled by the PIC microcontroller, so it can be operated at half range (75 cm) via open switch button. What makes the sensor favorable is its small weight which is about 65 gm, also it offers proper protection for the sensor via thin transparent layer of plastic. The head hat is the second tool in the proposed blind electronic guidance system. e hat provides the system the ability to scan areas in the right and left side of the blind via two sensors fixed on it. the two sensors can work either on their full range 150 cm or their half range (75 cm) according to what is preferable by the user who can control it via switches.

The position in which the light falls can be used to calculate the distance from the transmitter to the obstacle using the following formula

$$L/A = F/X \text{ Therefore } L = (F \times A)/X$$

3.1.3. Reading IR Sensor Output with A/D Converter

The IR sensor's output voltages will change according to the detection distance. To calculate the approximate distance, the following formula is used:

$$R = (2914 / [V + 5]) - 1,$$

Where R is distance in centimeter unit and V is digital data from A/D converter.

3.1.4. Speakers

Speakers are main indicators of the designed system through which the blind can easily determine the shape and material of surrounding bodies around him/her. There are two speakers: left and right. If the tune sound is due to the left speaker then there is an object in the range of left IR sensor, and when tune is due to the right, it means that an object in right side of blind exits. When both speakers give the tune, it means that the obstacle is in front of blind. Another advantage for speakers is their small weight and size, so they do not constitute a burden to blind, and he/she can easily control the sound level via variable resistor to choose the sound level that does not make him/her annoyed.

3.1.5. Vibration Motor Driver

L293D is quad push-pull drivers designed to provide bidirectional drive current up to 1 A or 600 mA per channel. All channels are TTL-compatible logic inputs, and each output is a complete totem-pole drive circuit with Darlington transistor sink and pseudo-Darlington source. The main function of L293D in this system is to control the current that is delivered to vibration motor using an enable pin that is connected directly to PIC. Vibration motor indicates how much the detected body in range is closer to blind in both left and right sides, and when the vibrator works with the left or the right speaker, then it indicates that there is a body in front and left or right according to speaker that was working. Figure 6 shows the signal that controls the motor and the incremental change in pulses width that result because of the decreased distance from the barrier.

3.1.6. Switches

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

3.1.7 Buzzer

The Piezo buzzer produces sound based on reverse of the piezoelectric effect. The generation of Pressure variation or strain by the application of electric potential across a piezoelectric material is the underlying principle. These buzzers can be used to alert a user of an event correspaction, counter signal or sensor input. They are also used in alarm circuits. The buzzer produces a same noisy sound irrespective of the voltage variation applied to it. It consists of piezo crystals between two conductors. When a po conductor and pull on the other. This, push and pull action, results in a sound wave. Most buzzers produce sound in the range 2 to 4 kHz.

3.1.8 Voice record and play back device:

This circuit offers true single-chip voice recording, non volatile storage and Playback capability for 40 to 60 seconds. It supports both random and sequential access of multiple different modes. The device is ideal for use in portable voice recorders. The sensors are set a threshold limit if any obstacle is found within that range it gives beep speech through speaker. Obstacles found indifferent directions are indicated with different pattern beep and speech (Top, Middle, Pit and Water) to identify them easily.

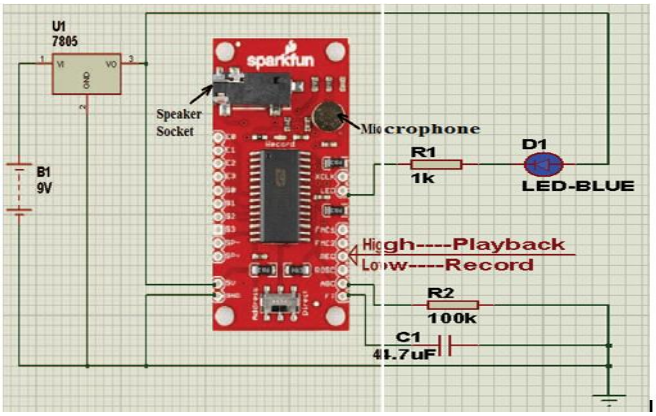

Figure 3: Voice record and play back device

IV. WORKING

When power is applied to the circuit for the first time, all the sensors and motors are switched off. All sensors are configured as inputs and motors, buzzer is configured as outputs.

The servomotor starts rotating toward the upward and forward direction, since the distance sensor is mounted on the servo motor its orientation also changes.
There are two sensors

1. Sensor1 measures the obstacle between the head and front side of the travelling path
2. Sensor2 measures the obstacle in the bottom direction for pits and floor based obstacles.

The sensors are set a threshold limit if any obstacle is found within that range it gives beep and also speech through speaker. Obstacles found in different directions are indicated with different pattern beep and speech (Top, Middle, Pit and Water) to identify them easily

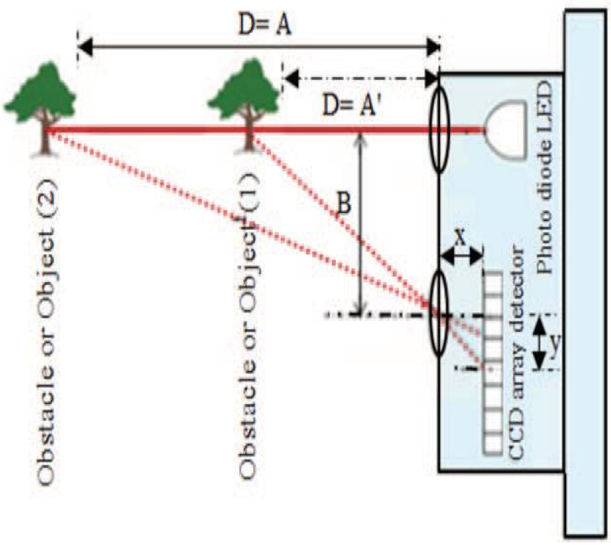

Figure 4: Object detector

V. RESULT AND DISCUSSION

The presented system is designed and configured for practical use. The system is able to handle seven states that may face the blind people. The system will respond to each state according to a specific program which is coded and installed in the PIC microcontroller. The first case is when the body is in the right direction of the blind, and then just the right speaker will give sound. The second case is when the body is at the left side of the blind, then just the left speaker will give sound. The third case is when the body is in front of the blind, and then both the left and right speakers will give sound. The forth case is when the body is located in the range of right and front sensors, that is, from front and right, then right speaker and vibration motor will work together. The fifth case is when the body is located in front and left sides of the blind, then left speaker and vibration motor will work. The sixth case is when the bodies are approaching the blind from both right and left directions, and then just vibration motor will work. The last case is when the bodies come in all directions (front, right, and left), then both speakers and vibration motor will work (worst case scenario).

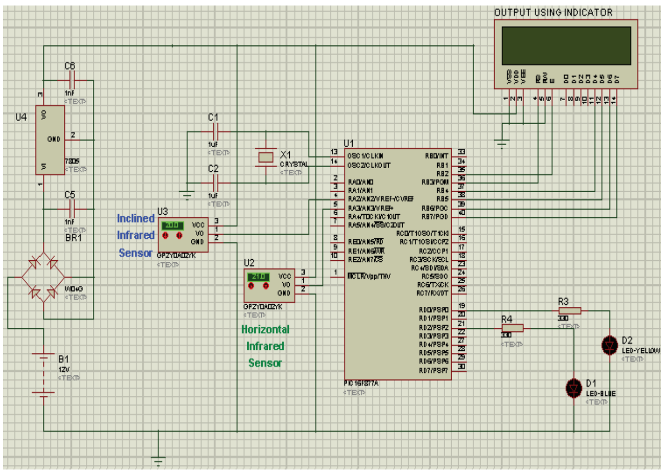

Figure 5: Simulation circuit

VI. TRIAL RESULT

To distinguish an obstacle from another, it is crucial to acquire the key features of the objects, such as material and form. The obstacle categorization can sufficiently be differentiated by its characteristics, so that it can be detected. According to the main aim of this work and to make use of simple sensors, the infrared sensors have been examined to identify the obstacle materials and surfaces. All 10 male blind subjects, aged 18–50, participated in the test of the system. Every participant was taught to understand one path (150 m long). The paths were selected to over multiple obstacles of different materials of interest.

VII. COMPARISON WITH OTHER SYSYTEM

As mentioned in the introduction, any new technology should be compared with what is already available and up to date technology. The proposed system is compared with the NavBelt system which is worn by the user like a belt around the waistline and through a set of stereo earphones to provide acoustic signals which direct the user around obstacles. However, the NavBelt system suffers from certain limitations such as the difficulty of conveying information to the user to allow rapid walking, on the other hand the NavBelt must be used together with white cane. At the stage of current development, it is clear that the white cane is potential in terms of cost, weight, electrical power, and reliability to reveal obstacles on the floor. However, if the floor is a fully reflective surface, then the cane laser scanning device fails. In addition to the revealed difficulties of the white cane in detecting hidden obstacles, it exhibits difficulty to the user in storing it in a public place. The results show that the suggested system can detect more distant obstacles by using infrared and other sensing devices and can provide more precise range information of the obstacle than the aforementioned sonar systems. Moreover, the system overcomes the limitations of the camera-based system due to its noninvasive nature, low power consumption, cheap cost, simplicity, and ease of customization. However, even at this early stage of the system's implementation, there are many advantages in using the newly proposed system: first of all it is safe, inexpensive and can be worn everywhere; when there are some obstacles, the system alerts the user and allows him/her to make better understanding of the space around him/her due to the detection of the material and shape of the object. Hence, the blind can change his/her way and move more safely and easily. Although the proposed system was able to work successfully, there is some future works which will be focused on 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.

VIII. CONCLUSION

A simple, cheap, configurable, easy to handle electronic guidance system is proposed to provide constructive assistant and support for blind and visually impaired persons. The system is designed, implemented, tested, and verified. The real-time results of the system are encouraging; it revealed an accuracy of 93% in detecting different shapes, materials, and distances. The results indicate that the system is efficient and unique in its capability in specifying the source and distance of the objects that may encounter the blind. It is able to scan areas left, right, and in front of the blind person regardless of its height or depth. Therefore, it was favored by those who participated in the test. The IR sensor has been fully utilized in order to advance the mobility of the blind and visual impaired people in safe and independent way. This system does not require a huge device to be hold for a long distance, and it also does not require any special training. This system also resolves limitations that are related to the most of the movement problems that may influence the blind people in their environment. Future work will be focused on enhancing 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 defferent rotational speeds across several distances will further be considered.

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