An Intelligent Walking Stick for the Blind in Indoor Environment

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ABSTRACT

Blindness has been regarded as one of the worst and incurable types of disabilities among humans across the globe as it hinders mobility of the impaired victims. This calls for the need to adopt new technologies to ease mobility problems among visually impaired victims. It was estimated in the year 2009 that there exists 160 million blind and partially visually impaired people worldwide.

This paper focuses on an embedded system adaptive technology to reduce navigation challenges being encountered among visually impaired people using sensorial and communication IT functionalities with an affordable cost as an efficient navigation tool. In this research, an ultrasonic sensor, microcontroller, buzzer, electrolytic capacitor, oscillator, and other hardware components were used to detect obstacles thereby sending vibration notification warning sound to the blind and keep them from hitting or getting to the point of obstructions / accident lying ahead.

(Keywords: blind, visually impaired, walking, sensor, stick, system, adaptive technologies).

INTRODUCTION

There are many blind persons across the globe that make use of a white stick / white cane to help their daily movement. The white stick being used by blind people only assists them in detecting obstructions around them and to avoid danger during their navigation / movements. With the limitations involved in using a white stick, there is need to develop a new walking stick that can detect any obstacles at long distances before them are impacted.

Human beings respond to their environment using sensory organs estimated in terms of percentage as follows: 1% by taste, 1.5% by tactile sense, 3.5% by smell, 11% by hearing and lastly, 83% by sight. This makes blindness one of the worst disabilities in humans. This research presents a concept to provide a smart electronic aid for the blind or sight impaired people with the intention to provide overall measures artificial vision and object detection system, real time assistance via global positioning system (GPS); by providing information about the environmental scenario of objects around them. Therefore, with the current advancements and innovations in the area of an embedded systems, the blind will be able to move around more easily and comfortably while interacting with their immediate environment.

BRIEF OVERVIEW

Several research projects have been carried out over the years on the design of an Intelligent walking stick to ease the visually impaired in their mobility by detecting obstacles that might be on their way using warning sounds. S. Innet and N. Ritnoom (1997) introduced a stick for distance measurement using infrared sensors, which is a complex and inefficient process. The stick has different vibration modes for different ranges and is difficult for a blind person to differentiate as it requires time for training. The stick thereby informs the person clearly at a dangerous stage but conveys less information and safety then optimally desired.

J. Na. (2000) proposed an interactive guide system for indoor positioning, which can't detect the obstacles. He introduced a laser cane with three photo diodes and three laser diodes which function as a receiver making an optical triangulation. The laser cane detects the obstacle in three different directions. One is 45˚ to the ground for overhanging obstacles, the second one is parallel to the ground, and third one is for sharp deepness. However, said laser cane has no system for determining location and position in detecting incoming or obstacles ahead.

In 2012, Divya, et al., proposed the application of infrared (IR) sensor in developing an Electronic Guiding Stick for the blind. The stick was used as a tool for guiding them to walk or move away from their places and to detect the presence of obstacles along the pathway of the blind people.

The application of Radio Frequency Identification (RFID) for the Blind Navigation System was also proposed by Bin Ding, Haitao Yuan, Li Jiang and Xiaoning Zang in 2007. However, in this paper, an Ultrasonic sensor is used for the design and development of an intelligent walking stick to override the limitations encountered in the previous / past research conducted by several authors. This proposed system will detect the nearest obstacles via stereoscopic sonar system and sends back vibro-tactile feedback to inform the blind about its localization.

METHODOLOGY

Two important components are involved in the design and construction of this research project, namely hardware and software. The hardware involved the construction of the walking stick, a PIC 16f683 microcontroller, ultrasonic sensor, a LM7805 buzzer, electrolytic capacitor, crystal oscillator, battery clip, a 9v battery, switches and wires. It also involves the software which interfaces the operation of the system peripheral components for the overall construction of the walking stick.

In this system we are using the Ultrasonic sensor, GPS receiver, level convertor, buzzer, embedded system and battery. Ultrasonic sensors works on a principle similar to radar or sonar which evaluates attributes of a target by interpreting the echoes from radio or sound waves, respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. That signal is sent to the embedded systems.

DESIGN PHASE

The systems design is made up of an ultrasonic sensors, the microcontroller, buzzer, electrolytic capacitor, oscillator, resistors, switch, a ready-made handheld ordinary walking stick built with Aluminum was purchased from the shop - 100cm long (Figure 1) and 5V (LM7805) dual terminals voltage supply (9V, 400mAH minimum).

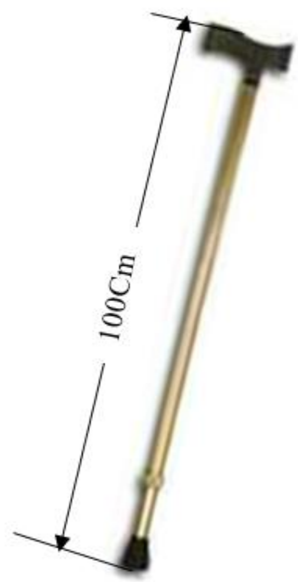

Figure 1: Ordinary Aluminum Walking Stick.

Ultrasonic sensors are installed on the stick to detect obstacles in the user path from a distance between the obstacle and the user. The output of the sensor will be sent to the microcontroller which receives the output signal from the sensors and processes them. If the output signal is within the programmed distance range, the microcontroller will activate the indicator (the buzzer) being triggered by the DC power source (Figure 2).

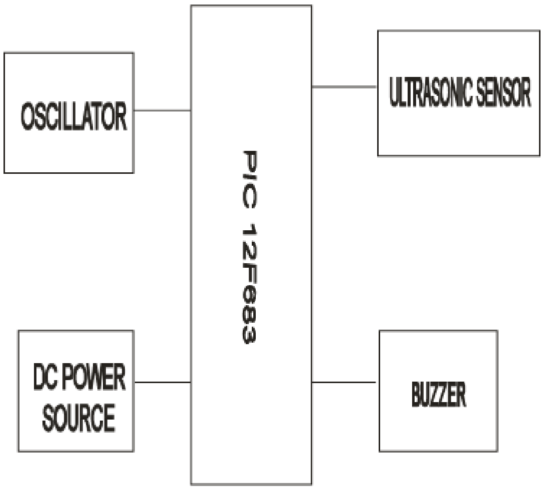

Figure 2: Design Representation.

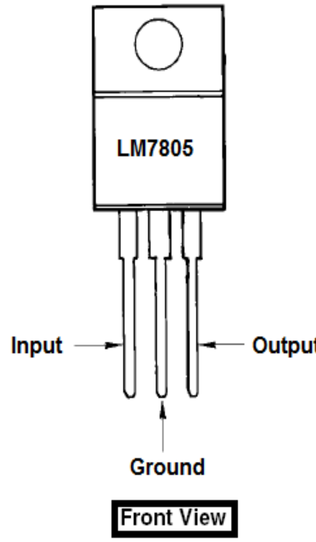

Figure 3: LM 7805 Voltage Regulator.

A microcontroller is made up of several chips integrated with microprocessors to form a single chip component required to control series of instructions and access I/O operations being carried out. The main purpose of the embedded capacitor is to store electrical energy by electrostatic stress in the dielectric. Its plates are at different potential and it is referred to as capacitance of the capacitor. However the 4MHz crystal oscillator controls the speed of the micro-controller, to provide clock (connected to pin 13 and pin 114 of micro-controller) using mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency.

The LM 7805 on the other hands provides and regulates direct current to drive the circuit as it generates required electromotive force as source of electrical energy (Figure 3). This then triggers the Buffer to produce a beeping sound based on the supplied voltage.

Finally, the ultrasonic range sensor detects the distance between the user and the obstacles for below-knee position using HC-SR04 model. It produces an audible sound waves, detects wind speed and direction as it can identifies discrete distances of moving objects. Also Its Resistance to external disturbances such as vibration, infrared radiation, ambient noise, and EMI radiation is of great relevance.

CIRCUIT DIAGRAM AND ANALYSIS

The Circuit maker software was used for the circuitry model comprises of the ultrasonic sensors, a buzzer, a push button switch, oscillator, capacitor, resistor, voltage regulator, battery and the microcontroller as shown below (Figure 4).

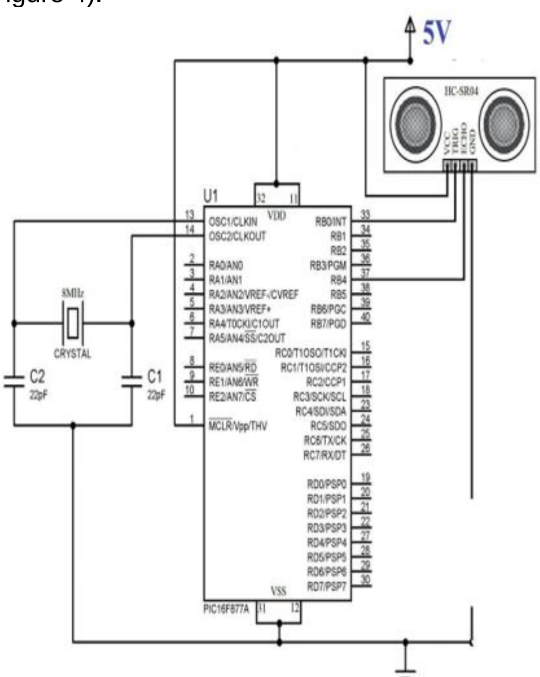

Figure 4: Circuit Diagram of Walking Stick.

The voltage supply activates the circuit while the "sensor transmitter" transmits the 40 kHz frequency, which reflects from the obstacle. The "Sensor receiver" receives the reflected frequency and transmits to the microcontroller.

The microcontroller processes it and gives signal to the buzzer. Buzzer gives a beef sound to inform the person that the obstacle is detected. This stick will provide the accurate location and position to the blind person through sensor. The basic concept of ultrasonic sensor is to determine distance of an object.

The experiments are conducted to evaluate the performance of the suggested methods. The ultrasonic sensor used gives the information about the distance within a specific range. The circuit has been designed to investigate the response of the sensor for various objects in cm as shown in Table 1).

Table 1: Detection Range for Various Obstacles.

Obstacle	T_1	T_2	T_3
Wall	200	158	140
Plastics	115	145	112
Human body	90	110	122
Metal	85	150	111

In this research, an ultrasonic sensor measures the distance between the obstacles and the blind as a sign of warning. The ultrasonic sensor works by generating high frequency sound waves and evaluates the echo which is received back by the sensor. The sensor calculates the time interval between sending the signal and receiving the echo to determine the distance of the obstacle. This signal is then sent to the microcontroller to activate / produce the corresponding sound signals.

After analyzing the performance of the sensor, the ultrasonic sensors were tested with the present of indicator as the output. For the first operational range, the distance is set to vary from 0 cm to 50cm. The second range is set from 50cm until it is out of range (Table 2).

Table 2: Description of Sensor Detection

No	Range (cm)	Output
1	0-50	Buzzer on
2	50-80	Sound produced

CONCLUSION

Development of an information technology (IT) based walking stick is of great importance to visually challenged people. This is because vision disabilities have been estimated to be on the rise most especially among lower income countries. The advancement in technology however has made the intelligent IT based walking stick easily implemented and affordable using several ways of distance measurement detection techniques for protecting the blind from being hit by incoming hazards.

Ultrasonic range sensor and infrared sensor are examples of sensors that are appropriate for the system. Meanwhile, ultrasonic range sensor is considered as the most appropriate type of sensor based on its size, range, adaptive nature to atmospheric (such as sunlight, dark materials among others) conditions and cost. The ultrasonic sensor adopted in this project were placed at below-knee positions to detect the obstacles on the user's path. This method is very helpful for the blind especially when they are moving alone for outdoor activities. The sensors and indicators are easy to program and implement with microcontrollers. This research is highly beneficial to the visually impaired persons and hereby recommended as mobility gadgets and safety tool for the blind.

REFERENCES

1. Sakhardande, J., P. Pattanayak, and M. Bhowmick. 2013. "Arduino Based Mobility Cane". *International Journal of Scientific & Engineering Research*. Mumbai, India. April, 2013.

2. Divya, K., P. Dhivya, R. Gayathri, and P. Govindaraj. 2012. "Electronic Guiding Stick to Assist the Visually Challenged". AIM/CCPE 2012, CCIS 296. Bangalore, India. 2012.

3. Ding, B., H. Yuan, and X. Zang. 2007. "The Research on Blind Navigation System Based on RFID". University of Science & Technology of China.

4. Bousbia-Salah, M., A. Redjati, M. Fezari, and M. Bettayeb. 2007. "An Ultrasonic Navigation System For Blind People". *IEEE International Conference on Signal Processing and Communications*. Dubai, United Arab Emirates. November 2007.

5. Faria, J., S. Lopes, H. Fernandes, P. Martins, and J. Barroso. 2010. "Electronic White Cane For Blind People Navigation Assistance". World Automation Congress.

6. Liyana B.R. 2011. "Development of An Electronic Walking Stick for The Visually Impaired with Z-Axis Detection". Bachelors Thesis. Universiti Teknologi Malaysia, Skudai.

7. Mohammad, T. 2009. "Using Ultrasonic and Infrared Sensors for Distance Measurement". *World Academy of Science, Engineering and Technology,* 2009- 03-26. Chittagong, Bangladesh. 2009.

8. Jafnie, J. 2014. "Evangeline, Guide Systems for the Blind Pedestrian Positioning and Artificial Vision". *International Journal of Innovative Science, Engineering & Technology*. 1(3): 42-44.

9. Shruti, D. and. A. Sakhare, 2011. "Smart Stick for Blind: Obstacle Detection: Artificial Vision and Real-Time Assistance via GPS". *International Journal of Computer Applications (IJCA)*. 31-33.

10. Alshbatat, A,B, 2013. "Automated Mobility and Orientation System for Blind or Partially Sighted People". *International Journal on Smart Sensing and Intelligent System*. 6(2): 568 582.

11. Marukatat, R., P. Manaspaibool, B. Khaiprapay, and P. Plienjai. 2010. "GPS Navigator for Blind Walking in a Campus". *World Academy of Science, Engineering and Technology*. 46: 89-92.

12. Shoval, S., I. Ulrich, and J. Borenstein. 2003. "Robotics-Based Obstacle-Avoidance Systems for the Blind and Visually Impaired". *Robotics in Bio-Engineering*. 10(1): 9-2

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