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Voice Enabled Electronic Cane Designed for Blind Assistance

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ABSTRACT

Voice enabled electronic cane as a working system involves a theoretical notion and a system prototype of bringing an apt electronic aid to assist blind people. The system is intended to offer overall measures – Artificial vision and object detection. It is a PVC fabricated walking stick equipped with multiple sensors that are synched to work in perfect harmony to give information about the environment via audiological alerts. The hardware consists of At89S52 microcontroller, sensors, voice and buzzer combo. This project uses regulated 5V, 750mA power supply. Unregulated 12V DC is used for relay. The Smart-Stick is a combination of simple mechanical plus software-based device to detect static obstacles on the ground such as uneven surfaces, water, holes and steps through simple tactile-force feedback. This device is light, portable, but its range is limited to its own size and is not used for dynamic components. This system works effectively at night and day timings, irrespective of the lighting intensity and has a battery backup of 5 hours. This ETA is completely reliable and effectual.

Keywords: Sensors, Blind, Smart stick, Audio alert, Obstacle detection

I. INTRODUCTION

Vision is a significant unit of human physiology as 83% of information humans acquire from the environment is through sight. According to the World Health Organization (WHO) 2011 statistics, 285 billion people suffer from visual impairment. 246 billion has low vision, whereas the other 39 billion people are blind. Crucial reasons for visual impairment include cataract, glaucoma, brain aneurysm, age related muscular degeneration, childhood blindness among others. The oldest and conventional travel aids for people with visual impairment are the guide dogs and walking cane [1]. But using these aids is not only time consuming, but also a deficit in accuracy. With the advancement of technology, both in hardware and software front have brought potential to provide intelligent navigation abilities. In the past few years, there has been a lot of Electronic Travel Aids (ETA) designed and devised to help the blind navigate independently and safely [2]. Significant work has been done in this field which is listed as follows:

1.1. The C5 Laser Cane

The C-5 Laser cane is a walking stick equipped with laser guided navigation and detection system, which particularly involves infrared sensor. The sensor emits and receives pulses by a photodiode located behind the receiving lens [3].

1.2. NavBelt

The NavBelt comprises a wide belt, an array of sensors (IR/US) and a mobile computer processor. This system takes in the input signals from the sensors, processes it and passes it through an obstacle avoidance algorithm. The output is obtained by the user via headphones, using a stereo-imaging technique [4].

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1.3. Guide Cane

Guide Cane comprises of a 'sensor head' unit and a long handle, affixed to the distal end of the handle. It uses ultrasonic sensors which are arranged on the sensor head, detecting the obstacles and steer the device around it. The whole setup is quite bulky and heavy [5].

1.4. Mowat Sensor

This device is a handheld ultrasonic based device, which uses the ultrasonic emitter and receiver to judge and inform the user of the distance to objects by means of tactile vibration [6].

1.5. Binaural Sonic Aid

The Binaural Sonic Aid, is basically a set of spectacle frames, with one ultrasonic wide-beam transmitter mounted in the middle of the spectacle lenses, i.e. between the ridge raft and one receiver on each side of the transmitter [7].

1.6. Medico Stick

The device includes a DTMF device with many sensors like pulse, vibration and ultrasonic sensor, the whole system is designed on hollow steel rods with small sized buttons that works for a specific set of sensors to be utilized by user. The brief working can be explained as: whenever an individual using that stick meets with any critical situation from an accident to fluctuations in his/her blood-pressure rate, a subsequent [8].

1.7. Assistive Infra-red Sensor Based Smart Stick for Blind People

This design represents the light-weight, cheap, user friendly, fast response and low power consumable blind stick based on the infrared technology. A pair of infrared sensor can detect staircases and other obstacle present on the path within the range of 2feet [9].

Despite of so many innovations mentioned above, ETA'S are still in the phase of continuous development. But we are yet to reach that extent where the blind individual can not only ensure the distance and location of an object, but also have a fair idea of what kind of objects are present in his/her path hindering his walk.

This paper aims to introduce the ETA designed and developed to provide enhanced cognizance to the user about the environment and the object or obstacle that lies in his path. Designed with a light-weight PVC pipe, the system will provide artificial guidance to the visually impaired people with the help of microcontrollers, sensors, an alarm and a completely functional voice module setup mounted on the stick to provide audio logical data, instructions and alarms for the user to be alerted simultaneously alerting the surrounding people.

Features embedded in this system to distinguish it from the current available systems and technologies are:

a) Light-weight design and effortless to handle.

b) Amalgamation of 5 sensors for distinguishing obstacles

c) A switch to turn the system ON or OFF

d) It is significantly cheaper

e) Works effectually in night and day timings.

f) Provides a battery backup of approximately 5 hours.

g) Conveys audio alerts for different obstacles

h) A 3.5mm jack for earphones

II. PROPOSED ALGORITHM

The prime objective of the proposed system is to notify the user about unfamiliar obstacles that come in their way during navigation, therefore assisting them. It comprises of five sensors: Ultrasonic sensor, IR sensor, LDR sensor, Water sensor, thermo sensor and a voice module, which are interfaced with microcontroller AT89S52.

2.1. Sensors

Ultrasonic sensors are devices that use electrical–mechanical energy transformation, as shown in figure 2.1, to compute the distance of the obstacle or object from the sensor [10].

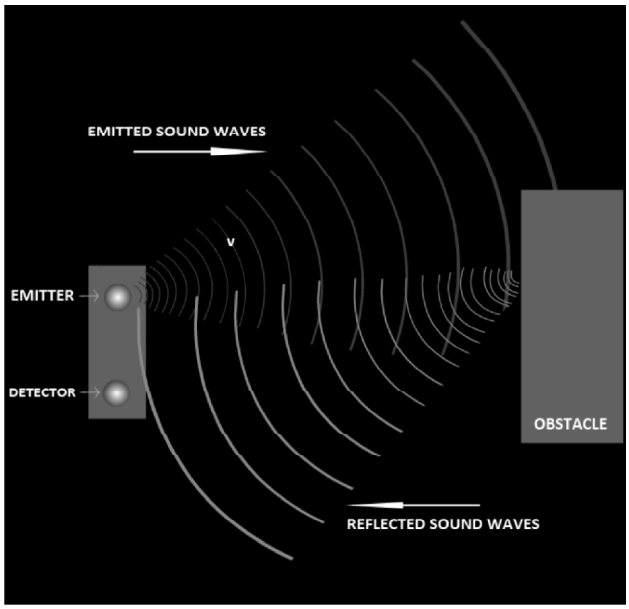

Figure 2.1: Working Principle of US Sensors [17]

An infrared sensor is an electronic instrument which is utilized to sense its surroundings by either emitting or detecting infrared radiation. Infrared sensors are also capable of computing the heat being released by an object and detecting motion [11]. It works on the principle, shown in figure 2.2, of emitting and then receiving the reflected IR rays by a photodiode.

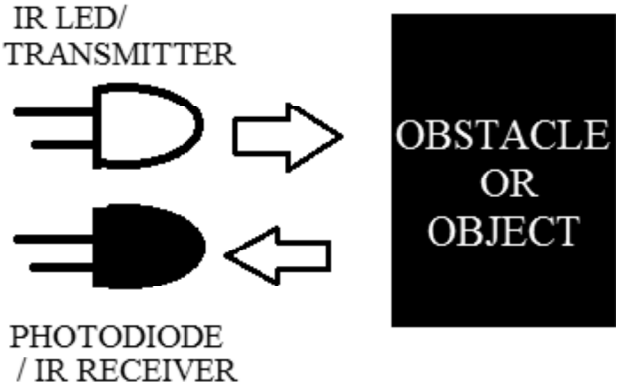

Figure 2.2: Working Principle of IR Sensors

The function of the water sensor depends upon the adsorption of water vapor into two conductive layers built on top of a base ceramic substrate [13]. Thermal sensor used for the proposed system is thermistor. Its working principle is that a constant current flowing via the resistor, and its changing resistance due to change in temperature, is measured as a voltage drop across it [12], demonstrated in figure 2.3.

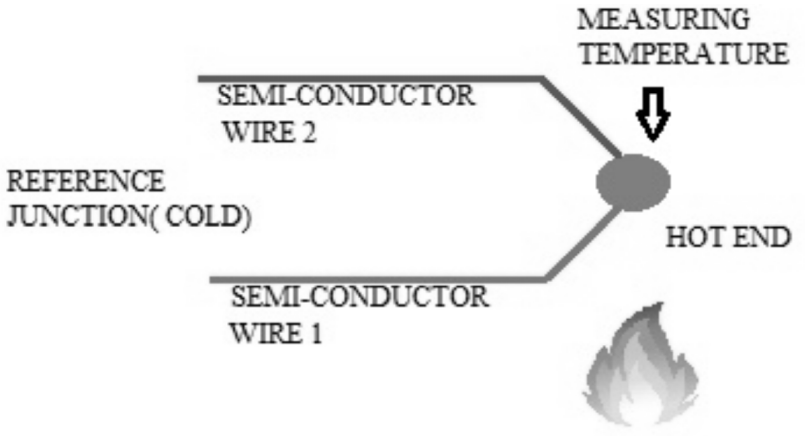

Figure 2.3: Temperature Sensor working principle

A **Light Dependent** Resistor (LDR) operates on the concept of photo conductivity i.e. when light falls on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band [14]. A schematic of LDR is shown below in figure 2.4.

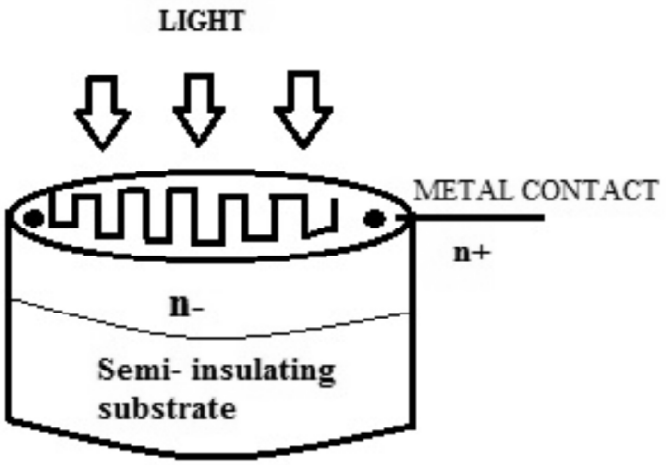

Figure 2.4: LDR schematic demonstrating its principle

2.2. APR 9600 Voice Module

The APR9600 voice module offers true single-chip voice recording, storage, and playback capability for 40 to 60 seconds. The module consists of an APR9600 chip, an electrets microphone, support components, a mode selection switch (-RE, MSEL1, MSEL2 and –M8) and 9 keys (-M1 to –M8 and CE).

Pins M1-M8 are utilized for the selection of dissimilar sounds. Pin CE is utilized to reset sound track counter to zero or stop and start. During sound recording, sound is picked up by the microphone [15]. Pin 15, SP- is a speaker, pin 17 is microphone input, pin 20 ANA-IN Audio input, -RE =0 to record, =1 to replay.

During the process of sound recording, a sound is picked up by the microphone. Its pre-amplifier amplifies the voltage signal from the microphone. An AGC circuit is included in the pre-amplifier, the

extent of which is controlled by an external capacitor and resistor. The sound signal passes through a filter and a sampling and hold circuit. The analogue voltage is then written into non-volatile flash analogue RAMs [15].

During sound replaying, the IC's control circuit reads analogue data from flash RAMs. The signal then passes through a low-pass filter, a power amplifier and output to an 8 to a 16 Ohm speaker. There are different sound recording and replaying modes. These modes are selected using MSEL1 (Pin 24), MSEL2 (Pin 25) and –M8 (Pin 9). –M1 to –M7 keys have different functions in different modes [15].

2.3. Microcontroller AT89S52

For the proper and effective functioning of the system, it is prerequisite that all the components and elements used are properly implemented and fabricated with each other. All the components were primarily connected and tested using a breadboard. All the five sensors and the voice module are interfaced with the microcontroller as shown in the figure 2.5.

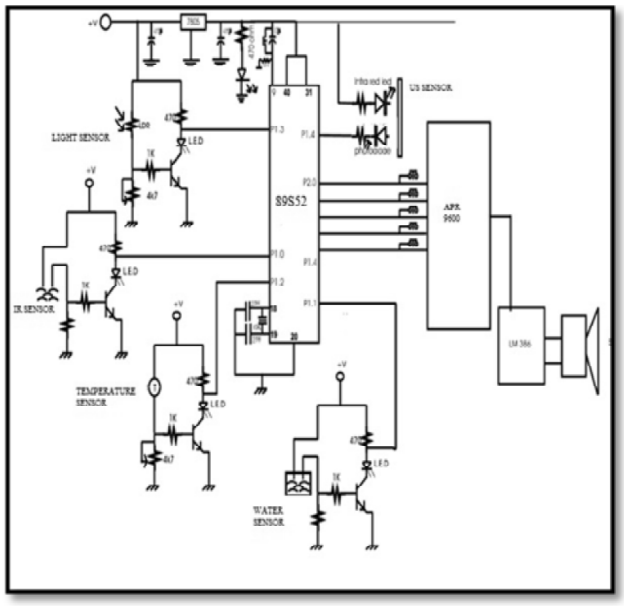

Figure 2.5: Microcontroller AT89S52 interfaced with sensors

III. DESIGN

Medium utilized for the fabrication of the stick is PVC pipe. It is strong, lightweight, unaffected by chemicals, and seems to last forever [16]. The length of the stick is 132 cm approximately. In a scenario of battery failure or discharge, it can be used as the conventional white cane due to its long length. Shown in Figure 3.1 is the schematic representation of the designed ETA. As already discussed in the previous section, the former ETAs were time-consuming and required the traveller's constant activity and conscious effort. This drawback has been eradicated in this stick. A switch has been provided to turn the ETA ON/OFF.

All the five sensors are connected to the stick keeping in mind their functions and sensing capabilities, to provide a user-friendly experience. A US sensor is attached to the lower half of the stick as shown in the figure below, which sends US waves and receive reflected waves. After receiving the reflected waves, a signal is sent to the buzzer via microcontroller. A buzzer is embedded inside the curved part of the stick, i.e. the handle, which buzzes when any object or obstacle is detected by the US sensor. Various components are embedded onto the PCB like APR 9600 voice recording module, mike, speakers, 3.5mm audio jack, resistors, comparators, voltage regulators, among others.

A cluster of LED's and a LDR sensor is attached, just below the PCB, in proximity with each other. This feature has been included in the stick exclusively for night time or a dark area.

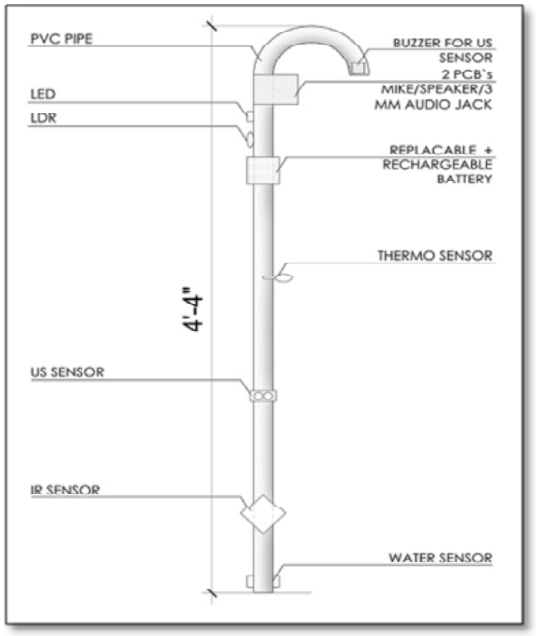

Figure 3.1: Design of the Alpenstock

A 12V rechargeable and replaceable battery for the complete effective working of the system. It provides a battery backup of 5 hours.A thermal sensor has been used for the detection of fire or increased temperature in an area.

IR sensor is affixed at the distal end of the stick. The key function of the IR sensor is to detect pits, holes, stones, upstairs or downstairs in a place. This function will assist the user by preventing accidents such as falling down off the stairs or falling due to some objects lying on the path such as stones or pits.

Water sensor is provided at the end of the stick for identifying water in the path of the user, for instance, muddy pathways or paths full of water or a water body.APR 9600, voice recording module, has been embedded on the PCB. With the help of this processor 4 different sounds have been recorded and generated. When any of the sensors detect unusual presence of any object or something else in the path of the user, the user will be able to distinguish between different obstacles with the help of this voice recording module.

With the help of earphones/headphones connected to the 3.5mm jack, the user will be able to hear about the obstacle. For instance, if water is present in the path of the user, then he will hear a sound saying "Water Detected" and similarly in other cases as well. By including all the above mentioned functions and features, a navigation stick has been designed and fabricated for the visually impaired which is light-weight and easy to handle, contrary to the other available ETA's.

IV. WORKING

Shown in the figure 4.1 is the flow chart of the system, describing the working of the sensors interfaced with buzzer and voice module. US sensor is interfaced with the buzzer only and not with the voice module, whereas the IR sensor is interfaced with voice module. This was done to differentiate between the obstacles detected by both the sensors. When US sensor detects an obstacle such as walls, trees, or any other big object the buzzer beeps. If no object is detected, sensor continues to send the US waves as programmed. The function of the IR sensor as mentioned in the previous section is to detect pits, holes or staircases.

When these are detected, “Obstacle Detected” is the sound that the user will hear. In case of no detection, IR sensor also continues to send IR waves.

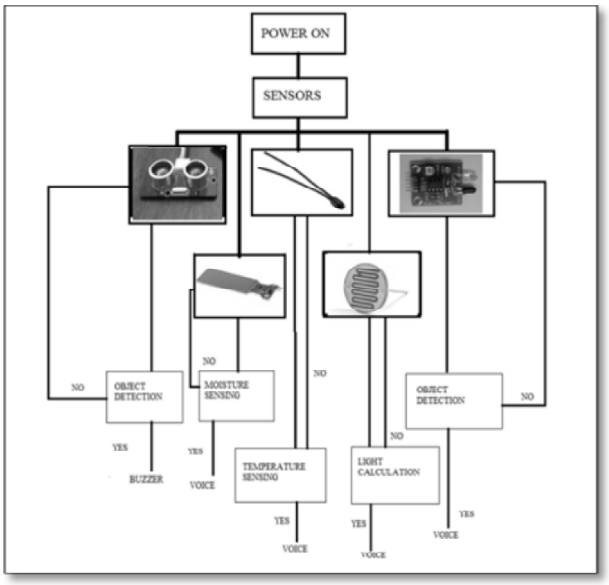

Figure 4.1: Flow Chart of the system

To the LDR sensor, we have attached a cluster of LED’s on the stick. In the dark when light falls on the LDR, the resistance decreases and hence the Led’s start radiating. The user will hear “Light Detected”. This sensor is useful for effective functioning of the voice stick in the night timings and in the dark.

When water sensor senses the moisture/water, the user will hear “water detected” for the indication of the obstacle i.e. water. Likewise for temperature sensor, “Fire Detected” voice can be heard.

V. CONCLUSION & FUTURE SCOPE

This project elaborates & showcases the design and construction of the Smart-Stick with the help of various combinations of sensors working in complete synchronization and harmony. The circuit works properly to detect the obstacles, pits, fire, water & light/ darkness. After designing the circuit which controls the probability of detecting the obstacles, the circuit has also been tested and validated. IR sensor and Ultrasonic sensor are the two main conditions in making the circuit work. Each sensor, will control the automated Voice module attached in the circuit, hence alerting the user audio logically about all the pre-defined voiced obstacles/ hindrances as per the detection logarithms by the fitted sensors. The whole Circuit and controller boards have been fitted on a personalized PVC fabricated framework, giving a light-weight and steady structure and functions on a 12 Volt rechargeable power supply/ battery.

Obstacle indication can be done wirelessly with the help of Bluetooth technology. The GPRS/ GPS navigation system can be embedded onto the system for safe navigation to unknown locations.

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