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Navigation Tool for Visually Challenged using Microcontroller

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Abstract— ***This paper describes the development of a navigation aid in order to assist blind and visually impaired people to navigate easily, safely and to detect any obstacles. The system is based on a microcontroller with synthetic speech output. In addition, it consists of two vibrators, two ultrasonic sensors mounted on the user's shoulders and another one integrated into the cane. This aid is able to give information to the blind about urban walking routes and to provide real-time information on the distance of over-hanging obstacles within six meters along the travel path ahead of the user. The suggested system consists then in sensing the surrounding environment via sonar sensors and sending vibro-tactile feedback to the user of the position of the closest obstacles in range. For the ultrasonic cane, it is used to detect any obstacle on the ground.***

Keywords— **Sensors, Microcontroller, Vibrator, Navigation**

I. INTRODUCTION

Mobility is one of the main problems encountered by the blind in their life. Overtime, blind and visually impaired people have used some methods and devices such as the long white cane and guide dog, to aid in mobility and to increase safe and independent travel .Due to the development of modern technologies, many different types of devices are now known as electronic travel aids. Among these aids are sonic pathfinder, Mowat –Sensor and Guide cane which are called clear path indicators or obstacle detectors since the blind can only know whether there is an obstacle in the path ahead. These devices are used to search for obstacle in front of the blind person, and they operate in a manner similar to a flashlight, which has very narrow directivity. Sonic-sensor since it has wide directivity enabling it to search for several obstacles at the same time.

The purpose of this project was to create a prototype of a device that can help blind people to travel with increased independence, safety and confidence.

In addition and in order to overcome the imperfections of existing electronic travel aids, the suggested method of measuring distance travelled in this system, is to use the It can supply the blind person with assistance about walking

The proposed system involves a microcontroller with speech output. It is a self contained portable electronic unit. routes by using spoken words to point out what decisions to make. In addition and in order to overcome the imperfections of existing electronic travel aids, the suggested method of measuring distance travelled in this system, is to use the acceleration of a moving body which in this case is the blind person.

An accelerometer, followed by two integrators is used to measure a distance travelled by blind. This technique is considered in inertial navigation system and suffers from drift problems caused by the double integration and offset of the accelerometer which are overcome by the footswitch. When this footswitch is closed, the acceleration and the velocity are known to be equal to zero and this can be used to apply a correction.

In order to help blind travellers to navigate safely and quickly among obstacles and other hazards faced by blind pedestrians, an obstacle detection system using ultrasonic sensor and vibrators has been considered in this aid. The proposed system detects then the nearest obstacle via stereoscopic sonar system and sends back vibro-tactile feedback to inform the blind about its localization. On the other hand, an ultrasonic cane equipped with wheels is considered to detect any obstacle which may be on the ground.

The system has then environment recognition and a clear path indicator functions.

II. REQUIREMENTS

Portability, low cost, and above all simplicity of controls are most important factors which govern the practicality and user acceptance of such devices.

The electronic travel aid (ETA) is a kind of portable device. Hence it should be a small sized and lightweight device to be proper for portability.

The blind is not able to see the display panel, control buttons, or labels. Hence the device should be easy to control. No complex, control buttons, switches and display panel should be present .Moreover, the ETA device should be low –price to used by more blind persons.

III. PRINCIPLE OF OPERATION

The aid consists of a microcontroller as a processor, an accelerometer, a footswitch, a speech analyser or synthesizer, and hexadecimal keypad, a mode switch, three ultrasonic sensors, two vibrators and a power switch.

The obstacle detection part of the system contains three ultrasonic transmitter-receivers and two vibrators.Two pairs of these ultrasonic sensors are mounted on the blind's shoulders. The other is the cane type subsystem. It is equipped with ultrasonic sensor and wheels. The user walks holding this cane in front of him like the white cane. The cane type system notifies whether any obstacle is there in middle of the direction he walks. Since the wheels are always contacted with the ground, the user can recognize the condition of ground such as depression, cavity and the stairs with his hands tactile sensation intuitively.

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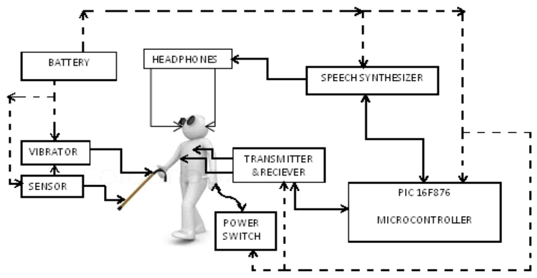

Fig 1 BLOCKS DIAGRAM

This obstacle detection system use a 40 KHz ultrasonic signal to acquire information and can detect the presence of any obstacle within specified measurement range of approximately 0.03 to 6 meters. It operates by sending out a pulse of ultrasound. Eventually the pulse is reflected from a solid object in the path of the pulse. The time between the outgoing pulse being transmitted and its echo being received corresponds to the distance between the transmitter and the object or obstacle. This information is then relayed to the blind in some vibro-tactile way and speech way.

One of the other methods we use is the 'MICROMAP'. The system has two modes of operation, record and playback. In addition, the playback mode has two directions, forward and reverses. The user selects one of these three possibilities by a switch.

In record mode, the blind walks the route of interest and the aid measures the distance travelled by the user. When the blind reaches the decision point for instance assume it as a right turn, the user will press the right side instruction.

-This has two effects

-The distance travelled by the user is stored in microcontroller memory, the counter reset to zero.

-The right turn instruction is stored.

Afterwards the blind walks to the next decision point and the same procedure is followed.

In the playback mode, the aid measures again the distance travelled by the user and if it is the same as that of the stored distance then i indicates the user to take right turn. Thus on decision points the blind can make any of the following decisions. Each decision has a separate key.

The system can store a number of routes each of which are numbered and be selected using the same set of keys as for the decisions. In practice the number is likely to be set by the size of the available memory.

IV. TECHNICAL DESCRIPTION

This section describes about the navigation components proposed in detail.

A. Microcontroller

The microcontroller used in the aid is the PIC 16F876 from 'MICROCHIP', with 8 k of 14 bits program memory, 368 bytes of RAM and 256 bytes of data EEPROM.

B. Accelerometer

The accelerometer used is the ADXL213 from 'Analogy Devices'. With this accelerometer, no A/D converter is then required as the output is digital.

C. Speech Synthesizer

The speech synthesizer device chosen is the ISD 5216 from 'Chipcorder' and is used as an audio output. The chip is a single chip solution offering digital storage capability and up to 16 minutes of high quality, audio record and playback functionality.

On the other hand, the speech synthesizer chip is activated by pulses from the microcontroller. The output gives different actions to the user.

For obstacle detection an increase of distance of obstacle results in a decrease in vibration, while a decrease of distance results in an increase in vibration.

Synthesized speech can be created by concatenating pieces of recorded speech that are stored in a database. Systems differ in the size of the stored speech units; a system that stores phones or diaphones provides the largest output range, but may lack clarity. For specific usage domains, the storage of entire words or sentences allows for high-quality output. Alternatively, a synthesizer can incorporate a model of the vocal tract and other human voice characteristics to create a completely "synthetic" voice output.

The quality of a speech synthesizer is judged by its similarity to the human voice and by its ability to be understood. An intelligible text-to-speech program allows people with visual impairments or reading disabilities to listen to written works on a home computer. Many computer operating systems have included speech synthesizers since the early 1980s.

D. Headphones

Since hearing for blind is very important, the headphones would dull this sense. For this system it has been considered to use headphones used in mobile phones and Walkman. The spoken words from the speech synthesizer which represent the different action to be taken will therefore be heard by the blind.

E. Hexadecimal keypad

In order to input information and hexadecimal 4*4 keypad is used in this aid. It is placed on the side of the case; the keypad switches enable the user to select routes and to enter decision. It is of course possible to label these keys with Braille symbols if it is thought necessary.

The footswitch is used to allow the PIC 16f876 to provide frequent corrections of drift effect. This footswitch 'S' needs to be attached to the heel of the shoe. When the blind starts to walk. 'S' is equal to zero. The microcontroller estimates then the acceleration and calculates the distance. When the footswitch is on the ground 'S' is equal to one. Afterwards, corrections are made. The micro switch is one example of switch which can be used became it is more flexible.

V. OBSTACLE DETECTION

For obstacle detection and as aforementioned, the aid is provided with an ultrasonic system attached to the jacket an ultrasonic cane. It is based on three ultrasonic sensors and two vibrators.

One of the most commonly used sensors for the detection of obstacle is PING sensor. This sensor can be used in any microcontroller even in arduino boards. The most advantageous thing about this arduino board is that these can be used using operating system.

A. A. Ping sensor

Parallax's PING ultrasonic sensor provides a very low-cost and easy method of distance measurement. This sensor is perfect for any number of applications that require you to perform measurements between moving or stationary objects. Naturally, robotics applications are very popular but you'll also find this product to be useful in security systems or as an infrared replacement if so desired. You will definitely appreciate the activity status LED and the economic use of just one I/O pin.

The Ping sensor measures distance using sonar; an ultrasonic (well above human hearing) pulse is transmitted from the unit and distance-to-target is determined by measuring the time required for the echo return. Output from the PING sensor is a variable-width pulse that corresponds to the distance to the target.

Interfacing to the BASIC Stamp and Javelin Stamp microcontrollers is a snap: a single (shared) I/O pin is use to trigger the Ping sensor and "listen" for the echo return pulse. And the intelligent trigger hold-off allows the PING to work with the BS1! An onboard three-pin header allows the PING to be plugged into a solder less breadboard (on a Boe-Bot, for example), and to be connected to its host through a standard three-pin servo extension cable.

B. PING Range Finder

The PING range finder is an ultrasound sensor from Parallax able of detecting objects up to a 3 mts distance. The sensor counts with 3 pins; two are dedicated to power and ground, while the third one is used both as input and output.
The pin dedicated to make the readings has to be shifting configuration from input to output according to the PING specification sheet. First we have to send a pulse that will make the sensor send an ultrasound tone and wait for an echo. Once the tone is received back, the sensor will send a pulse over the same pin as earlier. The width of that pulse will determine the distance to the object.

The example shown here was mounted by Marcus Hannerstig, while the software was created by David Cuartielles. The board is connected as explained using only wires coming from an old computer.
Coding for Detection of Obstacles

```
/* Ultrasound Sensor
 *------------------
 *
 * Reads values (00014-01199) from an ultrasound sensor (3m sensor)
 * and writes the values to the serialport.
*
 * http://www.xlab.se | http://www.0j0.org
 * copyleft 2005 Mackie for XLAB | DojoDave for DojoCorp
 *
 */
int ultraSoundSignal = 7; // Ultrasound signal pin
int val = 0;
int ultrasoundValue = 0;
int timecount = 0; // Echo counter
int ledPin = 13; // LED connected to digital pin 13

void setup() {
  beginSerial(9600);              // Sets the baud rate to 9600
  pinMode(ledPin, OUTPUT);            // Sets the digital pin as output
}
void loop() {
 timecount = 0;
 val = 0;
 pinMode(ultraSoundSignal, OUTPUT); // Switch signalpin to output

/* Send low-high-low pulse to activate the trigger pulse of the sensor
 * -------------------------------------------------------------------
 */
digitalWrite(ultraSoundSignal, LOW); // Send low pulse
delayMicroseconds(2); // Wait for 2 microseconds
digitalWrite(ultraSoundSignal, HIGH); // Send high pulse
delayMicroseconds(5); // Wait for 5 microseconds
digitalWrite(ultraSoundSignal, LOW); // Holdoff

/* Listening for echo pulse
 * -------------------------------------------------------------------
 */
pinMode(ultraSoundSignal, INPUT); // Switch signalpin to input
val = digitalRead(ultraSoundSignal); // Append signal value to val
while(val == LOW) { // Loop until pin reads a high value
  val = digitalRead(ultraSoundSignal);
}

while(val == HIGH) { // Loop until pin reads a high value
  val = digitalRead(ultraSoundSignal);

imecount = timecount +1;          // Count echo pulse time
}

/* Writing out values to the serial port
 * -------------------------------------------------------------------
 */
ultrasoundValue = timecount; // Append echo pulse time to ultrasoundValue
serialWrite('A'); // Example identifier for the sensor
printInteger(ultrasoundValue);
serialWrite(10);
serialWrite(13);
/* Lite up LED if any value is passed by the echo pulse
 * -------------------------------------------------------------------
 */
if(timecount > 0){
  digitalWrite(ledPin, HIGH);
}

/* Delay of program
 * -------------------------------------------------------------------
 */
delay(100);
}
```

C. Ultrasonic Sensor

The sonar system is based on two ultrasonic sensors mounted together. One emits an ultrasonic wave while the other measures the echo. By differentiation of the input and output signals the PIC16F876 computes the distance to the nearest obstacle. Then this information is transmitted as a Pulse Wide Modulation signal to the receiver.
The ultrasonic module used as a sensor for this application is MSU10 from ‘Lextronic’ .
-Angle of detection : approximately 72 degree
-Dimension :32 * 15 * 10 mm.

This technology can be used for measuring: wind speed and direction (anemometer), fullness of a tank and speed through air or water. For measuring speed or direction a device uses multiple detectors and calculates the speed from the relative distances to particulates in the air or water.

To measure the amount of liquid in a tank, the sensor measures the distance to the surface of the fluid. Further applications include: humidifiers, sonar, medical ultrasonography, burglar alarms and non-destructive testing.

Systems typically use a transducer which generates sound waves in the ultrasonic range, above 18,000 hertz, by turning electrical energy into sound, then upon receiving the echo turn the sound waves into electrical energy which can be measured and displayed. The technology is limited by the shapes of surfaces and the density or consistency of the material. For example foam on the surface of a fluid in a tank could distort a reading.

D. Vibrators

Vibrators are used in many different industrial applications both as components and as individual pieces of equipment. Vibratory feeders and vibrating hoppers are used extensively in the food, pharmaceutical, and chemical industries to move and position bulk material or small component parts. The application of vibration working with the force of gravity can often move materials through a process more effectively than other methods. Vibration is often used to position small components so that they can be gripped mechanically by automated equipment as required for assembly etc.

Vibrating screens are used to separate bulk materials in a mixture of different sized particles. For example sand, gravel, river rock and crushed rock, and other aggregates are often separated by size using vibrating screens.

Vibrating compactors are used for soil compaction especially in foundations for roads, railways, and buildings. Concrete vibrators consolidate freshly poured concrete so that trapped air and excess water are released and the concrete settles firmly in place in the formwork. Improper consolidation of concrete can cause product defects, compromise the concrete strength, and produce surface blemishes such as bug holes and honeycombing. An internal concrete vibrator is a steel cylinder about the size of the handle of a baseball bat, with a hose or electrical cord attached to one end. The vibrator head is immersed in the wet concrete.

External concrete vibrators attach, via a bracket or clamp system, to the concrete forms. There are a wide variety of external concrete vibrators available and some vibrator manufacturers have bracket or clamp systems designed to fit the major brands of concrete forms. External concrete vibrators are available in hydraulic, pneumatic or electric power.

Vibrating tables or shake tables are sometimes used to test products to determine or demonstrate their ability to withstand vibration. Testing of this type is commonly done in the automotive, aerospace, and defense industries. These machines are capable of producing three different types of vibration profile sine sweep, random vibration, and synthesized shock. In all three of these applications, the part under test will typically be instrumented with one or more accelerometers to measure component response to the vibration input. A sine sweep vibration profile typically starts vibrating at low frequency and increases in frequency at a set rate (measured in hertz per second or hertz per minute). The vibratory amplitude as measured in *gs* may increase or decrease as well. A sine sweep will find resonant frequencies in the part. A random vibration profile will excite different frequencies along a spectrum at different times. Significant calculation goes into making sure that all frequencies get excited to within an acceptable tolerance band. A random vibration test suite may range anywhere from 30 seconds up to several hours. It is intended to synthesize the effect of, for example, a car driving over rough terrain or a rocket taking off. A synthesized shock pulse is a short duration high level vibration calculated as a sum of many half-sine waves covering a range of frequencies. It is intended to simulate the effects of an impact or explosion. A shock pulse test typically lasts less than a second. Vibrating tables can also be used in the packaging process in material handling industries to shake or settle a container so it can hold more product.

VI. CONCLUSION

The proposed navigation aid has been developed in order to enhance the independent mobility of blind individuals. This system also focuses on most of the navigation problems faced by blind n indoor as well as outdoor. This proposal will make blind people to open their eyes by closing it. To conclude, we would like to say that engineering does not just stop at gaining knowledge and innovating, it ends when you are able to use that knowledge for the benefit of your fellow human beings. As the saying goes, “If engineering is the application of science for human benefit, then the engineer must be a student of not only the application of science but of human benefit as well.”

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