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Research Article

An IVR Based Intelligent Guidance Stick for Blind

Mohit Saraf[A], Mohd Shehzad[B] and Neeraj Jadhav[B]

[A] Department of Information Technology, University of Mumbai (Mumbai)
[B]K.J. Somaiya College of Engineering, Mumbai, Maharashtra.

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Abstract

The development of an IVR Based Intelligent Guidance Stick has been proposed in this paper. The system involves use of two different circuits embedded on a stick. The first circuit will consist of an Arduino Uno board interfaced with three ultrasonic sensors which will be used to detect obstacles and a speaker which will provide an audio output to the user accordingly regarding the direction of the incoming obstacle. It will continuously check for the obstacles in three directions and if an obstacle is found within a specified range it will notify the user about the obstacle and its direction. The second circuit will be used to detect the potholes present and will alert the user of the same using continuous beeps. It will continuously check for the potholes and once a pothole is detected the buzzer will sound continuous beeps. This circuit uses a traditional 8051 microcontroller technology and has one ultrasonic sensor interfaced with it. Once a pothole is detected by this sensor, the microcontroller will instruct the buzzer to start buzzing. The stick will also have a wheel at its base for mobility of the stick. The whole system will be powered by two 9V batteries one for each circuit respectively.

Keywords: *Arduino Uno, ATmega 328, Ultrasonic sensors, Range Sensing**,** Obstacle Detection, IVR system, 8051 microcontroller, Blind Stick.*

1. Introduction

Today the range sensing domain is seeing one of the most effective advancements in terms of technology. The technology which was once restricted to large projects only is now easily accessible to general technology enthusiasts. The most commonly used technology for range sensing is the SONAR (Sound Navigation and Ranging) technology used by submarines for estimating the depth of the ocean bed. This technology is seeing an upsurge in the field of robotics and Artificial Intelligence. Well we have seen Bats fly endlessly without colliding into something inspite of having very weak eyesight which is almost negligible. They use this concept of range sensing similar to a SONAR system with the help of ultrasonic wave generation and sensing capabilities. This made us think that if bats can effectively guide themselves through obstacles in its path possessing negligible eyesight why can't a blind person. This concept formed the basis of our research paper. In general, the blind travels using a white cane or carries a guidance dog. But, the guidance dog is very expensive for the blind and hard to maintain. Therefore, most blind use white canes without the information of environmental situation. The most important function for the blind persons is to get information on the shape of the road and the position of obstacles when they are in unknown places. With this information, they need to arrive at their destinations, avoiding unexpected obstacles. Many robot technologies have been applied to guide the blind and some are commercially available. Sonic pathfinder alarms the blind when detecting the obstacle by the acoustic difference. However, it does not provide the accurate path or the position of an obstacle. They also fail to predict the terrain of the road on which the blind person is travelling. Considering these drawbacks we proposed a system which would overcome all these limitations by making the use of two different technologies amongst which one is the recent technology of Arduino Uno which uses ATmega 328 microcontroller Chipset. The other technology we will be using is the traditional 8051 microcontroller technology. These two circuits will be embedded on a stick whose total weight is going to be around 3 kg and will be having a height of 4 feet. Thus it will serve as a compact system supported by wheels at the base for smooth movement .The blind person would require the least amount of training to get started with the system thus making it is simple and easy to use.

2. Principle of Ultrasonic Range Sensing

If you want to make your system to sense the objects in it's surroundings we suggest you to go for an ultrasonic sensor. Though the IR based sensors are cheap, their working range may vary due to change in ambient light and won't give accurate range values.

*Correspondin author: **Mohit Saraf**

In case of ultrasonic sensors they work based on the principle of RADAR (Radio Detection and Ranging). RADAR transmits electromagnetic "pulse" towards the target and receives the "echo" reflected by the target.

Then the range of the target is determined by the "time lagging" between transmitted pulse and the received "echo". Generally microwave and ultrasonic frequencies are used in RADARS.

Our HC-SR04 ultrasonic sensor works similar to the RADAR mechanism but in a simplified manner. This sensor consists of four pins.

1. Vcc: connect to 5V dc.
2. Trigger: pulse input that triggers the sensor.
3. Echo: indicates the reception of echo from the target.
4. Gnd: ground final.

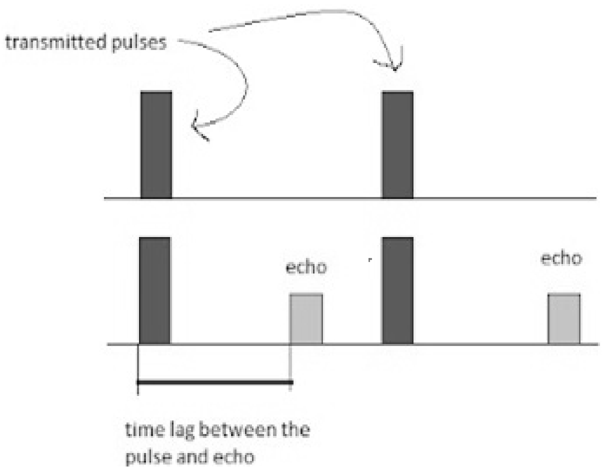

Fig.1 Diagram describing the basic algorithm in distance measurement using the sensor.

STEP1.

Make "Trig" pin of the sensor high for 10µs. This initiates a sensor cycle.

STEP2.

8 x 40 kHz pulses will be sent from the transmitting piezzo transducer of the sensor, after which time the "Echo" pin on the sensor will go from low to high.

STEP3.
The 40 kHz sound wave will bounce off the nearest object and return to the sensor.

STEP4.

When the sensor detects the reflected sound wave, the Echo pin will go low again.

STEP5.

The distance between the sensor and the detected object can be calculated based on the length of time the Echo pin is high.

STEP6.

If no object is detected, the Echo pin will stay high for 38ms and then go low.

The range of the obstacle can be calculated based on the time duration for which the echo pin is set high as shown below:

We know that the duration involves the time to travel towards the obstacle and time to travels back after reflection. Thus the signal traces the distance twice.

So the time taken by the signal to travel the distance is

$$Time = Total\ Duration/2$$

Since the ultrasonic pulse travels with the speed of sound i.e. 340.29 m/s or 34029 cm/s

$$The\ range\ of\ obstacle\ will\ be = Velocity * Time$$
$$= 34029 * Time$$

Since the Total duration will be calculated in microseconds by the timer, therefore

$$Range = 30429 * Time * 10^{-6}$$
$$Range = Total\ Duration/59$$

Type equation here.

3. System Architecture and Description

The system architecture is consists of two different modules. One is the obstacle detection module and the other one is the pothole detection module.

3.1 Obstacle Detection Module

The obstacle detection module uses the Arduino Uno Board which is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Table 1: Pin configuration used for interfacing with ultrasonic sensors

Sr. no	Sensor Direction	Arduino Pin no	Ultrasonic Pin no
1	Front	6	Echo
		7	Trigger
2	Right	3	Echo
		5	Trigger
3	Left	8	Echo
		10	Trigger

This is responsible for all the processing being done in the system. The arduino board has been interfaced with the three ultrasonic sensors respectively using the following pin configuration as shown in the table 1.

We have used HC-SR04 Ultrasonic sensors due to its simplicity in interfacing with Arduino Uno Board. The Arduino supports only 32 kb of on board flash memory which is insufficient for storing sound modules for this system. Thus we have interfaced the Arduino board with an SD Card Module using the following pin configuration as shown in table 2.

Table 2: Pin configuration used for interfacing with SD Card Module

SD Card Module	Arduino Uno
1 - GND	GND
2 - MISO	D12 (MISO)
3 - SCK	D13 (SCK)
4 - MOSI	D11 (MOSI)
5 - CS	D4 (SS)
6 - +5	+5V
7 - +3.3	N.C
8 - GND	N.C

A 0.5w 8 ohm speaker has also been connected to the Arduino Uno Board through a 100 ohm resistor using pin no 9 of the Arduino board. The SD card module contains the sound modules saved in it which are mapped to the corresponding instructions which gives the output through the speaker with respect to the direction of obstacle. The whole module will be powered by a 9v battery.

3.2 Pothole Detection Module

The pothole detection module has the AT89V51RD2 at its core. A key feature of the P89V51RD2 is its X2 mode option. The design engineer can choose to run the application with the conventional 80C51 clock rate (12 clocks per machine cycle) or select the X2 mode (six clocks per machine cycle) to achieve twice the throughput at the same clock frequency. Another way to benefit from this feature is to keep the same performance by reducing the clock frequency by half, thus dramatically reducing the EMI. The flash program memory supports both parallel programming and in serial ISP. Parallel programming mode offers gang-programming at high speed, reducing programming costs and time to market. ISP allows a device to be reprogrammed in the end product under software control. The capability to field /update the application firmware makes a wide range of applications possible. The P89V51RD2 is also capable of IAP, allowing the flash program memory to be reconfigured even while the application is running.

To interface the sensor to AT89V51RD2 microcontroller we need two I/O pins. One of them is external interrupt pin (INT0 or INT1) for measuring the pulse width at the echo pin and any other pin say P3.5. Connect the trigger pin of sensor to P3.5 of AT89V51RD2.Connect the echo pin of the sensor to INT0 (P3.3) 0f AT89V51RD2.Configure the TIMER0 of 8051 in 16 bit mode with “GATE” bit enabled. If the GATE pin is enabled and timer run control bit TR0 is set, the TIMER0 will be controlled by INT0 pin. When INT0 is high then the TIMER0 starts counting. Whenever INT0 goes low TIMER0 holds its count. So load the TMOD register with 00001010==0x0A. As the INT0 pin is input don’t forget to declare the pin input. Write “1” to the pin to make it input. Send a 10 micro second high pulse at trigger .Wait until the sensor transmits the eight 40 KHz pulses and signal reflection initially the echo pin is low when the transmitter completes the pulse the pin goes high then our TIMER0 starts counting. When input at INT0 goes low timer holds count. By this method we get the duration of the pulse. But sometimes due to errors in the sensor functioning the 8051 microcontroller may go into an infinite loop. For that there are two remedies:
1) Use watch dog timer
2) Generate a delay of 40 milliseconds after triggering the ultrasonic sensor.
The second option is preferred for beginners.
We have also connected a buzzer through an n-p-n transistor to pin 3.6 of the microcontroller. The module also has a voltage regulator I.C. 7805 as the microcontroller requires only 5V for its normal operations. This module is also powered by a separate 9V battery.

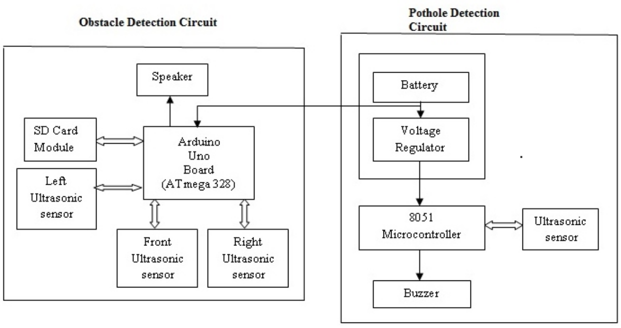

Fig.2 System architecture of the IVR based Intelligent Guidance Stick for blind

4. Working of the System

The working of the system consists of two parts one is the obstacle detection and the other part is pothole detection.
The obstacle detection circuit consists of three ultrasonic sensors interfaced to the Arduino Uno Board. They detect the presence of obstacle one by one in each direction and then the range of the obstacle is calculated. If the range is less than a minimum threshold in any of the three directions then it will give out a voice based instruction specifying the direction of the obstacle respectively through an IVR system.

The pothole detection system consists of an ultrasonic sensor and a buzzer interfaced with the 8051 microcontroller. The working of this circuit is based on the assumption that the height of the circuit embedded on the stick will remain constant in case of a plain path. But if there occurs any noticeable increase in its height from the ground above a certain threshold level then the buzzer will start buzzing. This will help the blind person in detecting a pothole or a staircase ahead. The following flowcharts show the working of the respective circuits.

Fig.3 Pothole detection algorithm

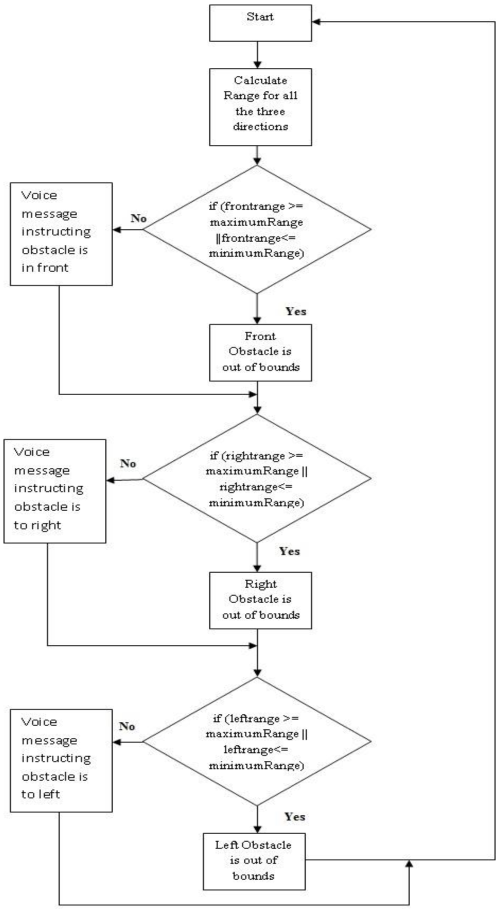

Fig.4 Obstacle detection algorithm

4. Tests and Results

The following screenshots show the various simulations carried out before implementing the actual system on the hardware. The 8051 program was simulated using the Keil uVision Compiler. We tested for change in values of the Dptr based on the duration for which the interrupt is kept high as shown in Fig 5 & 6.

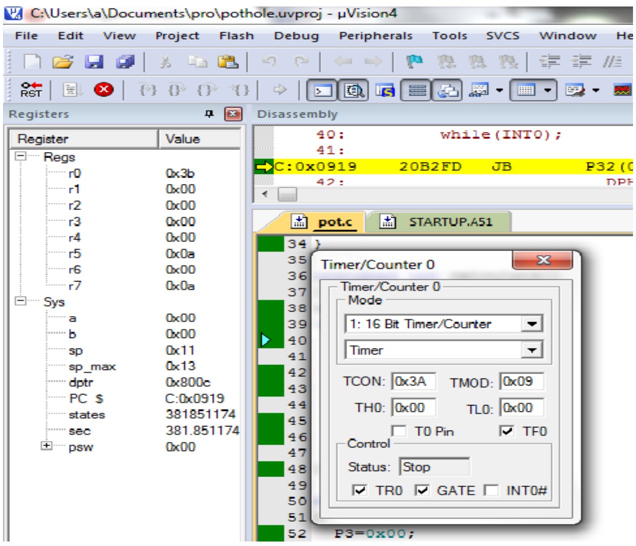

Fig.5 First Simulation result of 8051 on Keil uVision

The Arduino program was simulated using the Arduino IDE .In this we made use of serial monitor to check whether the obstacle is properly being detected for the respective direction or not as shown in Fig 7.

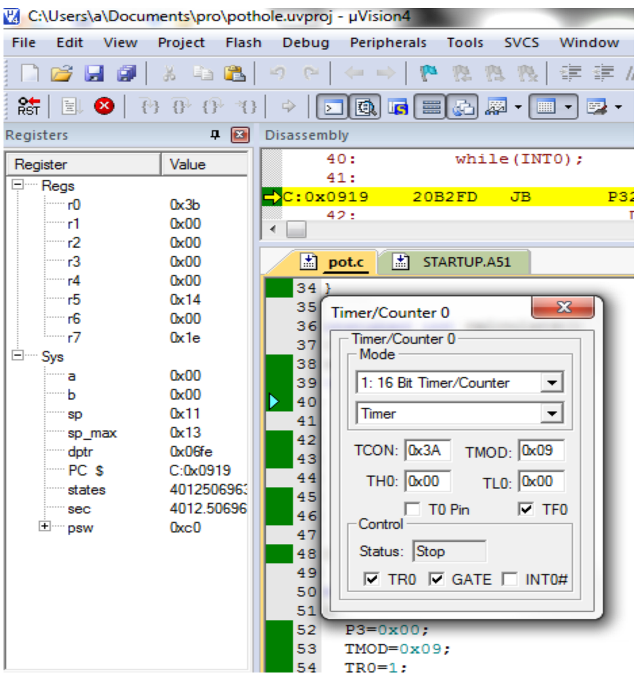

Fig.6 Second Simulation result of 8051 on Keil uVision

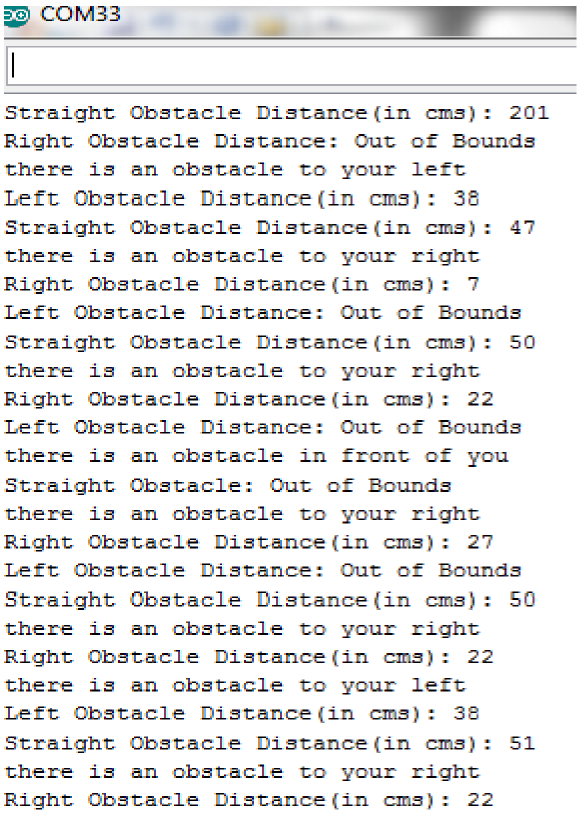

Fig.7 Simulation result of Arduino

Conclusions

This paper presents the implementation of an IVR based Intelligent Guidance Stick for blind. The system has been implemented using the two technologies which are 8051 microcontroller and Arduino. Thus we have reached the following conclusion implementing this system:

1) The system will be able to detect obstacles and notify the user regarding their directions using voice message.
2) The system will be able to detect the potholes and staircases and alert the users of the same.
3) The system will serve as a simple and compact aid for the blind.
4) In future a dynamo can also be attached with the wheels at the base to charge the battery.
5) GPS functionality could also be added to keep a track of the blind person.

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