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AN EFFICIENT ASSISTIVE SYSTEM FOR THE VISUALLY IMPAIRED

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ABSTRACT

This paper presents an assistive system for the visually impaired that helps the individual to move about in the environment freely and avoids obstacles in the process. This small and efficient obstacle detection system (ODS) is placed on the shoes of the visually challenged person to provide free mobility for the individual. The system contains a microcontroller ARM cortex M3 LPC1768 which receives data from two sensors for obstacle detection. An ultrasonic sensor is used as the range finder and an infrared sensor is used to decrease the number of false positives of detections and make the system more decisive. To increase the efficiency of the system, a force sensitive resistor (FSR) sensor is placed at the sole of the shoe. This system also sends the obstacle distance values to a cloud server which can be accessed anywhere and at any time.

Keywords: obstacle detection system, LPC1768, ultrasonic sensor, wireless, cloud.

1. INTRODUCTION

It is a big challenge for the visually impaired individuals to perform day to day activities without vision. Adjustable wireless obstacle detection system provides hand free interaction over other mobility assistive devices with various alarm units such as a tactile vibratory sensor, speech synthesiser and a buzzer to warn the person if there is an obstacle nearby [1]. There are electronic bracelets available which are echo location based obstacle detection and avoidance system. These provide obstacle detection at waist or chest level with the use of ultrasonic sensors [2]. There are obstacle detection systems which use multiple sensors and alarm units to minimize contact with the obstacles and move around easily [3]. Different pre-recorded messages and vibrations are used based on the distance between the obstacle and the individual. Sensors such as optical sensors and ultrasonic sensors have been used for the obstacle detection system [4] but optical sensors are known to be very expensive. Infrared sensor based smart sticks are also available which use two infrared sensors, one for detecting the height of the obstacle and the other which is inclined is used for detecting staircases and ground obstacles [5]. Portable ultrasonic navigation systems use stereoscopic sonar system to detect obstacles and send back vibro-tactile feedback to inform the visually impaired about the location [6]. This aid provides information about the urban walking routes to the user and points out what decision to make. Ultrasonic stick for the blind used ultrasonic sensors which when the obstacles are detected caused the activation of the buzzer and vibration motor [7]. Another intelligent walking stick used RFID tags and GPS system for indoor and outdoor navigation separately [8]. The ultrasonic stick was further modified by including a wireless remote control system which can be used in case the stick is lost [9]. A sensor assisted stick was developed to detect obstacles in various directions, detecting pits and manholes on the ground and to avoid them [10].

2. SYSTEM OVERVIEW

This paper presents an obstacle detection system, as shown in Figure-1, which uses ARM cortex M3 LPC1768 as the microcontroller. This microcontroller is a 32 bit processor with ARM v7-M architecture. It uses thumb-2 instruction set. It has a 512KB flash memory, a 64KB data memory and a processor frequency of 100Hz. It has 13 General Purpose Input-Output (GPIO) registers, 6 Pulse Width Modulation (PWM) pins and 8 channel 12-bit analog to digital converter (ADC). Using the data collected from the ultrasonic sensor, the microcontroller dynamically computes the distance of the obstacles detected in its path. The infrared sensor is used to decrease the number of false positives of detections. When the pressure is applied on the force sensitive resistor (FSR), the values from the ultrasonic sensor and infrared sensor are monitored.

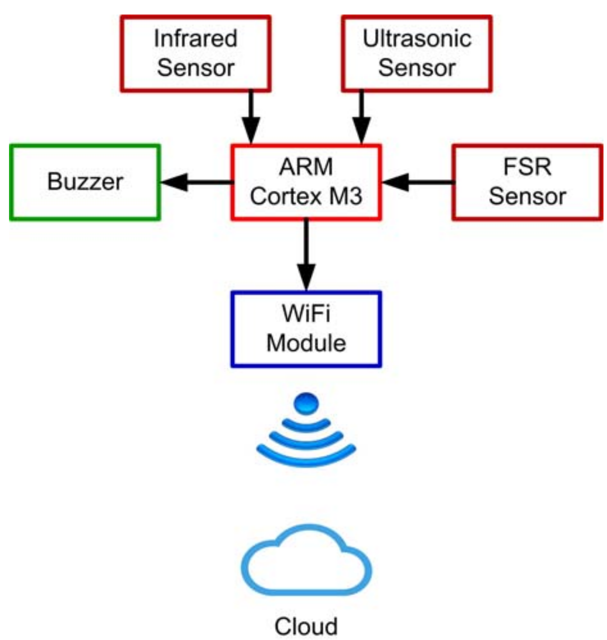

Figure-1. Obstacle detection system.

In the scenario of no pressure being applied on the FSR, we drive the microcontroller into sleep mode. This makes the system more efficient. The ultrasonic and the infrared sensors are placed on the top of the shoe while the FSR sensor is placed at the sole of the shoe. The Wi-Fi module used is ESP8226. The distance values are sent using this Wi-Fi module to a cloud server.

3. SYSTEM DESCRIPTION

A. FSR Sensor

The Force Sensitive Resistor (FSR) is placed at the bottom of the shoe as shown in Figure-4. The FSR works on the underlying principle that if there is any pressure applied to the piezoelectric part of the sensor the resistance decreases. The FSR when not in contact can be analysed as an infinite resistance and when certain pressure is applied on the piezoelectric part of the sensor the corresponding resistance decreases with respect to the applied pressure. The inclusion of FSR helps us to monitor the values from the sensor only when the individual is standing upright on his/her feet and walking, that is when the pressure is applied on this sensor placed at the sole of the shoe.

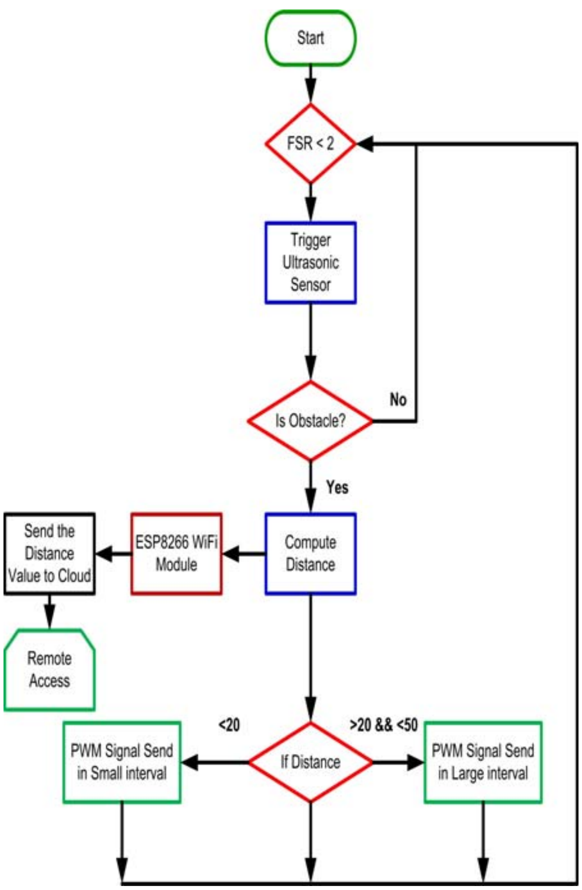

Figure-2. Decision making flow chart.

Figure-3. Device Prototype front view.

Figure-4. Device Prototype - FSR attached at the bottom of the shoe.

B. Obstacle detection and distance calculation

As shown in Figure-3, the obstacles are detected using two sensors. The infrared sensor is used to decrease the number of false positives of the detection and make the system more decisive. The ultrasonic sensor dynamically computes the distance using the echolocation principle. Here the transmitter sends short ultrasonic pulse which gets reflected by the obstacle and is receiver observes the first echo with a threshold level. The distance (d) between the ultrasonic sensor and the obstacle is calculated by multiplying the speed of sound in air (c) by the measured round trip time of flight (TOF) when the echo amplitude first exceeds the desired threshold [11].

$$d = \frac{(TOF \times c)}{2} \quad (1)$$

Once the ultrasonic sensor returns the distance value and based on the proximity of the object the buzzer is activated. If the distance of the object is close, then the intensity of vibration is high and henceforth. This change in the intensity value is achieved by using the PWM function of the microcontroller.

C. Wireless communication from the microcontroller to the cloud

The microcontroller is interfaced with a Wi-Fi module ESP8266. This Wi-Fi module acts as a gateway between the microcontroller and the internet. The distance values returned by the ultrasonic sensor to the microcontroller are communicated to the Thingspeak server via the Wi-Fi module which connects to the phone. The phone acts as the access point. This URL can be viewed from any part of the world. So, the caretaker of the impaired individual can constantly keep a check on the position of the impaired individual. If the person is very close to an obstacle then the caretaker can send a signal remotely and activate the buzzer.

4. RESULTS AND DISCUSSIONS

The distance values computed by the Ultrasonic sensor are successfully updated to the Thingspeak cloud platform, as shown in Figure-5.

This channel on Thingspeak server can be accessed using https://thingspeak.com/channels/250545. The channel is set to public view currently, but it can also be set to private view depending on the necessities of the user. The graph updates the values every minute and this also can be changed according to the desire of the user.

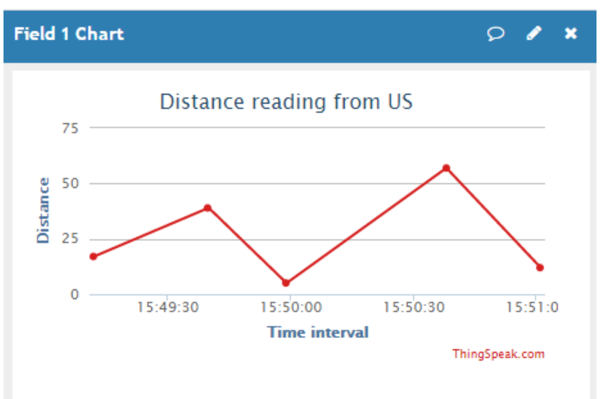

Figure-5. Thingspeak web page.

5. CONCLUSIONS

The Obstacle Detection System (ODS) detects the obstacle in its path, computes the distance and based on the computed distance it activates the buzzer. If the distance of the obstacle calculated is near, then the buzzer is sent a high frequency pulse which ensures that the buzzer is giving out a high intensity and loud sound output, and henceforth. The distance values are also sent to the server wirelessly with the help of a Wi-Fi module. The inclusion of the cloud platform helps the caretaker to monitor the individual from anywhere and send a signal remotely to activate the buzzer if the person is very close to the obstacle. In conclusion, this system is more reliable and efficient than the other similar systems proposed.

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