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Obstacle Detection Stick for the Visually Impaired Using HC-SR04 Ultrasonic Sensor and Arduino Nano Microcontroller-based Raindrop Sensor

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: With the stick, blind people can not only project their goals well, but also anticipate obstacles from the front, right, left, and unexpected puddles below without physical contact.
Study Design: Obstacle Detection Stick for the Visually Impaired Using HC-SR04 Ultrasonic Sensor and Arduino Nano Microcontroller-Based Raindrop Sensor.
Methodology: Calibration is performed by comparing the output value of the HC-SR04 ultrasonic sensor and the manual meter. The calibrated parameters are the distance of the obstacle at the

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front, left and right positions. The relationship between the measured values of the design tool and the manual measuring instrument is determined by the linear regression method to obtain the correction equation and the accuracy of the design tool.
Results: Based on the research, the working system of the tool for the blind using an ultrasonic sensor is that when the obstacle is in the left position, the tool will emit a right turn sound and vice versa, when the obstacle is in the front and left position of the sensor, the tool will emit a right turn sound and when the obstacle is in the front and left position of the sensor, the tool will emit a left turn sound, If the obstacle is in the front, left and right positions, the tool will emit a U-turn sound and if the obstacle is in the front position, the tool will emit a U-turn sound, the sound produced comes from the audio card's SD module where the sound was previously recorded and the media used as the obstacle is the card**.** The percentage level of accuracy obtained by the HC-SR04 ultrasonic sensor in the front position is 96.875%, in the left position is 90.625%, and in the right position is 93.75%. The maximum distance the ultrasonic sensor can detect is 147 cm. In the raindrop sensor, the buzzer sounds when the raindrop sensor detects water if the raindrop sensor reading is more than 5 cm from the bottom of the blind cane, and the buzzer does not sound if the raindrop sensor reading is less than 5 cm.
Conclusion: The HC-SR04 ultrasonic sensor works by using the obstacle's ability to reflect back the ultrasonic waves sent by the ultrasonic sensor to detect the distance between the stick and the obstacle.

Keywords: Visually impaired; arduino nano; HC-SR04 ultrasonic sensor; raindrop sensor.

1. INTRODUCTION

Advances in science and technology have encouraged humans to try to resolve all the problems that arise around them, and make existing work simpler, even providing solutions for people with disabilities, for example, by making aids for the blind [1].

When a person has a visual impairment, the information they receive is not as good as a person with normal vision, so their ability to move is more limited. Visual impairment is caused by accidents, age, disease, or birth defects [2].

I Gede Surya Adi Pranata and Prof. Dr. Drs. Anak Agung Ngurah Gunawan realized of visually impaired glasses using compass and distance sensors based on the AT89S52 microcontroller has been successful. The trial of this aid for the visually impaired is carried out with CMPS11 Directional and obstacle detection using HC-SR04, which uses 40,000 Hz ultrasonic waves with a success rate of 80%. Of the three different obstacles used in this study, the most stable distance measurement was obtained using a glass barrier with an average maximum deviation of -3 cm up to a distance of 400 cm, and the worst distance measurement stability was obtained using a mahogany tree trunk as a barrier with an average deviation of ±3 cm starting at a distance of 276 cm and a total deviation of 23.6 cm. Measurement of cardinal directions with the CMPS11 has an average error value of 0.43% [1].

Andreas and Wisnu Wedanto realized of visually impaired assistive sticks using ultrasonic sensors, arduino uno, buzzer and DC vibrator motors that can increase the tempo as the assistive stick approaches the object, and equipped with LEDs to display the status of the assistive stick is made to find objects at a distance of ≤50 cm and ≤150 cm accompanied by vibration of the DC vibrator with a pause of 0. 1 second, if barrier distance is <50 cm, buzzer sounds flashes very fast, <100 cm the sound flashes slowly and <300 cm the sound flashes very slowly and if the distance is >300 cm then there is no sound [3].

K. S .Manikanta T. S. S Phani and A. Pravin successful development the blind assistive stick using arduino nano, HC-SR04 ultrasonic sensor, GSM/GPS 800L, buzzer, and DC motor is a form of design and implementation of a smart stick that can help the blind navigate safely and either indoors or outdoors, this stick can detect obstacles in the user's path within a range of three meters. GPS and GSM module is used to communicate the location of the blind person to relatives or family [4].

The author designed an obstacle detection stick for blind people based on Arduino nano microcontroller using HC-SR04 ultrasonic sensor as input, buzzer as sound indicator, SD card audio module as sound indicator and raindrop sensor as water detector, and on/off button. With this tool, blind people can project their goals well,

in addition to anticipating obstacles from the front, right, left, and unexpected puddles below without physical contact.

1.1 Arduino Nano

Arduino nano is a microcontroller board based on ATMega328. Arduino nano has 14 digital input/output pins, 6 of which can be used as PWM outputs, 6 analog inputs, 16 MHz crystal oscillator, USB connector and reset button [5].

Arduino nano also has several ways to communicate with computers, other Arduinos, and other microcontrollers. Atmega328 provides serial UART TTL (5V) communication available on digital pins 0 (RX) and 1 (TX) [6]. The following physical form of Arduino nano is shown as in Fig. 1.

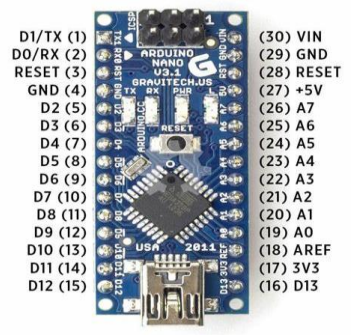

Fig. 1. Arduino nano

1.2 HC-SR04 Ultrasonic Sensor

HC-SR04 ultrasonic sensor is a sensor based on sound wave reflection principle and is the detection of the presence of a specific object in front of it, its operating frequency is in the range of sound waves from 40 KHz to 400 KHz. There are two parts to the HC-SR04 ultrasonic sensor, the transmitter and the receiver. A piezoelectric crystal attached to a mechanical anchor forms the structure of the transmitter and receiver units a vibrating diaphragm. Alternating voltage with an operating frequency of 40 KHz - 400 KHz is applied to the metal plate [7]. The physical form of the ultrasonic sensor is shown in Fig. 2.

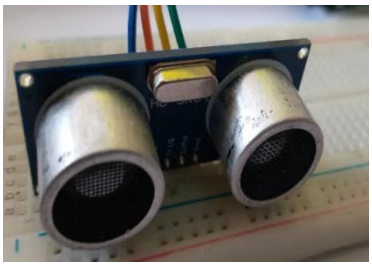

Fig. 2. HC-SR04 ultrasonic sensor

Atomic structure of the piezoelectric crystal shrinks (binds), expands or contracts against the polarity of the applied voltage, called the piezoelectric effect. Contraction that occurs is transmitted to the vibrating diaphragm, emitting ultrasonic waves into the air (surrounding space). The reflect of ultrasonic waves occurs when a certain object exists and the reflection of HC-SR04 ultrasonic sensor waves is returned by the receiving sensor unit. In addition, the receiving sensor unit will cause the vibrating diaphragm to vibrate and the piezoelectric effect will be activated will generate AC voltage of the same frequency [7].

1.3 Buzzer

Buzzer is a part of electronics with the use to convert electrical energy into vibration or sound. Buzzers have the same working principle as loudspeakers, the buzzer working process includes waves that are on the diaphragm and are electrified, which are commonly referred to as electromagnets, these waves will be attracted outward or inward, this depends on the polarity of the magnet and the direction of the current, there will be random wave movements that cause the air to vibrate and produce sound. Buzzers are often used as indicators of a process that is taking place or an error that has occurred [8,9]. The physical form of the buzzer is shown in Fig. 3.

Fig. 3. Buzzer

1.4 Raindrop Sensor

The raindrop sensor is a sensor that functions to detect the presence or absence of raindrop conditions, which can be used in various applications ranging from simple to complex applications [10]. The physical form of the raindrop sensor is shown in Fig. 4.

Fig. 4. Raindrop sensor

The working principle of this sensor module is that when rainwater falls and hits the sensor panel, a rainwater electrolysis process occurs. And because rainwater is included in the electrolyte liquid group, the liquid will conduct electric current. In this rain sensor there is a comparator IC where the output of this sensor can be in the form of high and low logic (on or off). And in this sensor module there is an output in the form of voltage [10].

2. METHODS

2.1 Design Results

The implementation of the research on obstacle detection stick for the blind using HC-SR04 ultrasonic sensor and Arduino nano microcontroller based raindrop sensor is carried out according to the system block diagram in Fig. 5.

2.1.1 Block digram

In Fig. 5, there is an arduino nano as a microcontroller to activate all the components. The ultrasonic sensor will receive input in the form of an obstacle, then the analog data obtained from the ultrasonic sensor will be processed by the arduino nano, which functions to convert the analog data into digital data, which will make the SD card module sound as an output. While the raindrop sensor receives input in the form of a puddle and has analog data, the input processed by arduino nano still produces analog data and output in the form of sound.

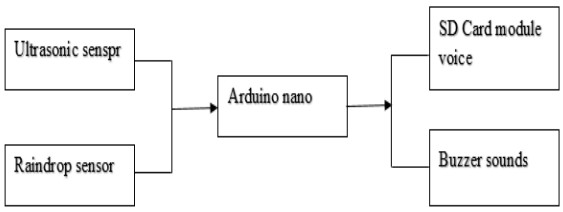

Fig. 5. Block diagram of design tool

2.1.2 Schematic of all components

Fig. 6 shows a schematic of all the components, consisting of three HC-SR04 ultrasonic sensors, a buzzer, a rain drop sensor, a speaker, a H.Q 5 W 8 Ω speaker, an SD card audio module, and a serial MP3 playback module connected to the Arduino nano pin.

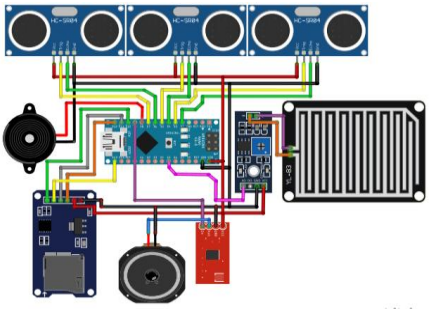

Fig. 6. Schematic of all components

3. RESULTS AND DISCUSSION

3.1 Results

The following design tools used in the research of obstacle detection stick for the blind using HC-SR04 ultrasonic sensor and Arduino nano microcontroller-based raindrop sensor are shown in Fig. 7.

The working system of the tool for the blind using an ultrasonic sensor is that when the obstacle is in the left position, the tool will emit a right turn sound and vice versa, when the obstacle is in the front and left position of the sensor, the tool will emit a right turn sound and when the obstacle is in the front and left position of the sensor, the tool will emit a left turn sound, If the obstacle is in the front, left and right positions, the tool will emit a U-turn sound and if the obstacle is in the front position, the tool will emit a U-turn sound, the sound produced comes from the audio card's SD module where the sound was previously recorded and the media used as the obstacle is the card. The maximum distance the ultrasonic sensor can detect is 147 cm [11-15].

3.2 Discussion

3.2.1 Calibration data

This study was measured using a meter with a minimum distance of 0 cm to a maximum distance of 147 cm for the front, left, and right positions. The results of the calibration data analysis obtained produce a linear graph as shown in Fig. 8, Fig. 9 and Fig. 10.

3.2.2 Accuracy calculation result

Based on the results obtained from the test data, an accuracy calculation is performed to determine the percentage level of accuracy of

the reference data with the sensor output data in the front, right and left positions, resulting in a value of 96.875% for the front position, 90.625% for the left position and 93.75% for the right position.

Fig. 7. Research design tool

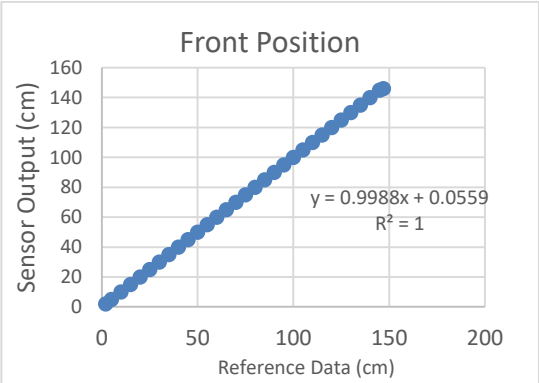

Fig. 8. Linear graph of front position tool test data

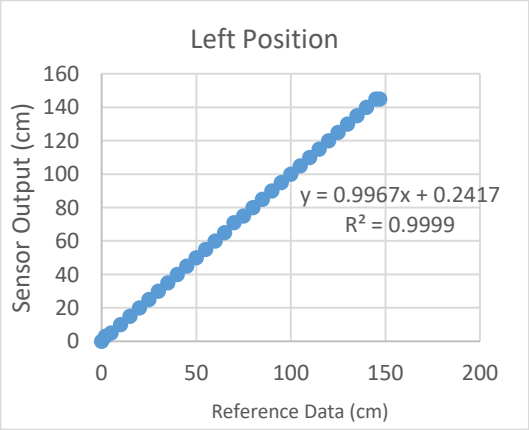

Fig. 9. Linear graph of left position tool test data

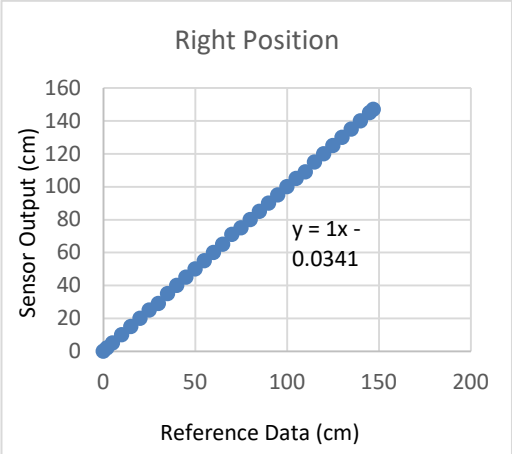

Fig. 10. Linear graph of right position tool test data

3.2.3 Raindrop sensor detection result

Based on the data obtained during the research, the buzzer will sound when the raindrop sensor detects water if the raindrop sensor reading is at a water depth of more than 5 cm under the blind stick, and the buzzer will not sound if the raindrop sensor reading is less than 5 cm.

4. CONCLUSION

Conclusions obtained are:

1. The stick can work when the HC-SR04 ultrasonic sensor detects an obstacle in the path of the stick user and outputs a sound from the audio SD card module.
2. The HC-SR04 ultrasonic sensor works based on the ability of the obstacle to reflect back the ultrasonic waves sent by the ultrasonic sensor so that it can detect the distance between the stick and the obstacle.
3. The percentage accuracy achieved by the HC-SR04 ultrasonic sensor in front position is 96.875%, in the left position is 90.625%, and in the right position is 93.75%.
4. On the raindrop sensor, the buzzer sounds when the raindrop sensor detects water if the raindrop sensor reading is more than 2 inches of water under the blind cane, and the buzzer does not sound if the raindrop sensor reading is less than 5 cm.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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