Smart-Cane for The Blind with A Sensor Detection Approach

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ABSTRACT

Not all humans are created with normal eyes. Blindness is not only interfered with daily activities but also has socio-economic impacts on the environment, society, and the country. Those who have visual impairment usually have difficulty when walking and doing activities, while they still generally use traditional and manual walking sticks to help them. This research aims to help blind people carry out activities and improve facilities to use more sophisticated technology. The method used in this study is to use the prototype method. It is a process where simple modeling allows visually impaired people to have a primary picture of the program and conduct initial testing on tools, and facilitate the blind to interact with each other during the manufacturing process so that developers can easily model the software to be made. The results of this study constructed an automatic stick that can detect obstructions in front and top and detect puddles using a buzzer as a notification if the tool detects a barrier object. With seven tests using different materials, the average front sensor error value is 0.68%, the sensor works well, with two testing trials using other materials, the average sensor error value is above 0.95% and can detect water in front of the tool user.

INTRODUCTION

The general term of the word visually impaired is often used in the condition of someone who experiences interference or obstacles in their sense of sight. The blindness of a blind person not only interferes with daily activities but also causes social and economic impacts on the family, the environment,
and its surroundings. That is, the low productivity of a blind person with particular limitations harms income that is not optimal from a family and an area of residence. On the other hand, it is the responsibility of relatives around him, and people who are physically fit to help move from one place to another or from one activity to another or in various activities that require vision so that the productivity of people who see it becomes constrained.

The location of the problem that occurs is the difficulty of a blind person maximizing his mobility, walking aids for those who are still using this tool manually due to the lack of media or aids for the blind in carrying out an activity. As stated above, the writer aims to build an Arduino Uno-based walking aid for the blind. To facilitate the visually impaired carrying out a walking activity, making the visually impaired, safer and more controlled when carrying out a walking activity. Improve facilities to use more sophisticated and modern technology. And provide comfort and safety for visually impaired walking or activities. Nowadays, many developing technologies help blind people walk with sensor modules, voice control (Deepthi et al., 2018), GPS, and others. This research enhances the device's function into an intelligent tool with a more comprehensive sensor detection approach on seven test materials.

There have been some microcontroller-based researches on blind mobility. There are two stages of design, namely manufacturing tools and testing tools. The device made using an HC-SR04 ultrasonic sensor, two Arduino nano, an SG90 servo motor, and a buzzer, has produced a smart-cane that has an accuracy of 99.995% with a precision (repeatability) of 98,600%. So this tool has a percentage of the success rate of 98,400% (Habibi, 2018).

The design of sticks that help blind people detect obstructions and water (Talele et al., 2019). Researchers discuss a device that can detect obstacles or detect water as objects that block blind people's activity (Rahman, 2018). Originated from a blind person's problem when activating, namely crashing into an object and falling. To prevent these problems, we need a tool that can help blind (Ali et al., 2018) people when walking. The Stick is equipped with a Soil Moisture Sensor, which functions as a water detector, and the SRF04 Ultrasonic Sensor functions as a barrier detector. In this case, it can be a solution to the problem of blind people when walking.

The third eye for the visually impaired uses ultrasonic sensors and Arduino Pro Mini 328, explaining technological advancements, replacing a very manual stick with an instrument that automatically uses an ultrasonic sensor to visually impaired people freer in motion (Nowshin et al., 2018). Ultrasonic sensors work by reflecting ultrasonic waves as a transmitter and calculating distances with the time difference. The accuracy of the ultrasonic sensor is from 2 cm to 200 cm. The data processor used is the Arduino pro mini 328 microcontroller and the MCU esp8266 node, and the output is in the form of sound issued by a raspberry pi. This visually impaired third eye tool uses an ultrasonic sensor and the Arduino Pro mini 328 clock-shaped as the main design. The sensor is placed in front to detect objects that are at the distance of the sensor reflection. Raspberry pi (Singh et al., 2019) is placed in the user's pocket and connected to the headset to warn when the ultrasonic sensor is active. The third eye tool visually-impaired uses ultrasonic sensors, and the Arduino Pro Mini 328 has specifications in detecting distances 45 cm ahead and 65 cm down. The distance from the sensory leg to the blind person is limited to 30-35 cm for the obstacles in front and 56 to 65 cm for the stairs (Subbiah et al., 2019).
RESEARCH METHODS

1. Design Diagram

System design can be formed in the form of a depiction of the process elements of a component. This design process can be said to be like the initial stages of the Arduino-Based Uno Blind Walking Aid design process.

The Activity Diagram illustrates the stage of system modeling, and this activity diagram can also be used to show the system's workflow. It can also be used to provide a history of event flow. To provide historical results in the order of activities that exist on the blind walking aids proposed to the blind can be seen in the activity diagram as follows:

![Activity Diagram of Proposed Tools](http://dx.doi.org/10.35671/telematika.v13i2.991)

Description of the figure 1 Activity Diagram of the proposed tool as a whole is a distance detection barrier and water detector where the device consists of proximity sensor I, proximity sensor II, water level sensor, and buzzer with material as a barrier object and a pool of water.

In each sequence diagram, there is the action of the first actor S1 will detect if in front there is a barrier such as a car, a wall, a tree, etc., which is a barrier object. When ultrasonic waves reflect the proximity sensor, the buzzer will sound as a sign that a barrier is detected in front of it. Likewise, the S2 will detect if there is a barrier at the top. When the proximity sensor gets reflected ultrasonic waves, the buzzer will sound as a sign that a barrier is detected in front of it. And the last is the water level sensor, where the water level sensor has been designed by adding two wires along with the Stick. The water level sensor will be designed as a water detector. An experiment was then carried out; if the end of the cable could respond to water, the buzzer notification would sound, and the program would run well.
2. Prototype Diagram

![Prototype Diagram]

Based on Figure 2 prototype Design of Proposed Tools, the function of proposed tools to be made by analysts can be described as follows, the battery functions as a power supply or voltage source for running devices and sensors. The Stick functions as a proposed tool framework, with simple design functionality but as a prototype design to meet the blind's needs in their activities. This box serves as a protector for Arduino Uno boards and other components from water and direct touch, causing components to be damaged. The wheel functions as a mover so that the blind person only needs to push the Stick forward. The wheel will roll down the road, and if you get an uneven or steep road, the user will feel it different. If the Stick without the wheel is just a few inches away, the Stick is raised to the next step, and the user will not know if there is a dangerous object in front of him, so this feature helps conventional mechanisms. Arduino Uno functions as the center of the proposed tool system and becomes the brain of other devices. Proximity sensors act as detectors if there are obstacles in the front and around the intended road. The water level sensor functions as a water detector, so this Stick can also detect a puddle of water in front of the user. A bell, as a notification, will sound to alert the user.

RESULTS AND DISCUSSION

1. Results.

The writer tests the proximity sensor hcr04.

Following are the results of the hcr04 proximity sensor test:

a. The author tested seven times seven types of barriers. A front sensor serves to detect obstacles in front with a distance of 0 cm – 100 cm from the sensor.

b. The author tests twice on two types of barriers. The top sensor serves to detect the obstacles above with a distance of 0 cm – 100 cm from the sensor.

c. The writer tests the water level sensor by placing water on the floor. The water level sensor has been designed so that it can detect that there is a pool of water in front.

Following are the results of the hcr04 proximity sensor test:
From the data Table 1, it has been determined manually measuring distances, respectively, for fabric and wall materials 70 cm, iron 100 cm, wood, and cardboard 60 cm, chairs 78 cm, and humans within 75 cm. And the test results with a distance above all sensors respond well by making a sound 'beep.' The graphic display can be seen in figure 3.

![Figure 3. Testing The Front Sensor Graph](image)

Table 2. Top Sensor Testing Table

<table>
<thead>
<tr>
<th>Material</th>
<th>Top Sensor</th>
<th>Manual Measuring Instrument</th>
<th>Buzzer</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-tube buffer iron</td>
<td>109 cm</td>
<td>110 cm</td>
<td>Reads</td>
<td>Active Sensor</td>
</tr>
<tr>
<td>Clothesline</td>
<td>70 cm</td>
<td>70 cm</td>
<td>Reads</td>
<td>Active Sensor</td>
</tr>
</tbody>
</table>

In the test results of Table 2 also produces a good response; all sensors are readable by sound on the buzzer.
From the results of testing the hcr04 proximity sensor that has been done above, it can be determined the value of the sensor error using the following equation:

\[ \%\text{error} = \frac{X - Xi}{X} \times 100 \]  

(1)

Information:

\( X \) = Measurement Results  

\( Xi \) = Test Result  

\( \%\text{Error} \) = Systematic Error

Calculation Of Error Values On Distance Testing With HCR04 (Front):

The test results above use a systematic error calculation at the distance sensor, and the calculation results are as follows:

a. \( \%\text{error} = \left( \frac{70 - 70}{70} \right) \times 100\% \)  
\( \%\text{error} = 0\% \)

b. \( \%\text{error} = \left( \frac{70 - 70}{70} \right) \times 100\% \)  
\( \%\text{error} = 0\% \)

c. \( \%\text{error} = \left( \frac{100 - 99}{100} \right) \times 100\% \)  
\( \%\text{error} = 1\% \)

d. \( \%\text{error} = \left( \frac{60 - 60}{60} \right) \times 100\% \)  
\( \%\text{error} = 0\% \)

e. \( \%\text{error} = \left( \frac{60 - 60}{60} \right) \times 100\% \)  
\( \%\text{error} = 0\% \)

f. \( \%\text{error} = \left( \frac{80 - 78}{80} \right) \times 100\% \)  
\( \%\text{error} = 2.5\% \)

g. \( \%\text{error} = \left( \frac{75 - 74}{75} \right) \times 100\% \)  
\( \%\text{error} = 1.3\% \)

Average error value on distance testing with HCR04 (front):

\[ \%\text{error} = \left( \frac{\sum \%\text{error}}{\text{number of trials}} \right) \]  

(2)

\[ \%\text{error} = \left( \frac{0 + 0 + 1 + 0 + 0 + 2.5 + 1.3}{7} \right) \]  

\( \%\text{error} = 0.68\% \)
Calculation of the error value on the hcsr04 front test:

![Graph Value% Front Sensor Error](image)

**Figure 5. Graph Value% Front Sensor Error**

The calculation results that are displayed visually in Figure 5 illustrate the error value that appears from calculating the distance of the object with the device from the front with manual counting. Against the sensor, cloth has an error rate of 1.3%, 2.5% walls, while other media work well with a value of 0%.

Calculation Of The Error Value On Distance Testing With Hcr04

\[
\%\text{error} = \left( \frac{\text{Actual} - \text{Expected}}{\text{Expected}} \right) \times 100\%
\]

a. \(\%\text{error} = \left( \frac{110 - 109}{110} \right) \times 100\% = 1.90\%
\]

b. \(\%\text{error} = \left( \frac{70 - 70}{70} \right) \times 100\% = 0\%
\]

Average error value for Distance testing with HCR04 (above):

\[
\%\text{error} = \left( \frac{\sum \%\text{error}}{\text{number of trials}} \right)
\]

\(\%\text{error} = \left( \frac{0 + 1.90}{2} \right) = 0.95\%
\]

Water Level Sensor Test Results:

<table>
<thead>
<tr>
<th>Testing</th>
<th>There is water</th>
<th>There is no water</th>
<th>Output/buzzer</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>No.</td>
<td>On</td>
<td>When the sensor touches the surface of the water the buzzer will automatically sound</td>
</tr>
<tr>
<td>2</td>
<td>No</td>
<td>Yes</td>
<td>Off</td>
<td>If the sensor does not touch the water, the buzzer will not sound</td>
</tr>
</tbody>
</table>

In Table 3, the test results explain that the sensor responds if it touches the water surface and vice versa. This aims to make blind people know if there is water in front of their steps that could be dangerous for them.
2. Discussion

In this section, the results obtained are then analyzed. It should be noted that this tool’s testing uses seven test material materials, which are usually faced by blind people in walking, including humans, chairs, cardboard, cloth, wood, iron, and walls. The seven materials were tested using an HCR04 sensor at close range through the front, top, and puddles. We know that several tools work to help the blind with different methods. Still, on this occasion, the author focuses on testing sensors with seven materials that are often encountered by blind people in walking.

The test results on the front sensor will detect if there is an object with a distance of 0 cm -100 cm from the sensor works well. With seven tests using different materials, the average value of the front sensor error is 0.68%. The top sensor will detect if there are objects with a distance of 0 cm -100 cm from the sensor. The sensor works well, with two trials using different materials, the average error value is 0.95%. Table 3 found that the water sensor will detect when there is a pool of water in front. The sensor works well and can detect the presence of water in front of the tool user.

CONCLUSIONS AND RECOMMENDATIONS

The application of blind walking aids is using detection using an ultrasonic sensor and one water level sensor. This tool can measure distances using an ultrasonic sensor and produce sound from the buzzer when the ultrasonic sensor detects objects at a distance between 0-100 cm at the top of the user. This Stick is also equipped with a water level sensor that can detect a pool of water in front of the user. From the results of testing the whole system, it can be concluded that the Stick can run optimally following the block diagram that has been prepared by the author. Future designs are suggested to design to get the best results from the system that has been implemented. The development can be adding value functions such as design improvements to be more practical and more comfortable, easily stored in a safe place, mostly out of the reach of children, adding GPS to detect the presence of visually impaired when outside the home. In the program, the library must increase the sound library so that ISD 2560 is needed for notification, such as distance information in cm for better and detailed information received by the user.

REFERENCES


