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Smart-Cane for The Blind with A Sensor Detection Approach

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ABSTRAK

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.

Kata kunci:
Arduino Uno
Tongkat Cerdas
Tunanetra
Sensor

ABSTRACT

Tidak semua manusia diciptakan dengan kondisi mata normal. Kebutaan tidak hanya mengganggu aktivitas sehari-hari tetapi juga berdampak sosial-ekonomi pada lingkungan, masyarakat, dan negara. Orang buta biasanya mengalami kesulitan saat berjalan dan melakukan aktivitas. Tongkat yang sering digunakan oleh tunanetra berjalan umumnya manual. Tujuan dari penelitian ini adalah untuk memfasilitasi orang buta dalam melakukan kegiatan dan meningkatkan fasilitas untuk menggunakan teknologi yang lebih canggih. Metode yang digunakan dalam penelitian ini adalah dengan menggunakan metode prototipe, yang merupakan proses di mana pemodelan sederhana memungkinkan tunanetra memiliki gambaran dasar dari program dan melakukan pengujian awal pada alat, dan memfasilitasi orang buta untuk berinteraksi satu sama lain selama proses pembuatan sehingga pengembang dapat dengan mudah memodelkan perangkat lunak yang akan dibuat. Hasil penelitian ini membuat tongkat cerdas yang dapat mendeteksi penghalang di depan dan atas serta mendeteksi genangan air menggunakan suara sebagai pemberitahuan jika alat mendeteksi objek penghalang. Dengan tujuh tes menggunakan bahan yang berbeda, nilai kesalahan sensor depan rata-rata adalah 0,68%, sensor bekerja dengan baik, dengan dua uji coba menggunakan bahan yang berbeda nilai kesalahan sensor rata-rata di atas 0,95% dan dapat mendeteksi keberadaan air di depan alat pengguna.

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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:

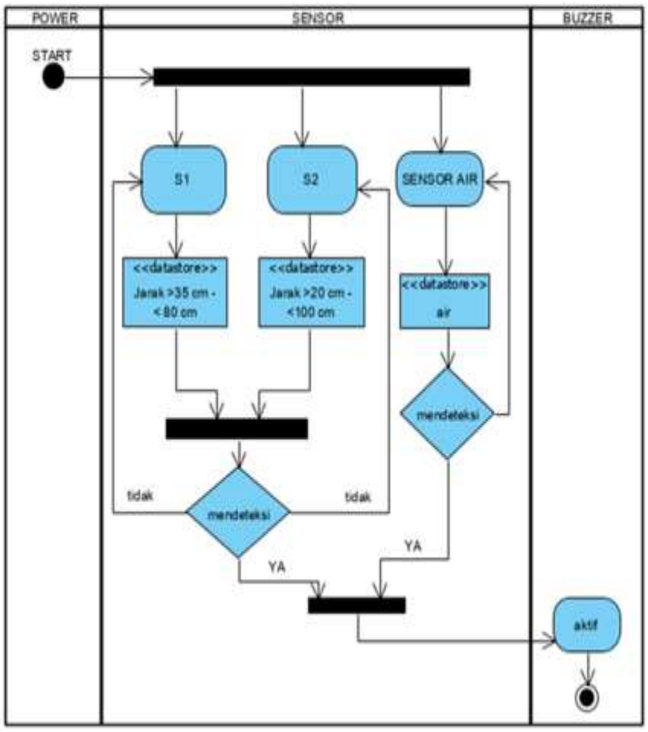

Figure 1. Activity Diagram of Proposed Tools

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

Figure 2. Proposed Prototype Tool Design

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:

Table 1. Front sensor testing table

Material	Front Sensor	Manual Measuring Devices	Buzzer	Information
Clotch	70 Cm	70 Cm	Reads	Active Sensor
Wall	70 Cm	70 Cm	Reads	Active Sensor
Iron	99 Cm	100 Cm	Reads	Active Sensor
Wood	60 Cm	60 Cm	Reads	Active Sensor
Cartboard	60 Cm	60 Cm	Reads	Active Sensor
Chair	78 Cm	80 Cm	Reads	Active Sensor
Human	74 Cm	75 Cm	Reads	Active Sensor

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.

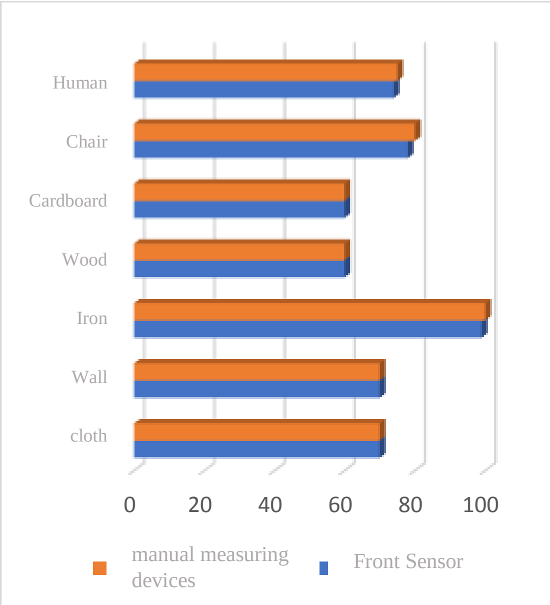

Figure 3. Testing The Front Sensor Graph

Figure 3 is a visual representation of the test results between objects and devices to get an optimal response with sensor sound. The best response is iron only 0.1 cm adrift of numbers, followed by chairs in second place. Iron has a better value, and this is because iron reflects ultrasonic waves better than other media. However, in reality, every day, the blind face the various media above depends on their activities.

Table 2. Top Sensor Testing Table

Material	Top Sensor	Manual Measuring Instrument	Buzzer	Information
Water-tube buffer iron	109 cm	110 cm	Reads	Active Sensor
Clothesline	70 cm	70 cm	Reads	Active Sensor

In the test results of Table 2 also produces a good response; all sensors are readable by sound on the buzzer.

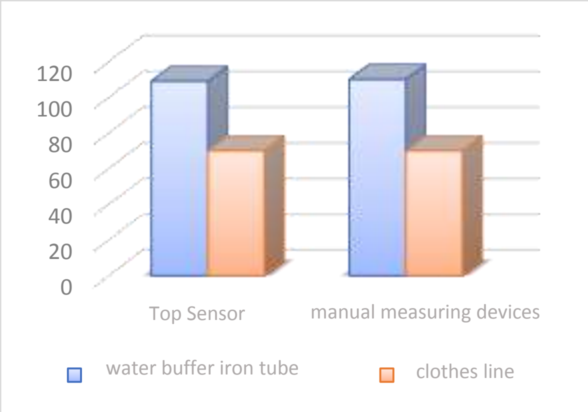

Figure 4. The Top Sensor Testing Chart

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:

$$\%error = \frac{X - Xi}{X} \times 100 \quad (1)$$

Information :

X = Measurement Results

Xi = Test Result

% 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. $\%error = \left(\frac{70-70}{70} \; x \; 100\%\right)$
$\%error = 0\ \%$

b. $\%error = \left(\frac{70-70}{70} \; x \; 100\%\right)$
$\%error = 0\ \%$

c. $\%error = \left(\frac{100-99}{100} \; x \; 100\%\right)$
$\%error = 1\ \%$

d. $\%error = \left(\frac{60-60}{60} \; x \; 100\%\right)$
$\%error = 0\ \%$

e. $\%error = \left(\frac{60-60}{60} \; x \; 100\%\right)$
$\%error = 0\%$

f. $\%error = \left(\frac{80-78}{80} \; x \; 100\%\right)$
$\%error = 2.5\%$

g. $\%error = \left(\frac{75-74}{75} \; x \; 100\%\right)$
$\%error = 1.3\%$

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

$$\%error = \left(\frac{\sum\%error}{number\ of\ trials}\right) \quad (2)$$

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

$\boldsymbol{\%error = 0.68}\ \%$

Calculation of the error value on the hcsr04 front test:

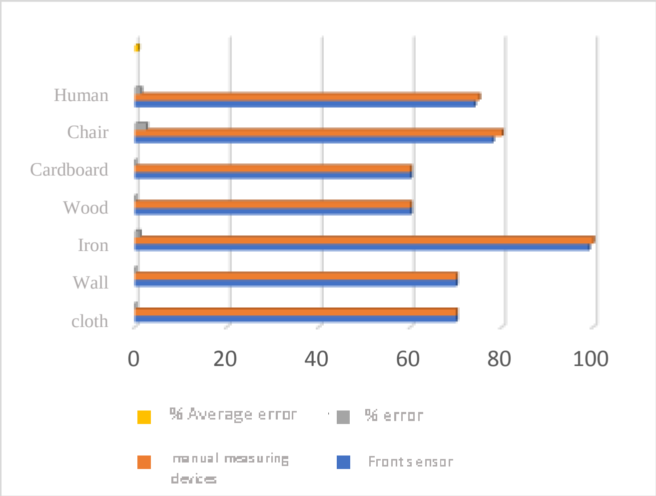

Figure 5. Graph Value% Front Sensor Error

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

a. $\%error = \left(\frac{110-109}{110} \; x \; 100\%\right)$

$\%error = 1.90\ \%$

$b.\ \%error = \left(\frac{70-70}{70} \; x \; 100\%\right)$

$\%error = 0\ \%$

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

$$\%error = \left(\frac{\sum \%error}{number\ of\ trials}\right) \tag{3}$$

$$\%error = \left(\frac{0+1.90}{2}\right)$$

$$\%error = 0.95\ \%$$

Water Level Sensor Test Results:

Table 3. Water Sensor Performance Testing

Testing	There is water	There is no water	Output/buzzer	Information
1	Yes	No.	On	When the sensor touches the surface of the water the buzzer will automatically sound
2	No	Yes	Off	If the sensor does not touch the water, the buzzer will not sound

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.

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