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Development of a Microcontroller-Based Blind Smart Tool Design to Detect Obstacles Above and Below Automatically

Siti Nafisa Ifansyah[1]*, Nurmahni Harahap[2], Rizka Anggia Dinda[3]
[1,2,3]MTsN 1 Banda Aceh, Indonesia

Abstract

The senses that function to record the surroundings are the eyes, so that they can know the objects they see. In fact, normal eyes are not owned by all humans; there are also those who have had visual impairments since birth. Blind canes are commonly used by blind people to walk. But sometimes blind people still have difficulty when there are potholes, so it is not uncommon for blind people to fall into the hole. If there are obstacles in front of or around them and the road surface is uneven or has potholes, the blind will also have difficulty. Therefore, there is a great need for a walker in the form of a stick that is more adequate for blind people. Utilizing an ultrasonic sensor as a necessity is one of the designs of a blind cane. The function of the ultrasonic sensor is to detect holes, bumps, and obstacles that are above or below. The ultrasonic sensor works by using several main components, namely Arduino Uno as a controller, an MP3 module as an output, and a buzzer that will sound when detecting obstacles encountered. The purpose of this research is to find out about the development of a microcontroller-based smart stick (smart tool) to detect obstacles above and below automatically. The blind smart tool development process has gone through two stages of product revision. The results of the feasibility test in product revision test 2 are very feasible, with a total score of 30. The reading distance of the lower sensor is 60 cm, and the upper sensor is 100 cm.

Keyword: Ultrasonic Sensor; Smart Tool; Visually Impaired

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INTRODUCTION

In general, humans have five senses to sense changes that occur in the environment around their body. The sense of sight is one of them. The sense that functions to record the state or condition is the eye, so that humans can know the objects they see. In fact, normal eyes are not owned by all humans; some have had visual impairments since birth (Hidayat, 2019; Taringan, 2020; Fergiyana, 2018).

Technological developments make it easier for humans to carry out all activities, ranging from sports, work, driving, and the like. However, people who are visually impaired (blind) cannot experience technological advances as felt by others, especially people who are visually impaired (blind). Not all visually impaired people are totally blind; some still have some residual vision (low vision). Due to the reduced function of the sense of vision, the blind try to maximize the function of other senses such as touch, smell, hearing, and so on (Junfithrana, 2015; Faruk, 2017; Taneo, 2022).

During this time, blind people only trust their sense of hearing; this is because they have high hearing catchability. Ordinary blind sticks are still a way for blind people to walk. But sometimes blind people still have difficulty when there are potholes, so it is not uncommon for blind people to fall into the hole (Munidar, 2024; Paull, 2024; Rahmadani, 2024; Cristina, 2024). If there are obstacles in front of or around them and the road surface is uneven or has potholes, blind people will also have difficulty. For blind people, accidents often occur. So many families of blind people need a nurse to accompany them (Benny, 2019; Ramdani, 2021).

Therefore, blind people really need a walking aid in the form of a cane. A cane is one of the simplest assistive devices when compared to other assistive devices. This tool is still the main choice because the price is cheap. This tool serves to show the way and also provides comfort when walking or doing activities in his house. So that they can be more independent and carry out their own activities (Rahman, 2023; Tiara, 2022; Misbah, 2019; Aziz, 2023; Husna, 2020). However, the disadvantage of ordinary sticks is that they can only be used to feel objects or obstacles at a limited distance. This causes blind people to be required to always be vigilant and feel anxious if they walk alone and get lost or in an emergency (Al-Hasan, 2017; Hafidhin, 2015; Tangdiongan, 2017).

Based on the above problems, the design of a blind cane by utilizing technology in the form of an ultrasonic sensor is a necessity. Ultrasonic sensors function to detect bumps, holes, and obstacles that are above or below. The ultrasonic sensor works by using several main components, consisting of an Arduino Uno as a controller, an MP3 module as an output, and a buzzer that will sound when detecting obstacles encountered. Thus, knowing the development of a microcontroller-based smart stick (smart tool) to detect obstacles above and below automatically is the goal of this research (Rio, 2020; Nusa, 2017).

Advances in technology make it easy to make an Arduino microcontroller-based tool that uses ultrasonic sensors. Ultrasonic waves have a signal that, when emitted from an object, will be partially reflected back. The reflected signal received by the receiver is then processed by the microcontroller, which emits a sound through the buzzer. This stick that uses an Arduino microcontroller functions to make it easier for blind people to walk using a stick without touching an object in front of them. This stick functions to detect obstructing objects, making it easier for blind people (Rusito, 2020; Wicaksono, 2017).

METHOD

This This research uses secondary and primary data. Literature studies can produce secondary and primary data from the results of a feasibility test by a team of experts. To get the data needed, researchers use research instruments. The instrument in the study was an assessment of the feasibility of smart tool products in the development of the of the products in this study.

The Likert scale used in this study is 1–4, namely not feasible (TL), less feasible (KL), feasible (L), and very feasible (SL). Each question item consists of three different answer scores. While there are 4 categories for this feasibility test, namely not feasible (X<12), less feasible (12<X<18), feasible (18<X24<), and very feasible (X>24),.

The research and development technique refers to Sugiyono's (2013) development model through 10 sequential steps, namely potential and problems, data collection, product design, design validation, design revision, product trial, product revision I, trial use, product revision II, and mass production. An explanation of the steps in developing a blind smart tool is as follows:

1) Potential and problems

Potential and problems are everything that exists around the environment and can be used for its beneficial value, so that it will have added value in its utilization to be developed into a product that can be used by the community.

2) Data collection

After the potential and problems are found, the researcher collects information and data as material for product planning, which is expected to overcome existing problems.

3) Product design

The next step is for researchers to create a product design that will be developed. The product design was developed based on observations from the data collection above.

4) Design validation

The next step is for researchers to make a product design that will be developed. The products produced in research and development (R&D) research vary. The product produced in this study is a smart blind tool. The product design was developed based on the needs analysis from the data collection above.

5) Design revision

The design revision is carried out according to the assessment and suggestions from the validator. If weaknesses are found in the product design, the researcher tries to overcome these weaknesses by making improvements to the robot design to produce an effective product.

6) Product trial

Product trials are carried out after receiving revisions from the validator. The product trial serves to determine the effectiveness and feasibility of the product developed, and the researcher notes the advantages and disadvantages during the product work stage.

7) Product revision I

Product revision is carried out if, after conducting small and large group trials, there are deficiencies that must be corrected. Revisions were made to perfect the product.

8) Usage trial

Before the usage trial is carried out, product revisions from validators have been carried out. The usage trial serves as knowledge of the effectiveness of the product developed and used.

9) Product revision II
Product revision II is carried out if it has conducted a trial and if there are deficiencies that must be corrected. This product revision is carried out to perfect the product that has been developed.
10) Mass production

$$P = \frac{F}{N} X\ 100\ \%$$

Description:
P: Percentage
F: Number of values obtained
N: The maximum number of scores
The research method contains the type of data used, the type of research, population, sample, data collection method, and data analysis included in this section.

FINDING AND DISCUSSION

Finding

Smart Tool Development Process

The development of this smart tool product refers to the development of Sugiyono (2013). The results of the research and development have gone through eight (eight) stages, which are described sequentially as follows:

1) Potential and problems

The potential and problems encountered in this study are conditions that are often found in the environment around schools and madrasas. We find some blind people walking around the school environment using a stick that is beaten on the ground to find out the obstacles in front of the blind person. Because the sticks used are still manual, sometimes the activities of blind people run a little slow because the busy and crowded path is the traffic lane around the school, especially at certain times such as in the morning (when entering school), at noon (during lunch break), and in the afternoon (when leaving school). So, if blind people pass through the school at these times of heavy traffic, it will indirectly cause disruption and congestion.

2) Data collection

After getting the potential problem, the researcher made observations and collected information by making observations and asking direct questions openly to blind people. The results of direct observation and observation are used to see the extent to which the research plan can be used as a tool for blind people.

3) Product design

Based on the results of observations and analysis in the field, it is continuing with the product design stage to be developed. The result of the research is a blind smart tool (initial design).

4) Design validation

After doing product design, the next step is design validation. This validation is carried out to assess or test the feasibility of this smart tool product. The validation results at this stage are 100% less feasible, so product revision I is carried out according to the validator team's suggestions.

5) Product Revision I

Product revisions were made according to the assessment and suggestions of the validator team. Some of the revisions made were the placement of the sensor tool, the safety of the sensor tool against weather (such as rain), and the reading distance of the sensor. The reading distance of the lower sensor is 50 cm, and the reading distance of the upper sensor is 50 cm. Around the sensor is a plastic box so that it is safe when it rains.

6) Product trial

The design revision in product revision was carried out before the product trial. This product test is carried out by testing the product whose design has been revised. To determine the feasibility of the product, a product trial was carried out by means of a validity test by a team of validators. This product test shows the difference between the revised product and the initial product. The validation results at this stage are 100% feasible. To further improve the product, the validation team suggested making a second revision, especially the sensor reading distance.

7) Product revision II

To perfect the previously revised product, product revision II was carried out. Based on suggestions and input from the validator team, this revision was carried out by changing the sensor reading distance to make it more effective in field use. The reading distance of the lower sensor is 60 cm, and the reading distance of the upper sensor is 100 cm.

8) Usage trial

The trial of use was carried out after revising the product. After the product was revised, the feasibility test was again carried out by a team of validators. The results of the validation/feasibility test at this stage are 100% very feasible. This states that the product is effective enough to be used and developed. Usage trials were carried out by placing obstacles at the top and bottom. Then the smart tool is used, and it is seen how effectively it can recognize these obstacles. from the validator. The usage trial serves to determine the effectiveness of the product that has been developed and used. The sound or ringing buzzer is distinguished at the bottom and top sensors to make it easier to recognize the position of obstacles.

Feasibility Assessment Results

Feasibility assessment is a validation activity for the design of the planned and developed product. This feasibility assessment is carried out in several stages, namely the design stage, product revision stage 1, and product revision stage 2 (final). The team that validates this product consists of two people who have experience and knowledge in the field of smart tool design.

The validators in this study were two people, namely academics from universities. The first validator is Rizki Aulia Nanda, MT, who is a lecturer in mechanical engineering at Buana Perjuangan University, Karawang. The second validator is Mursyidi, MT, who is a lecturer in electrical engineering education at UIN Ar Raniry, Aceh. The validation results consist of 4 stages, namely:

1. Design stage validation

The design-stage validation was conducted on September 5, 2022. The results of the validation by the validator team received a total score of 16. This value is > 12 and < 18, the relative frequency. If it is percentageed, then it gets a percentage value of 89% less feasible design (KL). Product revisions were carried out at the direction of the validator team.

No	Assessed Aspect	Statement	Score		Description
			1	**2**	
1	Materials to use	No risk factor (zero risk) for smart tool users	2	2	
2		Smart tools are made of materials that can be produced relatively long term	2	2	
3		Life-time (length of use of smart tools)	1	2	
4		The availability of smart tool raw materials is easily accessible	2	2	
5	How to use smart tools	Useable (easy to use and simple)	1	2	
6		Ease of smart tools to be moved	2	2	
7	Form	High aesthetic value	1	1	
8		Make it easy for users	2	2	
9	Benefits and values	Useful for smart tool users	1	1	
10	Maintenance	Maintable (can be maintained / managed easily)	1	1	
		Total	15	17	
		Description	KL	KL	

Source: Primary data processing results (2022)

2. Validation of product trial stage 1

Validation of product revision stage 1 was conducted on October 14, 2022. The results of the validation by the validator team received a total score of 23. This value is > 18 and < 24, the relative frequency. If it is percentageized, then it gets a percentage value of 96% feasible product (L). Product revisions were carried out at the direction of the validator team.

No	Assessed Aspect	Statement	Score		Description
			1	**2**	
1	Materials to use	Contains no risk factor (zero risk) for those who use smart tools	2	3	
2		Smart tools are made of materials that can be produced relatively long term	3	3	
3		Life-time (long service life)	2	2	

4		The availability of smart tool raw materials is easy to reach	2	2
5	How to use smart tools	Useable (easy to use and simple)	3	2
6		Ease of smart tools to be moved	3	2
7	Form	High aesthetic value	2	2
8		Make it easy for users	2	3
9	Benefits and values	Useful for smart tool users	2	2
10	Maintenance	Maintable (can be maintained / managed easily)	2	2
		Total	23	23
		Description	L	L

Source: Primary data processing results (2022)

3. Validation of product usage trial 2

Validation of product revision stage 1 was carried out on December 2, 2022. The results of the validation by the validator team received a total score of 30. This value is > 24, the relative frequency if it is percented, then it gets a percentage value of 100%, the product is very feasible (SL). Based on the results of the feasibility test, this product can be developed and used.

No	**Assessed Aspect**	**Statement**	**Score**		**Description**
			1	**2**	
1	Materials to use	Contains no risk factor (zero risk) for those who use smart tools	3	3	
2		Smart tools are made of materials that can be produced relatively long term	3	3	
3		Life-time (length of use of smart tools)	3	3	
4		The availability of smart tool raw materials is easily accessible	3	3	
5	How to use smart tools	Useable (easy to use and simple)	3	3	
6		Ease of smart tools to be moved	3	3	
7	Form	High aesthetic value	3	2	
8		Make it easy for users	3	3	
9	Benefits and values	Useful for smart tool users	3	3	

10	Maintenance	Maintable (can be maintained / managed easily)	3	3
		Total	30	29
		Description	SL	SL

Source: Primary data processing results (2022)

Discussion

Based on the title, Designing a Walker for the Blind Based on Arduino, the main system controls when designing a microcontroller-based assistive device come from the microcontroller system used. In the first part, there is an Arduino along with a battery. In the second part, the sensor is placed. The core part of this tool is the arm, and the arm will be held by the hand. This mitrocontroller system serves to control the main system when designing a microcontroller system-based assistive device. The placement of the Arduino and battery is the first part. Sensor placement is the second part. The arm part is the core part, and this sensor part will be held by the hand. The sensor has a button on the side that detects the surrounding area and generates vibration. The sensor component has three ports connected to pin 5v, GND, and pin 7 on the Arduino, and the DC motor has two ports connected to pin GND and pin 13 on the Arduino. In this way, Arduino programming makes it easy for you to set the range.

Based on the title Auxiliary Stick Design of Barrier Detection, Water, and Blind Location, the blind can know the presence of obstacles, water, and the location of the blind by using a stick tool. To detect obstacles within a maximum distance of 1.5 meters, at the top and bottom there are distance sensors. Meanwhile, to detect trenches or puddles, there is a water sensor at the bottom of the stick. The microcontroller processes the output of the ultrasonic sensor and water sensor when an obstacle or puddle is detected. Then, the output is sent to the earphone to produce sound.

Based on the title Designing a Blind Guide Using Microcontroller-Based Ultrasonic Sensors, which states that ultrasonic sensors are used as a substitute for sticks, people can move more freely thanks to technological advances. Ultrasonic waves contained in ultrasonic sensors function as transmitters and calculate distances with time differences. The capture distance on the ultrasonic sensor is between 2 cm and 200 cm. The data processor used is an Arduino microcontroller, and the vibrating motor is the output. In this research, the belt is the main design of the blind guide tool. To detect objects within its reflection distance, sensors are placed on the left, front, and right sides of the belt. The vibrating motor is located on the side. The sensor functions to produce vibration when the ultrasonic sensor operates. The blind guide tool has the characteristics of detecting a distance of 30 cm on the left of the belt, 150 cm in front of the belt, 30 cm on the right side of the belt, and 120 to 125 cm below the belt.

Based on the title Obstacle Detecting Blind Walking Stick Using Ultrasonic Sensor Based on the Arduino Nano Microcontroller, it states that the Arduino Nano and HC-SR04 ultrasonic sensors are important media used to design a walking stick for the blind, which can read the distance programmed on the Arduino Nano and issue a 5 V buzzer. The range that this walker can detect is obstacles within 5 cm to 50 cm from the user. If the sensor is more than 50 cm from the obstacle, the buzzer will not sound, or there is no obstacle. The test results of the battery life of the blind walker show that the battery can last for 3.6 Wh for 9 hours with the battery used continuously or with the buzzer on.

The results of this study are the result of several previous studies. The sensor used in this research is the bottom sensor, which is 20 cm away from the bottom of the stick and functions to detect obstacles and obstacles that are at the bottom. The range that can be read by the lower sensor is 60 cm. While the upper sensor is 70 cm away from the lower sensor, this sensor functions to detect obstacles and obstacles that are at the top. The range that can be read by the upper sensor is 100 cm. When detecting obstacles, each sensor will send data, and the data is processed by the Arduino. The results of data processing will be sent to the buzzer. If the sensor reads an obstacle, the buzzer will sound automatically so that the user knows that there is an obstacle in front of him. The sound caused by the buzzer is different for the upper obstacle and the lower obstacle. This is so that blind people know where the obstacle is. So that they can anticipate better. If there are obstacles in both positions (top and bottom), then both types of sound will turn on simultaneously. The equipment used has been neatly arranged and covered with a plastic box so that it is safe from rain.

CONCLUSION

The conclusions that can be drawn based on the results of the development of several studies are as follows:

1. The blind smart tool development process can be used after going through two stages of product revision. The results of the feasibility test in product revision test 2 are very feasible, with a score of 30. The reading distance of the lower sensor is 60 cm, and the upper sensor is 100 cm.
2. This research has produced a blind cane that is able to detect objects at a predetermined distance with sound output using sensor technology to improve blind alertness and mobility.

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