

7-Pa Imam

by 7 Pa Imam

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The Development of a Magic Cane for Mobility of the Blind in a Swampy Terrain Using Digitalised Visual Sensors

Imam Yuwono, Mirnawati and Utomo

Special Education Program, Faculty of Education and Teacher Training, Universitas Lambung Mangkurat, Banjarmasin, South Kalimantan, Indonesia,

Corresponding Author: Imam Yuwono, Email: yuwonoulm@gmail.com

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Abstract - Most visually impaired people greatly rely on a cane for Orientation and Mobility (OM). Canes so far in use may not effectively accommodate the needs of blind people, in particular, for navigation in water body dominated terrains like swamps and river basins. The purpose of this study is to determine the effectiveness of a cane with audio signals to help orient the mobility of the blind in swampy areas. The method used is the R & D (Research and Development) ADDIE instructional systems design framework, which consists of five stages namely, Analysis, Design, Development, Implementation, and Evaluation. Research subjects composed of visually impaired people in The Barito River basin, of South Kalimantan in Indonesia. The data was collected by using action tests, questionnaires, and documentation. The data were analysed using descriptive statistics to determine the effectiveness and practicality of developing the magic cane. The novelty of this study is producing a product dubbed the 'magic cane', which is equipped with audio features that can identify obstacles around the user such as potholes, puddles, and fire/heat. The trial results showed that the magic cane's effectiveness reached 82% with very effective criteria, but from a practical point of view it was only around 60%, by practical criteria. Thus, it can be concluded that the development of the magic cane can be a vital mobility accessory for blind people in moving on terrain with water patches and swampy environments.

Index Terms - Magic cane development, orientation and mobility, visually impaired.

INTRODUCTION

Humans are born with different conditions, though it can be taken that most are born in good physical condition. However, it is also undeniable that some are born with impairments while others acquire them in their lifetime such as impaired vision, which for the affected presents obstacles and difficulties in carrying out their daily activities. A person who experiences problems with vision is ultimately called visually impaired [1].

As a result of experiencing obstacles in their vision, blind people cannot obtain complete information from the surrounding environment. Humans receive about 80% of information from the environment through vision. Therefore, for blind people, it is difficult to do well in natural life [2]. Because blind people experience limitations in their vision, their daily activities will also be hampered, especially with mobility such as walking, finding doors, recognizing someone who is coming or detecting their foothold when walking. Blind people need special techniques when get to mobility activities or moving places. Some of the techniques commonly used by the blind in orientation and mobility are the alert companion technique, self-protection technique, and cane technique [3]. The use of canes can affect the orientation and mobility skills of blind people [4], [5]. Blind people often rely on external assistance that can be provided by humans, trained dogs, canes or special electronic devices as a decision support system [6], [7].

Moving through an unfamiliar environment is a real challenge for people with visual impairments. Those who go out of the house with a white cane often use the old route

and have difficulty with the new route [8]. Often blind people face several problems on the road such as human obstacles, animals or walls, holes or stairs, muddy surfaces, fire and many others that can create problems such as accidents or injuries even though they have been assisted by a regular white cane [9]. The (conventional) white cane commonly used by the blind still relies on the sense of touch, so it has limitations in identifying obstacles encountered in mobility orientation [10].

This problem is also faced by blind people in South Kalimantan. The condition of the soil in South Kalimantan, especially the Banjarmasin area, is wetland or also known as peatland. This area is inundated by water, both permanently and seasonally and is overgrown with vegetation, so it is the largest swamp area in Indonesia [11]. Banjarmasin area geographically is a basin, it is in the lowlands so that it is inundated by river overflows and rainwater during the rainy season but receding water in the dry season leaves behind puddles and dried up potholes [12].

The Swamp terrain in the Banjarmasin area is a problem in itself for blind people, because the canes that have long been used by the blind so far are not sufficient to accommodate the needs of blind people, for example in identifying puddles, swampy areas and overgrown grass or foliage. Thus, the aim of this research is to develop a cane that compliments other senses to enable the user to achieve good orientation and mobility. The developed stick is equipped with Arduino IDE application and sensors that provide audio signals in identifying various obstacles on the road, such as puddles, air temperature, heat or fire, obstacles in front of objects, heights, and locations of holes. The ultrasonic sensors used are able to detect water and various other obstacles using ultrasonic waves [13].

METHODOLOGY

This research is a R & D (Research and Development) research type, which aims to produce a product in the form of the magic cane to facilitate the orientation and mobility of blind people in river basins. Research and development methods are used to produce a certain product and test the effectiveness of the product [14]. This research procedure adapted the ADDIE development model which consisted of five stages of Analysis, Design, Development, Implementation and Evaluation (Sugiyono, 2015).



FIGURE 1
ADDIE DEVELOPMENT MODEL

Analysis

At this stage, the main activity was to analyze the need to develop the magic cane for blind people by conducting

interviews regarding the needs of blind people in their orientation and mobility in wetlands.

Design

The design of the cane developed is described in the following stages:

a) Based on the results of interviews, it was found that blind people still have difficulty in orientation and mobility in wetlands, and the canes commonly used are not sufficient in detecting obstacles encountered by blind people in their mobility.

b) A plan was developed for making the cane beginning with a research concept, then collaborating with competent parties in assembling the sticks according to the research concept.

Development

The product design or concept prepared was then developed by partners. The product development stages included:

a) Assembling the stick according to the concept designed by the research team, then the researcher corrects the product before its validation, if it is appropriate then the product is ready for validation.

b) Expert validation was carried out to obtain assessments and advice from experts and users regarding the suitability of the developed cane.

c) After getting input from the validator, the researcher asks partners to make improvements according to the suggestions and input from the validator. If the product was revised and moved to the implementation stage.

Implementation

The implementation phase was carried out by blind people in the area along the Barito River. During the trial, the researcher made notes about the shortcomings of the product in its implementation. Interviews with the users were also conducted regarding the use of the developed product.

Evaluation

Evaluation is a process to analyze the use of sticks at the implementation stage whether there are still shortcomings and weaknesses or not. If there are no more revisions, then the stick is worth using.

The research subjects were blind people living in the wetland environment of the Barito River basin. The data collection techniques used were interviews, action tests, questionnaires, and observations. Interviews are used to find problems that must be researched, and to analyze the needs of blind people in orientation and mobility in the wetlands area. Action tests were used to determine the effectiveness of using the developed magic cane in orientation and mobility of blind people in wetland environments, a questionnaire was used to find out the practicality of using the magic cane in orientation and mobility activities carried out by blind people in a wetland environment, and documentation was used to complement data on the results of the implementation of the cane, in the form of photos of research activities.

Data on the effectiveness and practicality of the cane were analyzed using descriptive statistics with the formula:

$$N = \frac{f}{(n)} \times 100 \quad (1)$$

Where:

P = Percentage

f = The number of scores obtained

n = The highest number of scores

Making decisions about the effectiveness and practicality of developing the magic cane was conducted using the conversion level of achievement with a scale of five as shown in the following Table:

TABLE I
ACHIEVEMENT SCALE

No.	Achievement Level (%)	Qualification Effectiveness	Qualification Practicality
1.	81 – 100 %	Very effective	Very practical
2.	61 – 80 %	Effective	Practical
3.	41 – 60 %	Effective enough	Pretty practical
4.	21 – 40 %	Less effective	Less practical
5.	< 20 %	Very less effective	Very impractical

RESULTS

Magic cane development

The development of the magic cane began with the needs analysis stage, the results of the needs analysis become a reference for researchers in developing a magic cane development design concept that can accommodate the needs of blind people to carry out orientation and mobility in a wetland environment. The magic cane design that was conceptualized by the researcher was then submitted to partners carry out the assembly or manufacture of the magic cane. The stages carried out by partners in the process of developing this magic cane are as follows:

Design Tool

The design of the tool is divided into 2, namely designing hardware in the form of electronic components and designing software using the C language Arduino IDE application. The design is carried out based on the system flow process to get a match between the working principles of the tool as a whole with the working principles of each supporting component. The expected feature of the tool to be designed is that the smart cane is able to automatically notify several conditions in front of the user, such as there are objects / people, there are potholes, there is fire / residual heat from burning on the road and there is a puddle of water, through the media of human voice that informs the user.

Electronic Hardware Design

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From the description of the expected features, the component designs that can support the system's work are:

- Sensor Measuring object distance based on the sonar signal reflection
- Flame and temperature detection sensor
- Sensor detection if there is a pooled liquid.
- Sound file player with Micro SD storage

The main controller / processor which has small dimensions and has quite a lot of connection ports to the sensor.

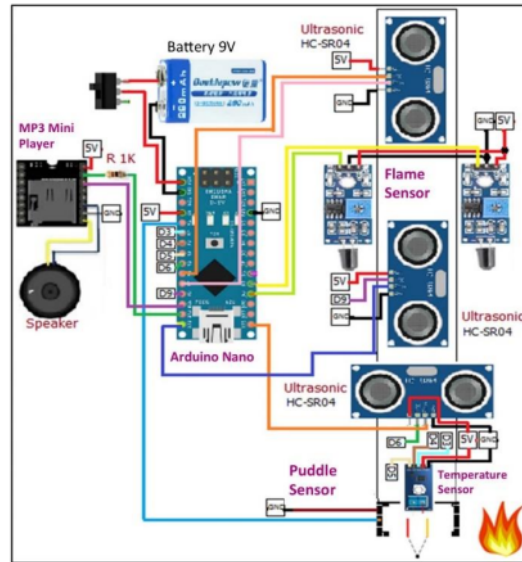


FIGURE 2
CONTROLLER/PROCESSOR

The main controller uses the Arduino Nano which has 13 digital pins and 8 analog pins. Components using digital pins and analog pins are as follows:

Digital Pin

Temperature Sensor - Thermocouple Type K Max6675

Pin data SO = pin 5.

Pin CS = pin 4.

Pin CLK = pin 3.

MP3 Mini Player: Pin 10 RX and Pin 11 TX

Proximity Sensor 1, Ultrasonic SR-HC04

Triger Pin = 7.

Echo Pin = 8.

Proximity Sensor 2, Ultrasonic SR-HC04

Triger Pin = 9.

Echo Pin = 12.

Perforated Road Sensor, Ultrasonic SR-HC04

Triger Pin = 13.

Echo Pin = 6.

Puddle Sensor: Pin 2. Analog Pin

sensorApi1 = A0.
sensorApi2 = A1.

Software Design

The flow of the software design system follows the work principle flow, as shown in the following figure:

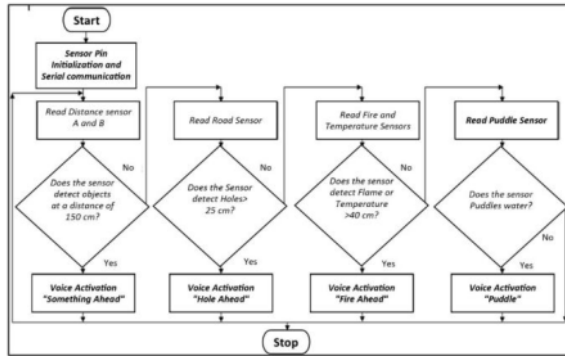


FIGURE 3 DESIGN FLOW

Design Tool

Initialization of Pins, Sensors and Serial Communications, is the stage for declaring the sensor pins that are used as Input or Output, serial communication with the MP3 Mini Player.

Read Distance Sensor A and Distance B, is a specification for detecting objects / people in front with an angle range of 30° to the right and to the left. There are 2 ultrasonic sensors SR-HC04 for this distance detection, at the top and bottom of the cane, such as shown in Figure 9. If one or both of these sensors read objects / people at a distance below 150 cm, then Arduino will activate the MP3 Mini Player, to run the MP3 file with the sound "There is something in front".



FIGURE 4 DISTANCE SENSORS

Perforated Road Read Sensor is a specification for detecting potholes that are in front with an angle of 30 to the right and to the left. There is 1 ultrasonic sensor SR-HC04 for distance detection on potholes, as shown in Figure 10. If the sensor reads the reflected signal from the road at a distance below 25 cm, then Arduino will activate the MP3 Mini

Player, to run MP3 files with the sound "There is a Hole in the Way".



FIGURE 5 HOLE SENSOR

The next specification is to detect fire and hot temperature detected by the cane. There are 2 flame sensors and 1 temperature sensor using Thermocouple Type K max6675. If the Flame sensor reads the wavelength of the flame over a range, the Arduino will activate the MP3 Mini Player, to run the MP3 file with the sound "There is Fire Ahead". Meanwhile, if the end of the cane where the temperature sensor is on a hot road is above 40 C, Arduino will also activate the MP3 Mini Player, to run the MP3 file with the sound "There is a Fire in Front". The placement of this fire sensor is as shown in the Figure 6:

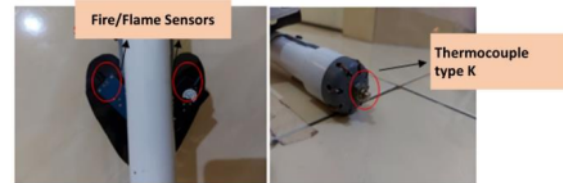


FIGURE 6 FIRE DETECTION SENSOR

To detect standing water in front, a puddle sensor is used. The 2 sensor cables are connected to the Ground pin and the Arduino pin respectively. If the sensor is in a pool of water, then pin D2 will be worth LOW, and Arduino will activate the MP3 Mini Player, to run MP3 files with the sound "There is a puddle of water". The placement of this fire sensor is as shown in the following figure:

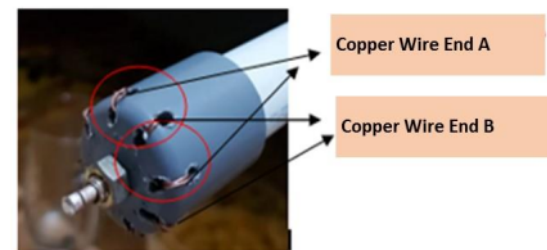


FIGURE 7 WATER PUDDLE SENSOR

3-1-Magic cane Product Development

The magic cane is a tool for the visually impaired orientation and mobility, as shown in Figure 13, with a length of 1.5 m and placement of several sensors.

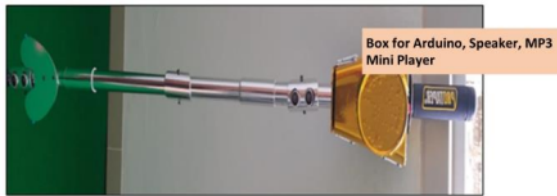


FIGURE 8
MAGIC CANE

After producing a product in the form of a magic cane as a tool for orientation and mobility for the visually impaired, the next step is to test the use of the magic cane in orientation and mobility in a wetland environment to evaluate the effectiveness and practicality of the magic cane being developed.

Effectiveness and Practicality of the Magic Cane

The effectiveness of the magic cane can be seen in the trial implementation by comparing the ability of blind people to perform mobility from one place to another by conditioning several obstacles when using an ordinary white cane and when using a developed magic cane. Some of the conditioned obstacles, included: 1) a rocky road; 2) Potholes; 3) Residual heat from combustion; 4) an inclined road; 5) a slope; 6) speed hump; 7) stagnant water; 8) other people on the street; and 9) an object on the road.:

Figure 6 shows that the effectiveness of using ordinary white canes in mobile in wetland environments by blind people is around 44% with the criteria of "quite effective" while the use of the magic cane by blind people for mobility.

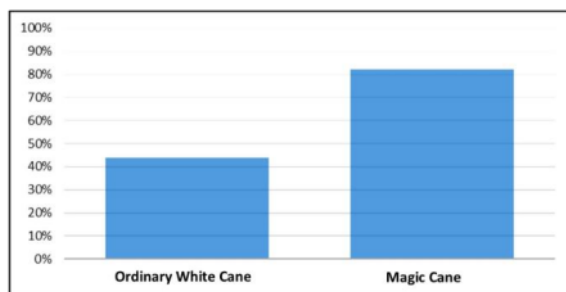


FIGURE 9
ILLUSTRATION OF EFFECTIVENESS OF THE MAGIC CANE

TABLE 2
POINT SIZES AND TYPE STYLES

No	Statement	Response	
		Yes (1)	No (0)
1	The stick is easy to use	√	
2	The cane is safe to use when walking	√	
3	The audio on the stick was clear	√	
4	The device in the wand does not interfere with use		√
5	Light stick		√
6	The young stick was brought		√
7	The stick can detect standing water	√	
8	The stick can detect fire	√	
9	The stick can detect potholes	√	
10	The size of the stick is not too big so it is comfortable to use		√
Percentage of effectiveness		60%	
Criteria		Quite Practical	

Based on the results of the questionnaire above, the magic cane that was developed was still in the "practical enough" category. Blind people considered that the magic cane that was developed was still not easy to carry anywhere because the size and device contained in the cane were still quite large and disturbing.

DISCUSSION

Blindness is a general term that describes a condition of loss of vision function either partially or completely which affects other aspects of life [2], [4]. Without the ability to see humans will have difficulty completing their tasks properly. One of the difficulties faced by blind people is mobility activities or moving from one place to another. There are three limitations experienced by blind people, namely limitations in the scope of diversity of experience, limitations in interacting with the environment and limitations on moving places [15], [16].

The problem of moving places faced by blind people is an urgent problem because it will have an impact on the dependence of the blind on the family and the people around them. So that blind people will experience limitations in obtaining information, interacting with the surrounding environment, and in other fields. Humans receive about 80% of information from the environment through vision [2]. If a blind person can move or move freely, one can interact with the environment and gain a lot of experience so that it can have a positive impact on various aspects of blind development [4].

The magic cane development which is carried out is based on the results of the needs analysis carried out through the assessment activity. the assessment activity is a comprehensive collection of information to get and fully understand the potential, limitations and needs of the blind, including in terms of orientation and mobility [17]. In order to accommodate the blind's need for mobility in a wetland environment, the development of a magic cane uses the power of Arduino and sensors. The use of Arduino

technology in white cane construction can be used by blind people and help them overcome problems in moving [18], [19]. Sensors and sound systems are designed to improve navigation for the visually impaired [20]-[22].

The development of a magic cane using the power of Arduino and sensors and MP3 produces a wand that can detect obstacles that are encountered while walking, such as potholes, puddles, and fire. Obstacles detected by the cane are conveyed by the blind in the form of audio or sound, as we know that blind people use hearing and audio to access information. The combination of several of these devices acts as a smart system so that people with visual impairments are helped by navigation so that they are aware of the obstacles they will pass [23]-[26].

The magic cane that has been developed is effective in assisting blind people in carrying out mobility, especially in wetland environments because the magic cane developed with Arduino and ultrasonic devices provides several features on the wand that can provide navigation assistance to the visually impaired in detecting puddles, the presence of fire, and roads. hollow. The use of Arduino is equipped with an ultrasonic sensor that has a Receiver and Transmitter to help users find out or be aware of obstacles on the road in their path so they can avoid them [27], as well as providing navigation assistance to the visually impaired in detecting puddles, holes and other obstacles so that they can move safely [28]. Smart walking canes help blind people to navigate and do their work easily and comfortably [11], [29]-[31].

Tests for the use of a magic cane by blind people were carried out by conditioning several obstacles, including rocky roads, potholes, residual heat from burning, uphill roads, downhill roads, speed bumps, puddles, meeting someone on the road, meeting an object on the road, compared to ordinary white sticks where the visually impaired walk while swinging the stick with the tip of the stick touching the road surface, the use of the magic cane by blind people requires to ensure that the sensor position is facing forward. The trial results show that in the end the magic cane developed was able to detect most of the obstacles that had been conditioned, so the effectiveness of the magic cane reached 82% with very effective criteria. When in use, the stick detects obstacles such as puddles of water, then the user is alerted by an audio signal through headsets used by the user, thus enabling the user to avoid obstacles and get to their destination safely. The percentage of reduction in the collision rate when using an ultrasonic walking cane developed with a normal white cane is 90.1, so the ultrasonic walking cane can be relied on for use by blind people [32]. However, the practicality of the cane is only around 60% with criteria that are quite practical. The specifications of the development of the magic cane are not easy to carry and are not comfortable to use by blind people because the size of the cane is still relatively large.

CONCLUSION

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The process of developing the magic cane began with a need's analysis, which was then carried out by the researcher's conceptual design based on a need's analysis, the conceptual design is then submitted to partners for assembly or product development, the finished product is then tested on blind people for further evaluation. The trial results showed that the effectiveness of the magic cane that was developed reached 82% effectiveness. Meanwhile, the practicality of the magic cane that was developed was only around 60% effectiveness categorized as quite practical. Due to limited funds improving the cane's practicability to a higher level of effectiveness was not carried out. Thus, the developed magic cane being quite practical can be a useful tool for blind people in enhancing their mobility in an environment with water patches in the terrain like swampy areas and river basin regions.

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AUTHOR INFORMATION

Yuwono: is an Associate Professor of Universitas Lambung Mangkurat teaching in the Faculty of Teacher Training and Education as a full-time staff on the Program of Special Education with a specialty in blindness and visual impairment studies. In addition, is also currently a deputy dean in charge of finance and human resources.

Mirnawati: is a specialist in blindness and visual impairment studies, is a lecturer on the Program of Special Education in the Faculty of Teacher Training and Education at Universitas Lambung Mangkurat, Banjarmasin, Indonesia.

Utomo: is a specialist in blindness and visual impairment studies. He is a senior lecturer in the Faculty of Teacher Training and Education at Universitas Lambung Mangkurat.

All the three authors have contributed equally to the writing of this paper.

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