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Voice Warning to Identify Distance to Obstacles on Smart Cane for Blind People

Atmiasri [1], Akhmad Solikin [2], Rasyida Shabihah Zukro Aini [3]
[1,2,3] Teknik Elektro, Universitas PGRI Adi Buana, Surabaya, Indoneisa

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ABSTRACT

Blind people are often hampered in their mobility, while currently available assistive technology includes manual sticks and electronic mobility devices. Currently, the development of smart canes is still being carried out in many studies. Smart cane works by detecting the distance of the cane to obstacles in front of you. From detecting this distance, the response the user gets is generally in the form of vibrations and sounds from the buzzer. The sound provided by the buzzer cannot differentiate the distance between obstacles. Therefore, this study proposes the existence of additional sound playback responses to differentiate far, middle, and near obstacles. Apart from that, the design of the prototype refers to the shape of a flashlight. The smart cane is designed using an Arduini UNO microcontroller with a rechargeable battery power supply with three response components, namely two ISD 1820 modules connected to a speaker to detect long distances (201-300 cm) with a "Hati-hati" sound and medium distances (101-200 cm) with an "Awas" sound, as well as a buzzer and piezoelectric component in the form of a "beep" sound and vibration for close distances (1-100 cm) to obstacles. The result is that both the ultrasonic sensor and response components work according to design. Apart from that, the rechargeable battery supply feature and the implementation of the prototype design make it easier for users to store and use for daily activities.

Corresponding Author:
Atmiasri
Teknik Elektro, Universitas PGRI Adi Buana, Jl. Dukuh Menanggal XII, Surabaya, 60234. Indonesia
Email: atmi.asri@unipasby.ac.id

1. INTRODUCTION

Blind people or individuals who experience damage or obstruction to the eye organs. The visually impaired are divided into two groups: total blindness and low vision [1]. Blindness has basic limitations in controlling the environment and one's relationships. Mental orientation and physical locomotion are important factors that must be developed [2]. So far, the assistive technology available to help the mobility of blind people includes service animals, manual canes, and electronic mobility aids.

Among the three, quite rapid development has been realised by electronic mobility aids, especially the modification of canes with the help of distance sensors as a warning to people of obstacles. Several studies [1], [2], [3], [4], [5] utilise ultrasonic sensors to consider the distance of obstacles. Apart from the sensor system, microcontroller technology is also integrated. Considerations for using a microcontroller are based on needs. The Arduino UNO, which has an ATMega 328 processor, is superior with larger memory and external interrupts than the ATMega8535, so the Arduino UNO has more potential. With various modifications for obstacle detection, the feedback the user receives is a 'beep' sound from the buzzer [6] as a warning.

The concern arises from existing studies in the form of assessments of prototype designs, such as in the study conducted by Suhaeb [1], the feedback sound from the buzzer cannot differentiate the distance between existing obstacles, for example, obstacles within minimal reach and obstacles too close which must be avoided. Apart from that, based on the results of trials on the visually impaired, it proves that there is a lack of comfort factors, namely the design of the electronic cane is too big, the weight of the cane is quite heavy, and the cane cannot be folded.

Therefore, it is proposed to add a feature that can differentiate the distance of obstacles by playing a warning sound. This is compared to the sound-producing hardware device used by D. Zhangaskanov et al. [7], which uses three components: an SD card reader, an SD card, and a speaker. The ISD 1820 module component is more practical; it only requires a speaker component as a sound output medium, and the recording process can be done in real time. With the help of sound, it is hoped that the cane user can differentiate two distance parameters from obstacles, namely the "Hati-hati" distance and the "Awas" distance, which means that the user must avoid the obstacle detected by the cane as quickly as possible. Apart from that, the prototype model uses an Arduino UNO microcontroller, and its shape resembles a flashlight, making it more comfortable for users than the previous model.

2. METHOD

The research method comprises two parts: System Design and System Performance. The smart cane is designed with the principle of obstacle detection from an ultrasonic sensor at distance parameters within a range of up to three meters. The result is a warning to the user if there are obstacles to three indicators: vibration, buzzer sound and sound playback.

2.1. System Design

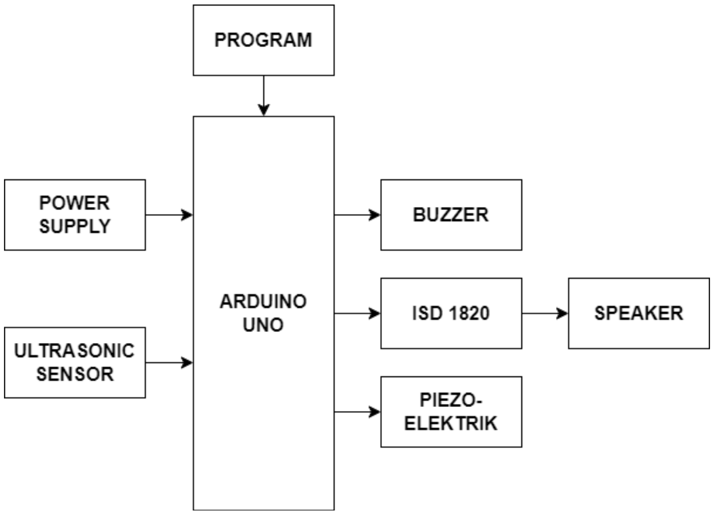

Figure 1. System Block Diagram

The smart cane system is designed with two blocks, namely a hardware block and a software block. Figures. 1 shows all system hardware except program blocks. The program is adapted to the Arduino UNO microcontroller so that the C++ programming language is implemented in the Arduino IDE. The microcontroller is the brain that integrates all system work, Arduino UNO based on ATMEGA328, which has 14 digital input/output pins (6 of which are used as PWM output, six other pins as analogue input, clock speed 16 MHZ, USB connection, a power jack, ICSP header, and reset button) [8].

In the designed system, obstacle detection uses distance parameters from the HC-SR04 ultrasonic sensor. The sensor works by sending sound waves at a frequency (within human hearing tolerance) and bouncing back after being hit by an object. The estimated distance that this sensor can measure is 2-400 cm [9].

Other components contained in the system design are feedback from cane users through a buzzer, sound playback on speakers with an ISD 1820 module, and vibration-producing piezoelectrics. As an alarm that produces sound vibrations at an obstacle distance of 100 cm, the buzzer is activated via input voltage. Piezoelectricity functions to convert electrical energy into sound vibrations (sound). Piezoelectric works with the buzzer, which is active within an obstacle distance of 100 cm.

Unlike the other two feedbacks, the ISD 1820 provides output in the form of a "caution" sound for a distance of 201-300 cm and "caution" for a distance of 101-200 cm. The ISD 7820 contains a sound recording or playback module. This module offers true single-chip voice recording, non-volatile storage, and recording capabilities of approximately 10 seconds. This module can also be controlled either manually or via a microcontroller. To increase the sound output, a speaker amplifier is used.

2.2. System Working Principle

The working principle of the smart cane system starts with pressing the ON switch (power supply condition). All system components will be active. Furthermore, when the cane is used, the ultrasonic sensor detects the presence of objects around the user. The sensor will send the distance to the microcontroller if an obstacle is detected. The microcontroller maps the distance range to the feedback response that will be regulated. If the distance is between 201 and 300 cm, the microcontroller activates the ISD 1820 module, which contains a "Hati-hati" voice recording. If the distance is between 101 and 200 cm, the microcontroller activates ISD 1820, which contains an "Awas" sound. If the distance is below 101 cm, the microcontroller activates the buzzer and piezoelectric or emits a "beep" sound and vibration.

In contrast, if an obstacle distance of more than 300 cm is found, the microcontroller will not activate the ISD, buzzer or piezoelectric. This happens again if the ultrasonic sensor reads the distance between the barrier and the cane again. The system will completely stop when the OFF switch is pressed. A comprehensive reading of the system workflow is shown in Figure 2.

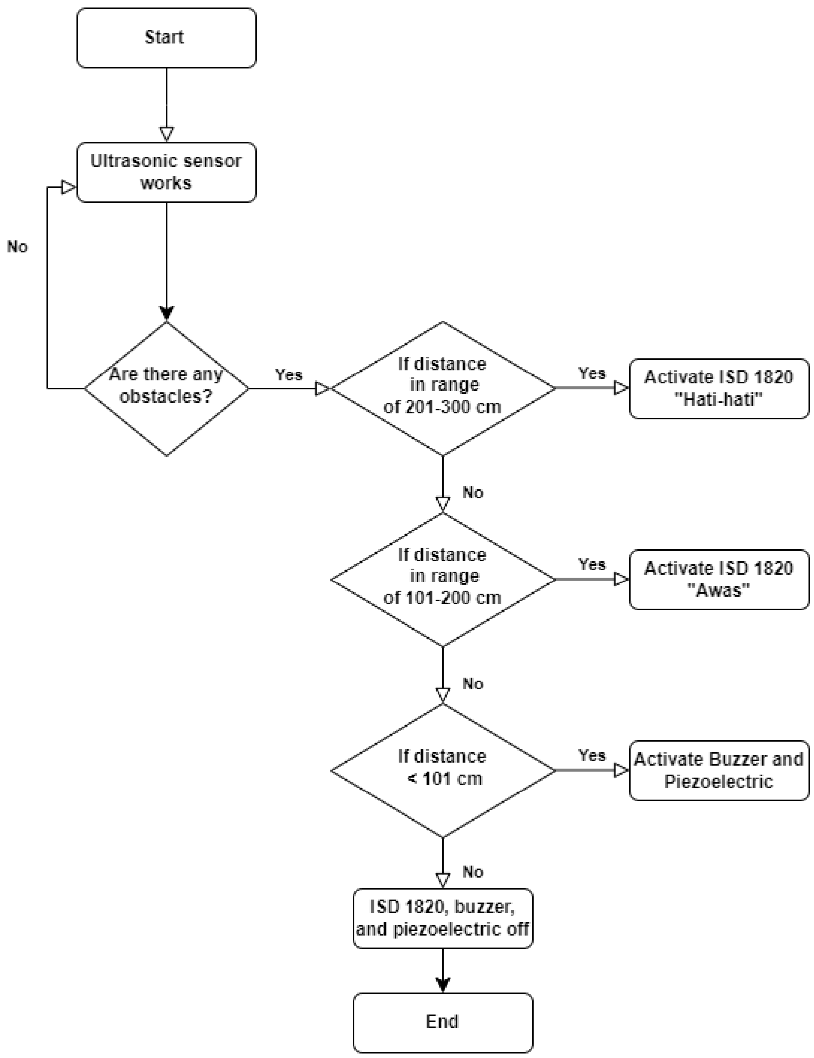

Figure 2. System flow diagram

3. RESULTS AND DISCUSSION

The design results of adding a warning sound feature to the smart cane to identify the distance to obstacles consist of two parts. The first part is the performance of the feedback component regarding distance parameters. Meanwhile, the second part is a system prototype.

3.1. ISD 1820 Module Testing

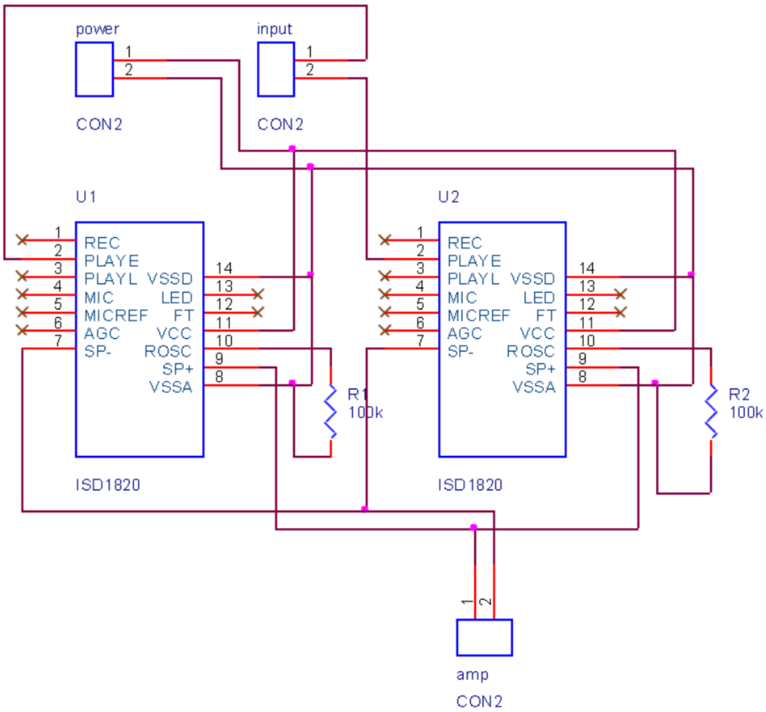

Figure 3. ISD 1820 wiring module system

Table 1. Testing the condition of the Arduino UNO pin on ISD 1820 performance

Arduino Pins	Condition	Voice Output
14	HIGH	“Awas”
15	HIGH	“Hati-hati

The ISD 1820 works by first getting a voltage from the Arduino of 5V DC, which is connected to the PLAYE pin of each ISD 1820 module. When the voltage flows, the ISD1820 module LED will flash. Next, the recording stage is carried out on both modules, with U1 containing the "Caution" sound and U2 containing the "Caution" sound via the REC button. The recording results are stored in real time on the ISD 1820 IC. The ISD 1820 module wiring system is shown in Figure 3. On the Arduino UNO, pin 14 calls U1 to produce sound output and alternately, pin 15 calls U2 to produce sound output. These two pins are connected to the PLAYE push button. Table 1. Shows the condition of the pins that are called to produce sound output. The sound output of each module is continued to the amplifier component for output strengthening.

3.2. Buzzer, Piezoelectric and ISD 1820 Performance on Distance Parameters

Table 2. The performance of feedback components against distance parameters

No	Distance	Buzzer	Piezoelectric	ISD 1820
1	1-50 cm	on	on	off
2	51-100 cm	on	on	off
3	101-150 cm	off	off	“Awas”
4	151-200 cm	off	off	“Awas”
5	201-250 cm	off	off	“Hati-hati”
6	251-300 cm	off	off	“Hati-hati”
7	301-350 cm	off	off	off

8	351-400 cm	off	off	off
9	401-450 cm	off	off	off
10	451-500 cm	off	off	off

The maximum distance detected by the HC-SR04 ultrasonic sensor is 400 cm, according to the datasheet. According to tests carried out at 1 to 500 cm, the sensor can only detect obstacles in the front at a maximum distance of 400 cm. More than 400 cm, the sensor can no longer detect. There is a very small delay, namely in the range of microseconds, in detecting the distance between obstacles; this is due to the way the ultrasonic sensor works, which has the principle of capturing sound reflections on obstacles by the receiver. It takes time based on the speed of sound in the air.

The performance of each feedback component is appropriate based on the distance determined at the beginning. The ISD 1820 sound playback component can complement the response received by the cane user to differentiate the distance of obstacles (long distance and medium distance). Future improvements can be made by increasing the effectiveness of sound over distance by playing only through a headset so that the user can only hear the sound.

3.3. Implementation of System Prototype

Figure 4. Smart cane prototype

Based on the results of implementing the smart cane prototype design in Figure 4, a form that is very practical and easy to carry is produced. With the "flashlight" shape that is carried, sufferers do not need to carry a stick that is large enough to detect obstacles. Users can easily turn the smart cane on and off with the button near the handle. Apart from that, this design is also equipped with a chargeable battery. This cannot be validated in terms of comfort because the smart cane has not been tested directly on people with low vision.

4. CONCLUSION

Based on the design results of adding sound warnings to the smart cane as a mobility aid for the blind, it can be concluded that adding a sound playback component can help users differentiate the distance of obstacles detected by the sensor. The obstacle distance can be divided into long distance (201-300 cm), namely with the sound "Hati-hati" and medium distance (101-200 cm) with the sound "Awas". Apart from that, proximity to obstacles is also warned by vibrations from piezoelectrics and a "beep" sound from the buzzer. Apart from the distance difference, the proposed design is considered very practical and easy for daily activities.

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