Embedded Glove Prototype using Ultrasonic and Flame Sensors for Helping Visually Impaired People in Indonesia

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Joni Welman Simatupang and Bintang Ramadhan Prasetya

Electrical Engineering Study Program, Faculty of Engineering, President University, Cikarang, 17530 - Indonesia

joniwsmtp@president.ac.id, penerbangan25@gmail.com

Abstract—Visually impaired is someone's condition of lacking visual observation due to neurological and physiological factors. Also, wildfire and coronavirus cases made the situation worst for the visually impaired people. A helping tool is very needed to overcome these problems. This paper proposes a prototype of an embedded glove using ultrasonic and flame sensors to provide a convenient and safe method for the visually impaired people to overcome difficulties in daily life. Smart glove prototype based on Arduino UNO microcontroller, ultrasonic and flame sensors, SIM800L GSM module for communication, and buzzer for alarm notification. Then, full device prototype was tested using both the acrylic box and when it was embedded at one's hand as a proof-of-concept for emphasizing the reliability and usefulness of our work. The results show that the ultrasonic sensor works well for detecting object with coverage of 40 cm from the blind. The flame sensor also works well when using flame detection mode for detecting the small flame (at distance about 15 cm) or big flame (at distance about 20 cm) and will be sending a message to the respected person through SIM800L GSM. The only drawback for this device is a bit heavy when used on hand and still lack of IoT system. However, further research will be conducted to overcome these problems in the future.

Keywords—Visually impaired, Blind, Covid-19 pandemic, Ultrasonic, Flame, Sensor.

I. INTRODUCTION

Blindness is the condition of lacking visual observation due to neurological and physiological factors [1]. First global estimate on the magnitude and causes of visual impairment was based on the 1990 world population data (38 million blind). This estimate was later extrapolated to the 1996 world population (45 million blind), and to the projected 2020 world population (76 million blind), indicating a twofold increase in the magnitude of visual impairment in the world by 2020 [2]. Currently, among 7.79 billion people living in 2020, an estimated 49.1 million (about 0.6%) were blind [3]. According to The Fred Hollows Foundation the number of blindness case in Indonesia was reached 3.6 million people: 70% having cataracts and the rest are blind due to several cases, such as an abnormality during pregnancy, a fatal accident, or a health problem. Moreover, eyes health cases will be predicted increase by almost 120,000 people a year [4]. The extent of blindness as a public health problem has been estimated in rural Indonesia for bilateral low vision and blindness rates are about 5.8% and 2.2%, respectively [5]. Besides, 503 cases of home and building wildfire in Jakarta happened last year of 2020 [6]. To prevent this case, such a fire alarm sensor has been built [7]. But, how to prevent something bad, unwanted and unpredictable things happen caused by fire, especially for visually impaired people or blind family member which we care about?

Furthermore, the currently Covid-19 pandemic situation has made chaos throughout the world. This pandemic as well as its impact has affected the life of visually impaired people seriously because many of them depend on the support of their guides, family or friends [8]. Therefore, the existence of helping tool such as an embedded glove sensor is needed to keep their active movements happening without being worry to be infected by coronavirus when touching other things or other people.

In order to show the proof-of-concept, we have conducted a research work to develop a prototype of an embedded (smart) glove sensor. For the hardware, ultrasonic sensors will be used as a sensor to detect obstacles at the front and it will send signal to Arduino UNO which act as microcontroller. For the software, the design of the circuit is done using Fritzing software and the program will be done using Arduino software by installing through Arduino library [9]. This embedded smart glove sensor prototype can detect not only distances or obstacles in front of the visually impaired, but also to detect if a fire occurs at home and can immediately notify the family members to be aware if the possible bad situation will be happening in the future.

The rest of the paper can be outlined as follows: Section II explains some related works. Section III presents the design method and implementation of this prototype. Section IV shows the experimental results and analysis. Section V is Conclusion.

II. RELATED WORKS

Several researchers have developed similar prototypes. First, two joint research group of Ghate, Kanal, and Chavan [9,10] made a development of an affordable (smart) hand-glove using ultrasonic sensor and with addition of vibrator which functions to give vibrations in the hand when there is an obstacle in front of the person. Then Linn, et al [11] made sensor glove using Lilypad Arduino and ultrasonic sensor to detect distance. Finally, Alkandari, et al [12] proposed a smart glove using an Arduino Lilypad microcontroller and also an ultrasonic sensor to detect the distance. However, none of them used the flame sensor to detect fire.

Table 1 shows the comparison parameters of this work with some previous works which have been discussed above in terms of hardware and sensors, microcontroller, and detecting obstacle & fire at the same device prototype.

Table 1. Comparison with previous related works.

Microcontroller	Hardware & Sensors	Detecting obstacle & fire	Authors
Arduino UNO	Ultrasonic & Vibrator	NO	Ghate & Chavan [9]
Arduino UNO	Vibrator and Ultrasonic	NO	Kanal & Chavan [10]
Lilypad UNO	Ultrasonic & Vibrator	NO	Linn, Jwaid, and Clark [11]
Lilypad UNO	Ultrasonic & Vibrator	NO	Alkandari, et al [12]
Arduino UNO	SIM800L & Ultrasonic, Flame	YES	This work

III. DESIGN IMPLEMENTATION

A. Microcontroller

The required microcontroller using in this research work is Arduino Uno R3 as shown in Fig. 1. This microcontroller board comprised of Atmega328P with IC (Integrated Circuit) 14 digital input/output pins (6 pins can be used for PWM output), 6 analog input, reset button, USB connection, and also 16 MHz clock speed. Through USB connection in Arduino, it can transfer the voltage from the computer or battery or employ the external power from AC-DC adapter.

B. Ultrasonic and Flame Sensors

There are two sensors used in this device prototype. First one is ultrasonic sensor HC-SR04. This sensor has an ability to determine the distance of objects with high accuracy and provide stable reading of data. The sensor is widely used for the blind because it does not affected by environmental noise.

This sensor has two different parts: ultrasonic wave detector as a receiver and wave emitter as a transmitter. This type offers a distance from 2 to 400 cm with high degree of accuracy is 3 mm and has working frequency around 40 kHz. If the transmitter sends a small pulse of signal when the signal reaches any object it returns back to the receiver. Then, we are calculating the distance of object or obstacle using the traveling time of the signal in the air. This is a working principle of the ultrasonic sensor as shown in Fig. 2.
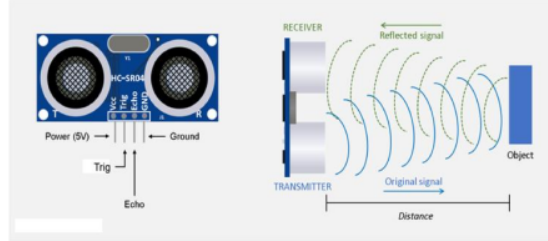

Fig. 1. Arduino UNO R3 module.

Fig. 2. Working principle of ultrasonic sensor [13].

Second is the KY-026 flame sensor module as shown in Fig. 3. The module has both digital and analogue outputs and a potentiometer to adjust the sensitivity. This sensor has a distance range of up to 100 cm. The principal work of this sensor is to detect infra-red or ultraviolet radiation by fire or from burning flames. This sensor will give some signal to Arduino if there is any fire at some distance. In other side, infra-red sensor is the color of visible light with a wavelength of about 700 nm to 1 mm and ultraviolet will emit light with a wavelength of about 300 to 400 nm.
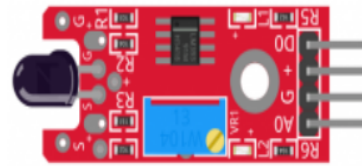

Fig. 3. KY-026 Sensor Module [14].

C. SIM800L GSM

SIM800L GSM is the one of very popular that used by an electrician beginner people or professional one. This device, as shown in Fig. 4, can be applied in every various remote-control project via message form a phone with a type of micro sim card. Not only for sending message, this module of SIM800L can make or receive a call, connecting the internet through TCP/IP, GPRS, and many more.

Inside this device, there are several important parts such as u.fI connector, pin for helical antenna, network status indicator, and Sim800L chip.

Fig. 4. The module of Sim800L GSM.

D. Alarm Buzzer

Buzzer is one of electronic components where it can change the electric to become sound of vibration. The familiar type which are often sold in the market is Piezo buzzer. This buzzer will give the range of frequency about 1 – 5 kHz until 100 kHz which can be applied to ultrasound.

E. Design of Device Prototype

The method used in this research is an experimental setup which of course aims to produce and to test a tool (prototype) of the embedded smart glove. So, we have to produce a real tool (prototype) and of course we can directly test it in the field and of course the results of this method can be maximized or revised again if at the time of the experiment we find things that are not right or something.

As we can see, there are two modes (sensors) that are placed together, namely a flame and also an ultrasonic sensor. Figure 5 shows that all function in mode 1 and 2 will be processed by Arduino and after that it will be immediately executed according to the selected function. While Fig 6 puts all the components together as one schematic diagram of full device prototype.

Here we can see, when the push button 1 is pressed the ultrasonic sensor will turn on. At that time, the sensor was connected to the Arduino and also the buzzer. When there are any obstacles, then the ultrasonic sensor will immediately send a reflected signal which is sent to the transmitter (ultrasonic trigger pin) to the receiver (Echo pin ultrasonic) and then the buzzer will sound.

Then, when the push button 2 is pressed, the mode will detect the presence of a fire and send a message directly through the flame sensor and SIM800L as an intermediary. The two components are of course already connected to Arduino. This mode is only used when the user senses a fire, by slightly moving their hand to find for the fire's presence and also confirms it by themselves. The flame sensor immediately detects and sounds a buzzer and will send a message to the user's family when there is a fire either at home or around them.
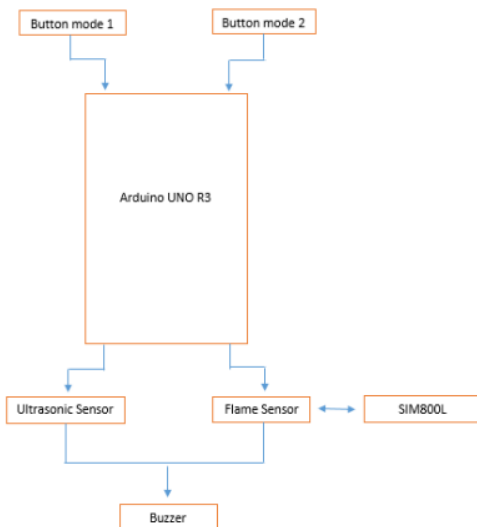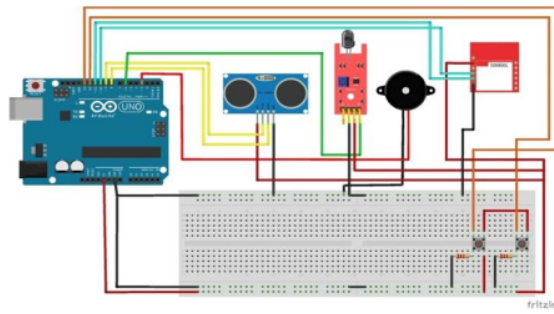

Fig. 6. Schematic diagram of full device prototype.

Figure 7 shows the flow-chart of the glove prototype mechanism in a more detail and step-by-step procedural method. While Fig. 8 is the front view of the full device prototype which are ready to be tested.
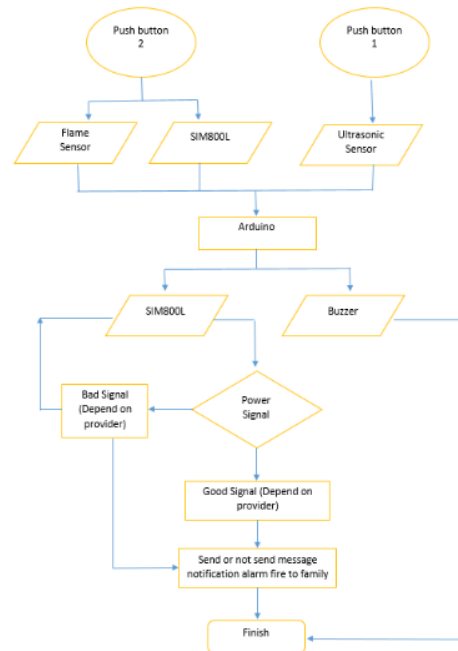

Fig. 7. Flow-chart of the (smart) glove mechanism.

Fig. 5. Block diagram of full device prototype.

Fig. 8. Front-view of full device prototype.

IV. RESULTS AND ANALYSIS

Here the results will be grouped into two parts. It aims to make it easy for readers to understand that this prototype has two similar results for each function according to the user.

The first result, a test is conducted on the glove before using it on the hand. In this test, button 1 will be pressed, using a hurdle in the form of an acrylic box in front of the gloves and the results can be seen in Table 2. And the second result is gotten (Table 3) when the device puts on the blind people's hand as shown in Fig. 9.

Table 2. Results when using acrylic box.

Total Experiment with acrylic box	Measurement with Ultrasonic (cm)	Buzzer ON/OFF
1	60	OFF
2	50	OFF
3	40	ON
4	30	ON
5	20	ON
6	10	ON

Table 3. Results when putting the prototype on hand.

Total Experiment which put it on hand	Measurement with Ultrasonic (cm)	Buzzer ON/OFF
1	60	OFF
2	50	OFF
3	40	ON
4	30	ON
5	20	ON
6	10	ON

Table 2 and 3 show the results of the various experiments tested. For the first and second tests with the acrylic box, the 60 cm distance was not able to make the ultrasonic detect an obstacle and the buzzer did not sound. However, for the third to sixth test, when the box is brought near, the ultrasonic and buzzer immediately detect and emit a sound, respectively.

Fig. 9. Experimental testing when the device is put on hand.
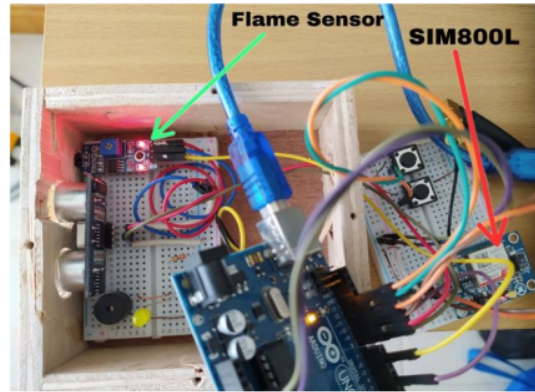

Fig. 10. Placement of flame sensor and SIM800L module.

Figure 10 above shows the placement position for the flame sensor and SIM800L. We put the flame sensor inside the wood box and SIM800L was placed outside the wood box because it will be easier for the sensor to find the signal for communication.

Figures 11 and 12 are showing two conducted experiments to check the ability of the sensor device to detect the existence of small fire using matches and the big fire by burning the paper.

Fig. 11. Experiment using matches to produce a detected fire.

Fig. 12. Experiment using burned paper to detect a fire.

As mentioned in Chapter III, we tend to use the digital output type flame sensor which only detects the numbers of 0 and 1. Number 0 indicates that there is no fire at all in the room or around that person, while number 1 indicates that there is a fire in the room or around that person. The distance that can be reached in the event of a big fire is about more or less than 20 cm. While for a small fire, the distance that can be reached is more or less than 15 cm.

If a fire occurs, this sensor will detect the fire and will give a sound through the buzzer inside. When the buzzer goes on, the SIM800L will immediately send a message to their family. The number of SMS will continue to be sent for 1 second (depending on signal conditions) if the fire has not been extinguished or maybe the fire is getting bigger. From the family, somebody can directly contact the nearest neighbours to check if there is a fire and help this blind person get out of the house or maybe you can directly call the fire officer. If the person's position is outside, then he can return to the distance detection mode again or he can just turn it off.

Unlike the case when using the analogue output version, the results can find out how close the fire to the user. But it will definitely be very confusing for the user because the sound that comes out of the flame sensor analogue output sounds the same "beeps" as the sound from the ultrasonic sensor and depending on a certain distance.

V. Conclusion

The embedded (smart) glove detection prototype has been successfully implemented and tested. When mode 1 is active, ultrasonic sensor will detect the obstacle and range and will give the tone through alarm buzzer. But, when mode 2 is active, flame sensor and SIM800L will be active to detected fire and quickly send the message to the family.

For the future works, some improvements can be made by changing the main box from wood to be acrylic to reduce weight when wearing it on hand and using IoT for activating another function like GPS tracker to find out the person's position whether they are at home or outside the house by sending map coordinates.

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