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Safety Hat for Blind People

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Abstract: People who are visually handicapped or blind find it challenging to travel alone, mostly because they are less aware of their surroundings and unable to feel potential risks. These might endanger themselves. Thus, this work proposed a Safety Hat for Blind People to assist them in performing their daily routines such as walking the dog and buying groceries, only to name a few. The safety hat is made up of three major systems: an obstacle avoidance system, a health monitoring system, and a rain monitoring system, all of which are connected to an Arduino Mega 2560. The obstacle avoidance system, which makes use of four pairs of ultrasonic sensors, shall be activated to alert the user of approaching obstacles from the front, back, left, or right side. Based on experiments, the obstacle avoidance system may detect an obstruction within 100 cm. The user's pulse rate and amount of oxygen (SpO_2) can be assessed by the health monitoring system, which employs a pulse oximeter and heart rate sensor, and the results are displayed on the LCD display attached to the safety hat. A buzzer that signals a high pulse rate shall be activated if the measured pulse rate exceeds 100 bpm. The rain monitoring system, on the other hand, uses a rain sensor module to detect the presence of water and uses a buzzer to alert the user. Based on the outcomes of the experiments, this Safety Hat for Blind People shall provide a secure environment for them to lead their daily life normally without any sense of danger.

Keywords: Safety hat, blind, ultrasonic sensor, pulse oximeter and heart rate sensor, rain sensor module

1. Introduction

Some people are blessed to be able to live normally. All five senses, touch, hearing, sight, smell, and taste are the most important traits for a human being [1]. Without either one of them, a person's life can change drastically that can make it worse. Visually impaired people or blind people are known as the person that is lacking one of the five senses, which is visual. Without a visual sense, one will face difficulties in observing and getting familiarized with the surrounding area. Furthermore, those who are affected by retinal diseases are likely to never recover [2].

Data taken from official source of World Health Organization (WHO) [3] states that there are about 285 million people worldwide with a visual impairment. 39 million of which consists of people that are visually impaired, and the rest are people with poor vision. Around 89% of them are from middle and third world countries and most of these people are mostly aged 50 or older [4]. If left untreated, visual impairment can cause a lot of damage, mainly towards the person itself. Early-onset severe vision impairment in young children can have a lasting impact on their motor, verbal, emotional, social, and cognitive development [5]. Children in school who have eye problems may also perform less well academically. Vision impairment in older people can increase their risk of falling and fractures, social isolation, difficulties walking, and early admission into nursing or care facilities.

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Visually impaired or blind people have difficulties in travelling alone mainly because they could not sense the obstacles and are less aware of their surroundings. These might put themselves in danger. Even though there are other similar devices such as walking cane and visually impaired sunglasses, it may lack certain safety features. This work proposes the use of hat rather than using a walking cane or sunglasses to assist a visually impaired person [6]. By utilizing a microcontroller Arduino Mega 2560 Rev3 [7] featuring ultrasonic sensor HC-SR04, it can help the user to be aware of oncoming obstacles such as walls, poles, holes as well as passersby, and prevent unwanted accident [8]. Ultrasonic wave is the integral element due to its effectiveness in sensing an object without leaving any unnecessary damages [9]. What makes this work unique is the implementation of various features such as rain alarm, heart rate sensor and vibration motor. Rain sensor module shall inform the moment the sensor detects moisture [10]. Heart rate sensor shall determine the user's heart rate pulse [11]. Vibrator motor feature shall alert the user of oncoming obstacles. All these features can provide much-needed help to visually impaired people.

2. Methodology

This section discusses the methodology applied in completing this work.

2.1 Block Diagram

Figure 1 shows the block diagram of Safety Hat for Blind People. From the figure, it can be seen that the safety hat is controlled by Arduino Mega 2560 as the main controlling unit. The key component, which is the ultrasonic sensor, acts as the input for object detection. Alongside the MAX30100 pulse oximeter and heart rate which measures the pulse rate and amount of oxygen of the heart and rain sensor module that detects the presence of water, these inputs will send signals to the microcontroller to be analyzed and processed. The processed signals will then be sent to the output which includes the I2C Serial Interface 1602 LCD Module, mini disc vibrating motor and Piezo buzzer to alert the blind person.

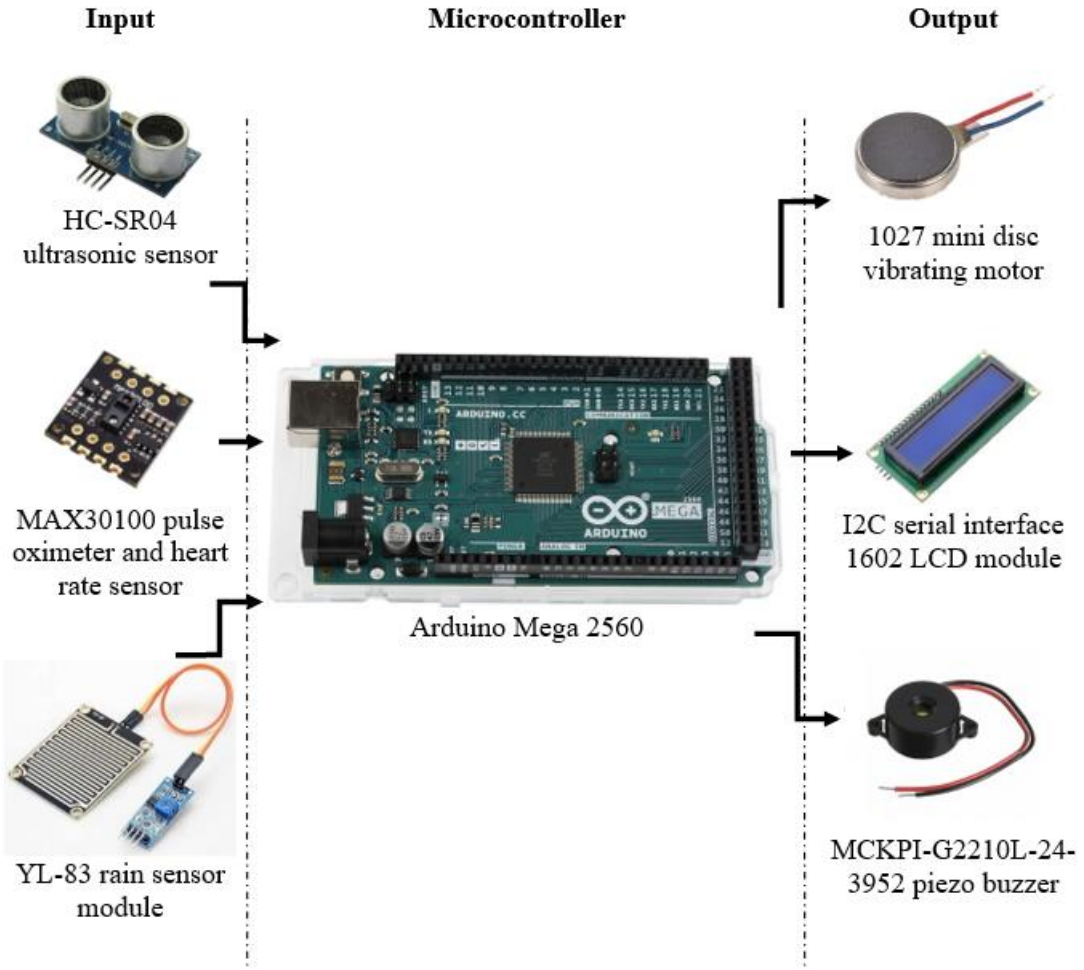


Fig. 1 - Block diagram of the safety hat for blind people

2.2 Arduino IDE Software

Arduino IDE is an open-source software, designed by Arduino.cc and mainly used for writing, compiling and uploading code to almost all Arduino modules. It is an official Arduino software, making code compilation too easy even for a common person with no prior technical knowledge. It is available for all operating systems i.e., MAC, Windows, Linux and runs on the Java platform that comes with inbuilt functions and commands that play a vital role in debugging, editing, and compiling the code [12]. The Arduino IDE interface, as can be viewed in Figure 2, mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module. This environment supports both C and C++ languages.

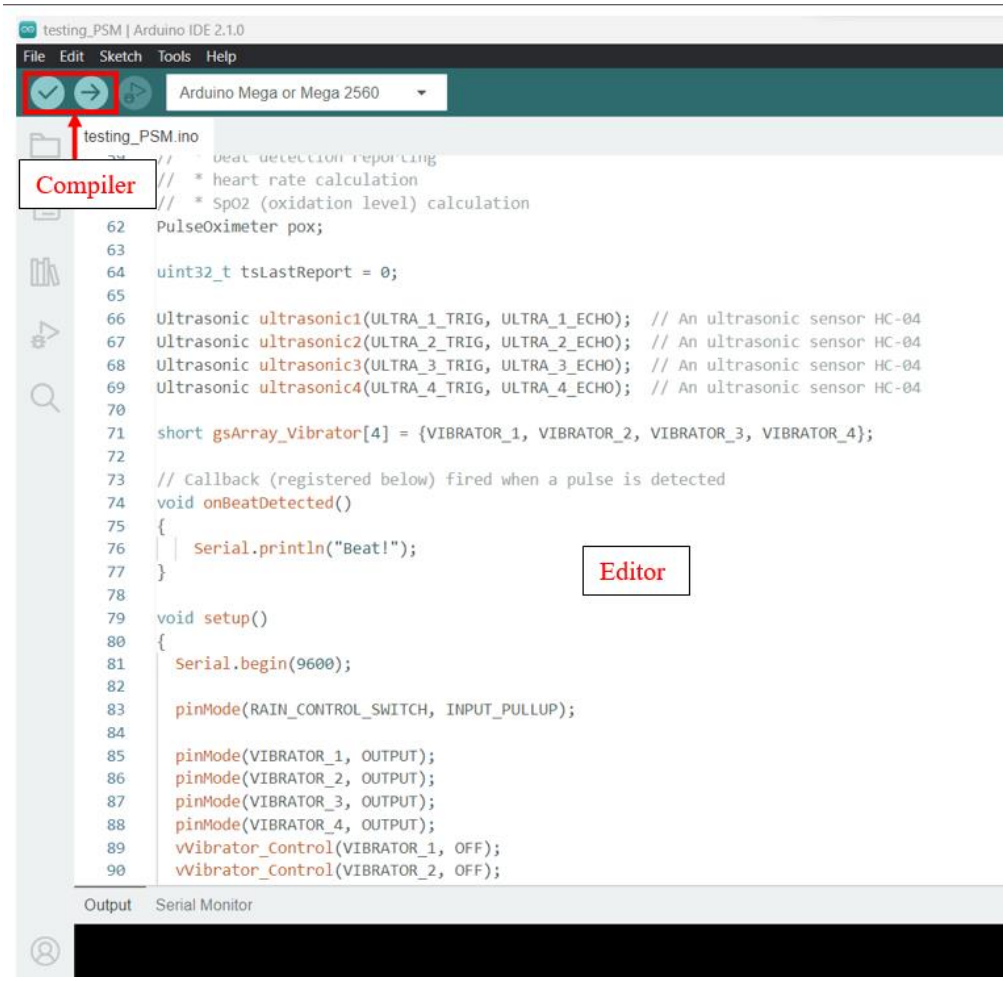


Fig. 2 - The Arduino IDE interface

3. Results and Analysis

This section discusses the result obtained from Safety Hat for Blind People that is divided into final product, obstacle avoidance system, health monitoring system and rain monitoring system.

3.1 Final Product

The final product in this work, as shown in Figure 3, which consists of an obstacle avoidance system to detect any oncoming obstacle, health monitoring system to keep track of heart rate and amount of oxygen and also rain monitoring system to warn user of incoming rain.

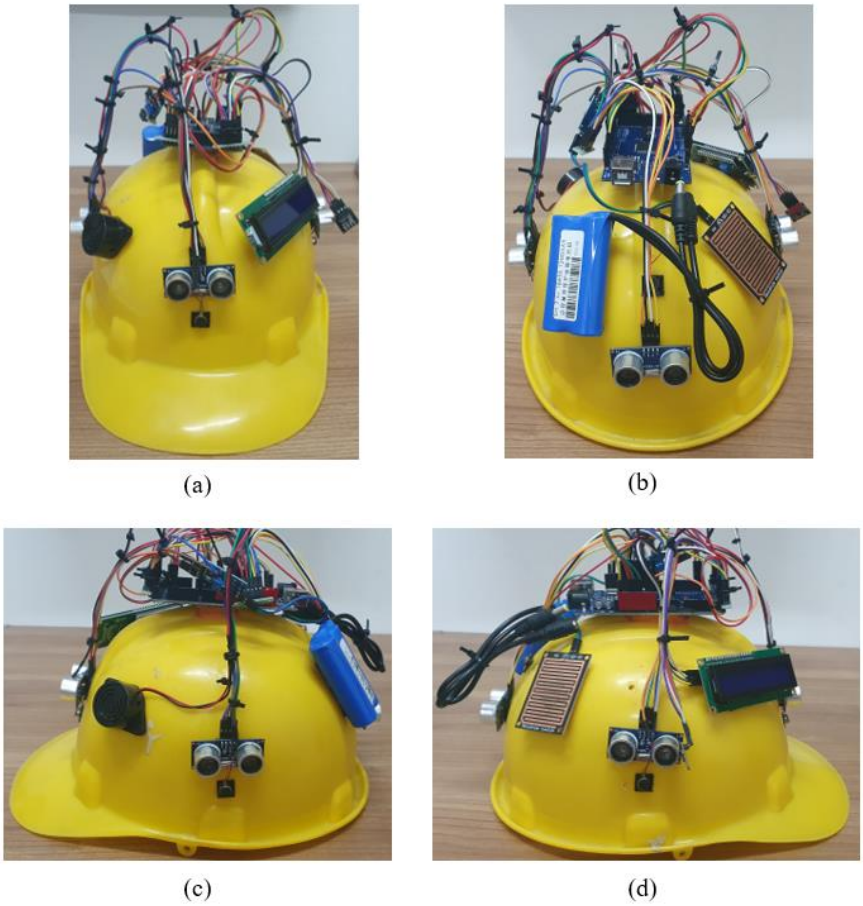


Fig. 3 - The complete prototype of safety hat for blind people: (a) front view; (b) back view; (c) left side view; (d) right side view

3.2 Obstacle Avoidance System

Figure 4 shows the configuration of obstacle avoidance system involving four pairs of ultrasonic sensor and mini disc vibrator on the Safety Hat. These sensors are placed at the front, left, right and back side of the safety hat in order to provide 360º protection. The mini disc vibrator is placed at the appropriate position so that the user can feel the vibration indicating that there is an obstacle.

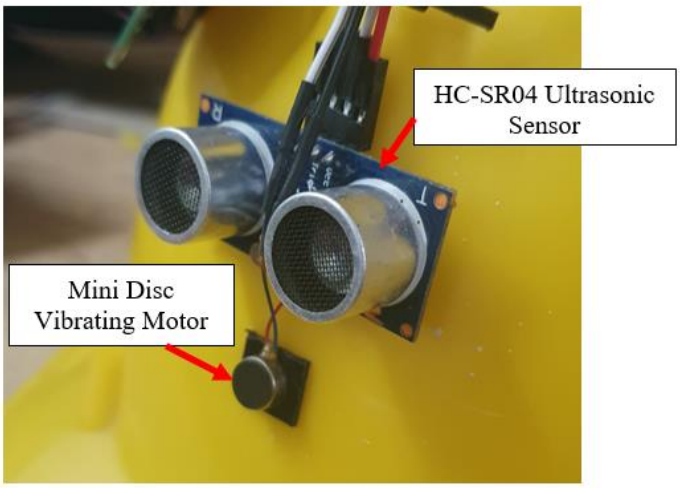
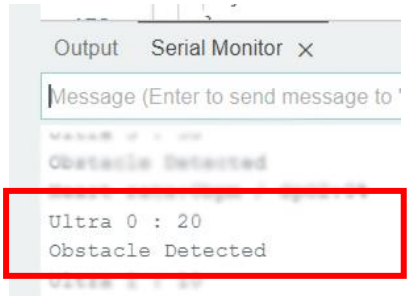
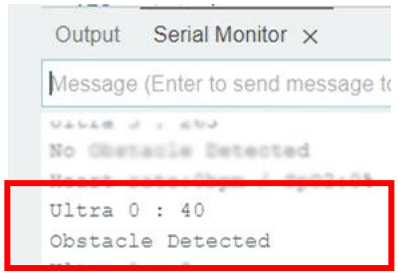
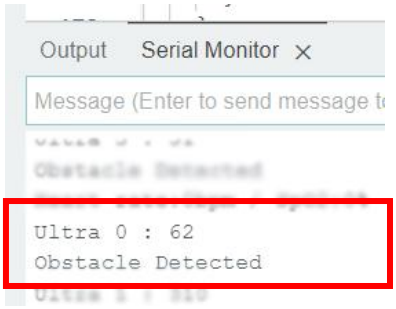
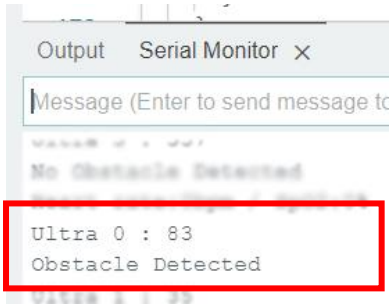
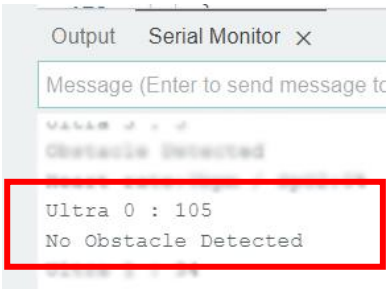


Fig. 4 - The configuration of obstacle avoidance system on the safety hat

Mini disc vibrator shall vibrate when there is an obstacle in front of the ultrasonic sensor. For the purpose of validation, an experiment is performed where an obstacle is located at 20 cm, 40 cm, 60 cm, 80 cm and > 100 cm from the ultrasonic sensor located at the front of the Safety Hat. The results are recorded and observation are summarized in Table 1.

Table 1 - The assessment of obstacle avoidance system with different distances

Obstacle distance from sensor	Displayed result on Arduino IDE serial monitor
20 cm	 **Observation:** It can be seen from the display of serial monitor that the **obstacle is detected** at 20 cm from the ultrasonic sensor located at the front of safety hat.
40 cm	 **Observation:** It can be seen from the display of serial monitor that the **obstacle is detected** at 40 cm from the ultrasonic sensor located at the front of safety hat.
60 cm	 **Observation:** It can be seen from the display of serial monitor that the **obstacle is detected** at 60 cm from the ultrasonic sensor located at the front of safety hat.

80 cm	 **Observation:** It can be seen from the display of serial monitor that the **obstacle is detected** at 80 cm from the ultrasonic sensor located at the front of safety hat.
> 100 cm	 **Observation:** It can be seen from the display of serial monitor that the **obstacle is not detected** at more than 100 cm from the ultrasonic sensor located at the front of safety hat. This shows that 100 cm is the maximum distance that can be covered by the front sensor which also implies similar performance by the rest of the sensors at the left, right and back side of the hat.

3.3 Health Monitoring System

The configuration of health monitoring system of the Safety Hat which consists of a MAX30100 pulse oximeter and heart rate sensor and I2C Serial Interface 1602 LCD Module can be seen in Figure 5. The LCD display is placed near the pulse oximeter and heart rate sensor for easy access to monitor the pulse rate.

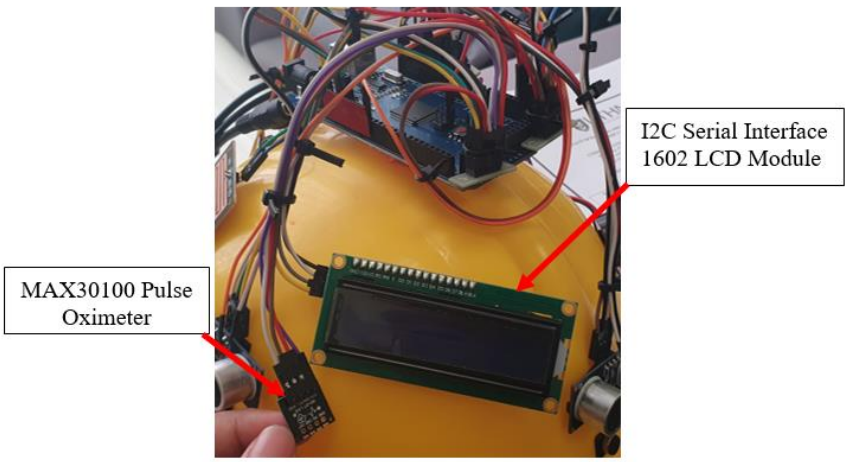


Fig. 5 - The configuration of health monitoring system on the safety hat

In order to obtain the pulse rate and amount of oxygen, the user needs to firstly place their forefinger appropriately onto the sensor with LED side facing up. The sensor will then transmit the red light from the LED through the user's forefinger tissue to measure the pulse rate and the amount of oxygen (SpO2). The results are then displayed on the LCD for the caretaker to take note. If the measured pulse rate is way over 100 bpm, then the buzzer will activate and thus, alarming the caretaker or surrounding people on the condition of the user. The observation on the heart rate and amount of oxygen are discussed in Table 2 based on different body state.

Table 2 - The evaluation of health monitoring system in different body state

Body state	Displayed result on LCD display
Relaxed	 **Observation:** It can be seen from the LCD display that the heart rate is **65 bpm** and amount of oxygen is **99%** when the body is in relaxed state.
Active (after workout)	 **Observation:** It can be seen from the LCD display that the pulse rate is **129 bpm** and the amount of oxygen is **99%** when the body is in active state (after workout). This shows that when the body is in an active state, the pulse rate increases compared to the relaxed state.

3.4 Rain Monitoring System

The rain monitoring system was configured as shown in Figure 6 as a part of Safety Hat. The system consists of a rain sensor module and buzzer. The rain sensor module is made up of a sensing pad and the sensor itself.

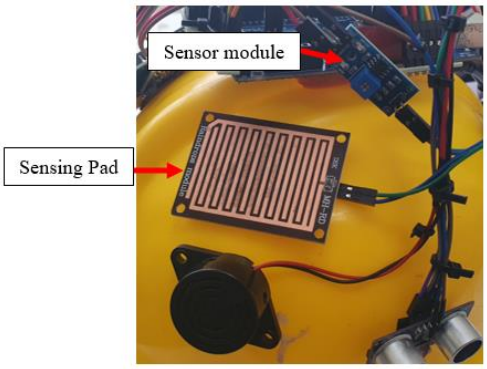
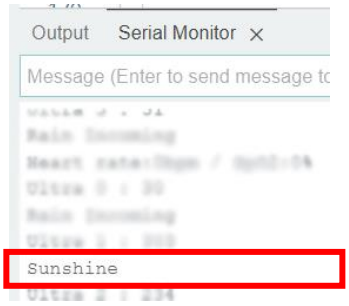
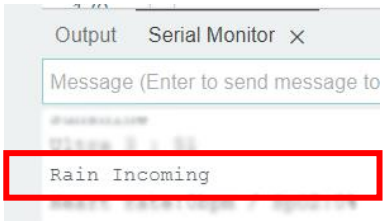


Fig. 6 - The configuration of rain monitoring system on the safety hat

The operation of rain monitoring system begins as soon as the sensing pad detects water. The power LED shall turn ON which indicates that the sensor is activated. In a case where water is present, the signal LED on the module shall turn ON. The circuit is now in ON state where it will activate the buzzer. Table 3 shows the output on Arduino IDE serial monitor with and without water.

Table 3 - The assessment of rain monitoring system with and without water

The presence of water	Displayed result on Arduino IDE serial monitor
Without water	 **Observation**: The serial monitor shall display **Sunshine** when there is no presence of water.
With water	 **Observation**: The serial monitor shall display the word **Rain Incoming** when there is a presence of water.

4. Conclusion

The Safety Hat for Blind People has been designed and developed in this work. The safety hat consists of three main systems which are the obstacle avoidance system, health monitoring system and rain monitoring system that are integrated together with Arduino Mega 2560. The obstacle avoidance system that utilizes four pairs of ultrasonic sensors, shall inform the user of an oncoming object through vibration either from the front, back, left or right side. Based on the experimental results, the obstacle avoidance system is able to detect an obstacle within 100 cm. The health monitoring system which uses a pulse oximeter and heart rate sensor, allows the caretaker to check the user pulse rate and amount of oxygen (SpO2) which are displayed on the LCD display attached to the hat. If the measured pulse rate is over 100 bpm, a buzzer shall activate which indicates that the pulse rate is high. On the other hand, the rain monitoring system which makes use of the rain sensor module shall warn the user of the presence of water from the sound of a buzzer which might indicate that it is raining. In conclusion, the Safety Hat shall provide a safe environment for blind people to lead their daily life normally without any sense of danger.

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