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Prototype Development of Hand Wearable RF Locator with Smart Walking Aid for the Blind

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ABSTRACT

This paper presents Prototype Development of Hand Wearable Radio Frequency (RF) Locator with Smart Walking Aid for the Blind. Visually impaired people have suffered a lot as they cannot move freely unless receive helping hands from someone close to them. Those blind persons, who have acquired walking aid before now, do misplace it without knowing. This has been a very big challenge to the blind people as they feel irrelevant to the society. However, this system is aimed at providing assistance to the visually impaired and helping them locate the smart walking aid when it gets missing. The system is made up of hardware and software. The hardware part consists of proximity sensor, buzzer, controller and other components put together to actualize the obstacle detecting and alarming capability of the system. The software part comprises of written codes in C language via Arduino IDE that makes both the smart walking aid and RF locator to communicate properly. This system was tested using blind person with successful exercise.

Keywords: Wearable RF Locator, Smart walking Aid, Blind, Arduino Microcontroller

1. INTRODUCTION

The development of navigation tools for people who are visually impaired had become an important concern in the research area of assistive technologies. It was obviously stated, from the review conducted that navigation systems for the target users lack some core features which are quite important for independent navigation [1]. Mobility, even a simple one, cannot be achieved independently without sufficient knowledge of our environment as discussed in [2]. This has becomes a challenge for visually impaired people as they require and rely on support to carry out their daily activity. Obstacle detection as well as obstacle warning can assist the mobility and also reduce the risk for the blind ahead of time. It has been a strenuous process for the blind and visually impaired people to easily trace the bus stop and transportation vehicle because of their sight problem. To tackle the problem, various devices had been built to aid in the mobility of the visually impaired people many years back. Those devices work with Global positioning system

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(GPS) and Satellite system which have drawback. They cannot function in any enclosed places while the wearable devices happened to be difficult for the blind to manage [3].

2. REVIEW OF RELATED WORKS

In [4], Wearable Smart System for Visually Impaired People is presented. The system was designed to aid the blind move freely on the street and public environment before asking of help from individual. It also creates awareness to people around them for help in case of any challenge or difficulty. The device at the same time sends message including the location of the visually impaired person (VIP) to any family member or caretaker registered phone for assistance. IoT-Based Wearable Assistive Device for Visually Impaired People was implemented in [5]. A sensor-based wearable assistive gadget to help visually impaired individuals stroll without anyone's help through the roads. When the user is in a noisy environment, the system vibrates various fingers of the user to create awareness of the obstacle direction ahead. Flame sensor added to the system helps to detect fire and warn the blind with vibration as well. The emergency button on the system is used to alert the caretaker of the visually impaired person, including location via message when pressed. In [6], a Real time Guide to Visually Impaired People for Obstacle and Fall Detection Monitoring was developed. Their system was able to detect obstacles ahead of the visually impaired person and sudden fall, then, informs the user's guardian. For easy tracking and alerting of locations to guardians of the user in case of difficulties, smartphone application is used. During test, the user was 50cm away from the obstacle and the system achieved accuracy of 98.34%. Autonomous Path Guiding Robot for Visually Impaired People developed in [7-9]. They introduced an intelligent and efficient path guidance robot that would help the blind navigate properly in their movement. The robot is capable to guide the user to travel places which cannot be traced using GPS. It can move along multiple paths and then remember as well as retrace all of them. In [10], a Novel Wearable Assistive Device for a Visually Impaired Person was constructed. Their device was based on range-based sensors and would work effectively in both indoor and outdoor conditions. Two separate modules were designed and used. The first module is meant to be worn on the user's waist belt and the second module worn on the ankle. The two modules communicate wirelessly to give fully coverage on the navigating path of the user. The device was integrated with the required network setup connection to help avoid interference of devices in a close range and allow easy use of it in a crowd mode. Design and Implementation of Microcontroller Based Mobility Aid for Visually Impaired People implemented in [11]. Their system used AT89C52 microcontroller to process various detection sensor signals and control the mobility of the visually impaired person through beeping sound alerts in case of water, dark areas and obstacles. The sensors were used to detect obstacle, water and dark areas on the user navigating path. These were achieved through the help of written program in assembly language. The light weight and low cost system was tested for accuracy by monitoring the walking process of the visually impaired person with successful result. Vision Navigator: A Smart and Intelligent Obstacle Recognition Model for Visually Impaired Users was developed in [12]. This device called smart-alert walker was built to alert the user concerning any close obstacle on the navigating path. The lightweight shoe, developed with SSD-RNN model, was tested in real time using visually impaired person. The performance at both indoor and outdoor environments was recorded successful. In [13], a Tracking System for Object Recognition to Assist Visually Impaired People using Convolutional Neural Network Technique was discussed. Their system provides navigation in real-time using an automated voice. Dataset containing 1000 categories was used to train a deep convolutional Neural Network (CNN) model for object detection and recognition and the model achieved an accuracy of 83.3%.

3. PROTOTYPE DESIGN METHODOLOGY

The design approach used in developing the system is prototyping method. The system is made up of hardware and software. The hardware section consists of smart walking stick and RF locator while the software is the written codes that controls the entire system and ensure steady communication within the user navigating environment.

3.1. System Hardware Section

The hardware of the system comprises of the power supply, transmitter, receiver, input/output, and control units as shown using block diagram of figure 1.

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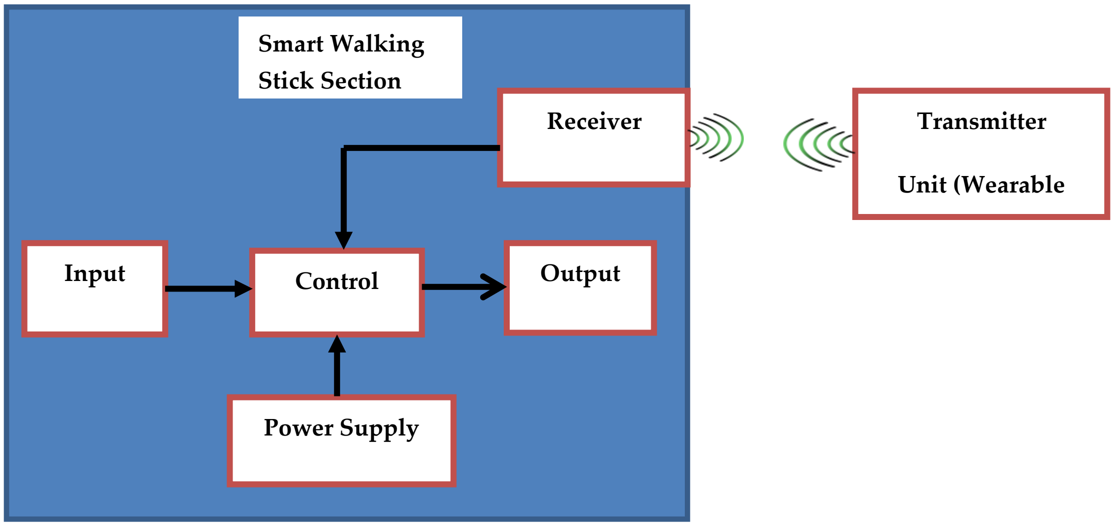


Figure 1: Block Diagram of Proximity detector with hand Wearable remote Locator

A. Power Supply Unit

The Smart walking stick system requires +5V DC to operate fully. A 9v DC battery was used to provide the DC power supply required. The power supply unit consists of 9v DC lithium ion rechargeable battery, 7805 voltage regulator, charging power control transistor switch Q1, filter capacitor C7 and C8, and charging control transistor as shown in figure 2. Capacitor C7 and C8 are used to improve on the stability of the 7805 voltage regulator IC and stabilize charging voltage during recharging.

The control unit constantly monitors the battery voltage through resistors R1 and R2 which are connected as voltage dividers to feed a portion of the battery voltage to the control unit. When the voltage of the battery goes lower than the set point, a signal is sent to the output unit that generate continuously a low pitch sound to alert the end user of low battery status. At the same time, switches on transistor Q1 to initiate charging of the battery from a 30v external charging source. While charging is taking place, the battery voltage is constantly being monitored as to terminate the charging process when the batteries are fully charged.

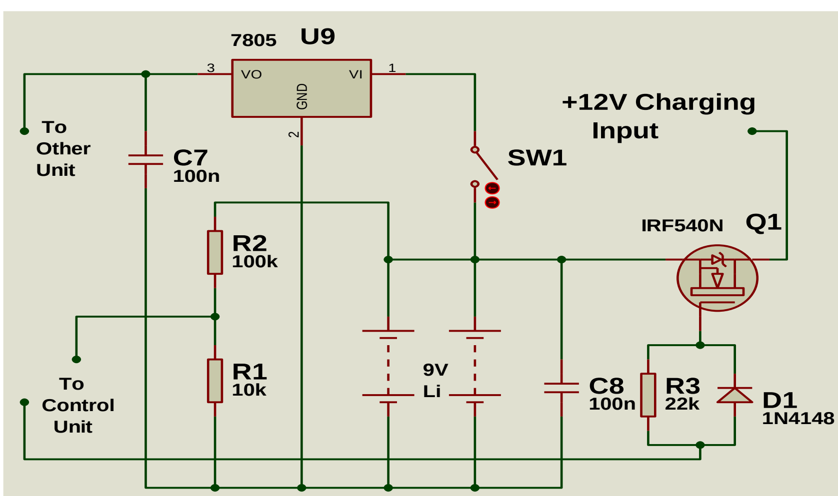
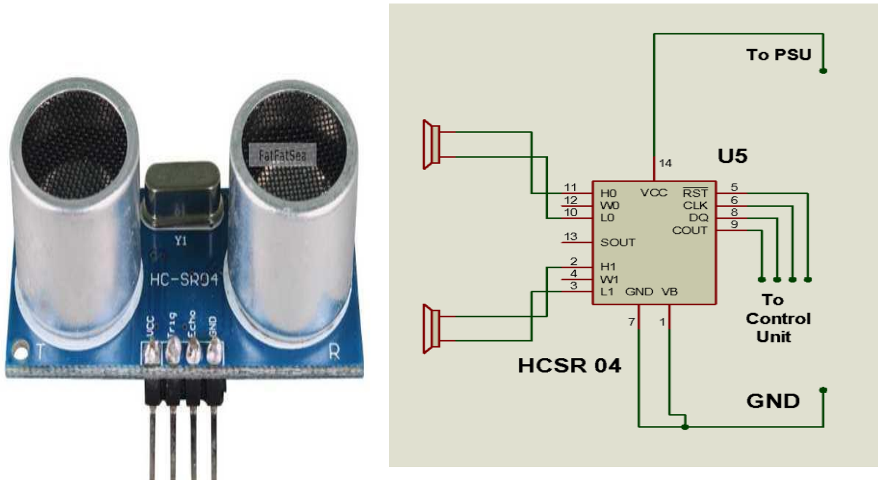


Figure 2: Circuit diagram of the Power supply unit of the system

B. Input Unit

The input unit consists of the HC - SR04 ultrasonic sensor that measures signal from 2cm to 400cm of distance of an object from the user. The output of the ultrasonic receiver or detector remains high if no reflected ultrasonic wave is detected but goes low when a 48 KHz burst of ultrasonic wave is detected. Figure 3 shows the Image of the HC - SR04 and the circuit diagram connection.



sensor and circuit diagram connection

C. Control Unit

The control unit consists of Arduino Uno ATmega328P microcontroller board which is used to control the behavior of the smart walking stick. During operation, signal line from the receiver is constantly monitored to know if the button on the remote has been pressed. If it is, the control unit initiates a transistor to start playing an embedded music. If there is no signal from the receiver unit, the control unit switches to the obstacle detection mode. The Arduno ATmega 328P with circuit connection diagram is shown in figure 4.

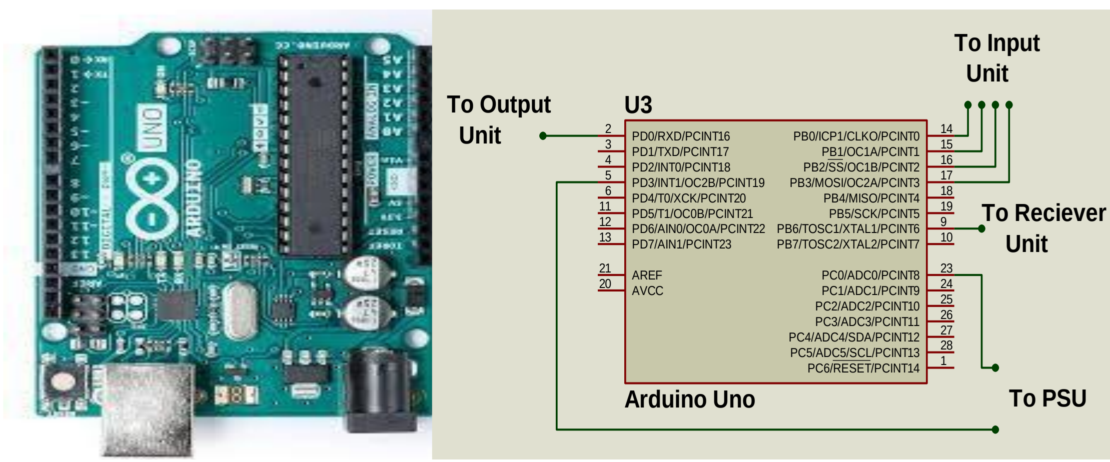


Figure 4: Arduino ATMega 328P with circuit connection diagram

D. Receiver Unit

The receiver unit is designed to receive and decode the transmitted signals from the remote transmitter unit (RF locator). The receiver unit consists of the 433 MHz radio frequency receiver pair and a 555 timer monostable circuit as shown in Figure 5. The transmitted radio wave signal is received and decoded before being applied to the control and 555 timer monostable circuits for proper signal conditioning.

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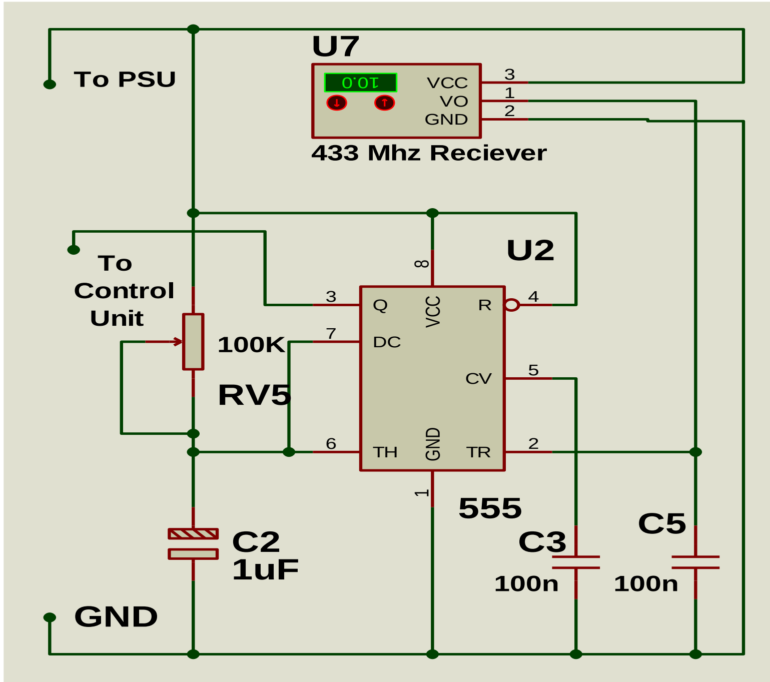

Figure 5: Receiver unit of the smart walking stick

E. Transmitter Unit (RF locator)

The remote control unit is used to activate the buzzer sound if the button on the remote is depressed. It consists of the 555 timer integrated circuit (IC) that is wired as a one-shot multivibrator and a 433 MHz radio frequency transmitter module. The 433MHz transmitter has its corresponding receiver pair that can receive and decode any signal radiated out by the transmitter unit as radio waves. The one shot multivibrator is required to generate a pulse of about 20ms duration that is applied to the data input of the 433 MHz transmitter for transmission. The circuit diagram of the transmitter circuit is shown in figure 6.

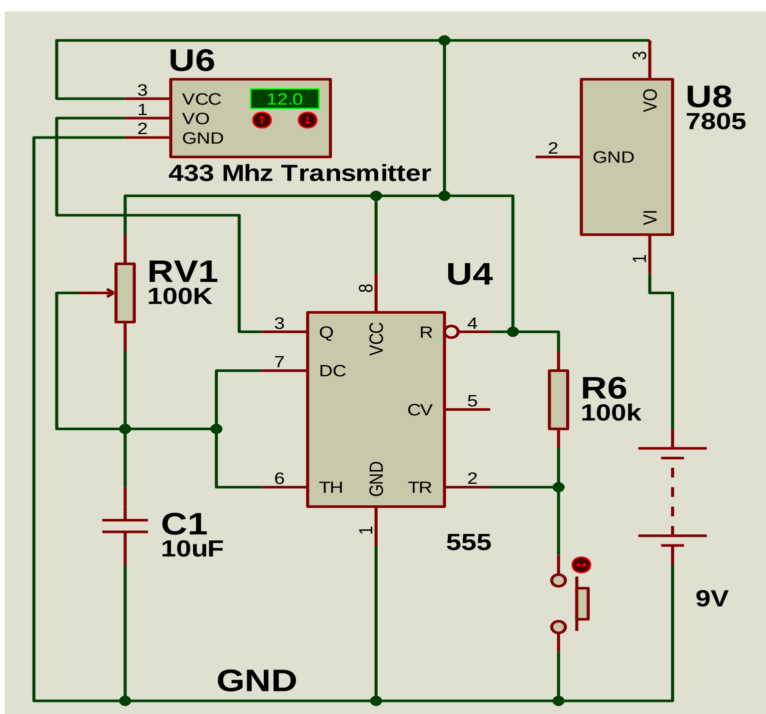

Figure 6: The circuit diagram of the transmitter unit

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F. Output Unit

The output unit gives the required sound through the inbuilt buzzer connected via switching transistor when an obstacle is detected or remote transmitter button is pressed. It basically consist s of a switching transistor and a buzzer for alerting purposes as shown below in figure 7. This unit is responsible for alerting the presence of an obstacle depending on signal received from the transmitter unit. The transistor base Q2 is triggered from the control unit to switch on the power through the buzzer from Vcc when an obstacle is detected. The buzzer has a load resistance of 200Ω (measured) and the current gain of the BC440 output transistor.

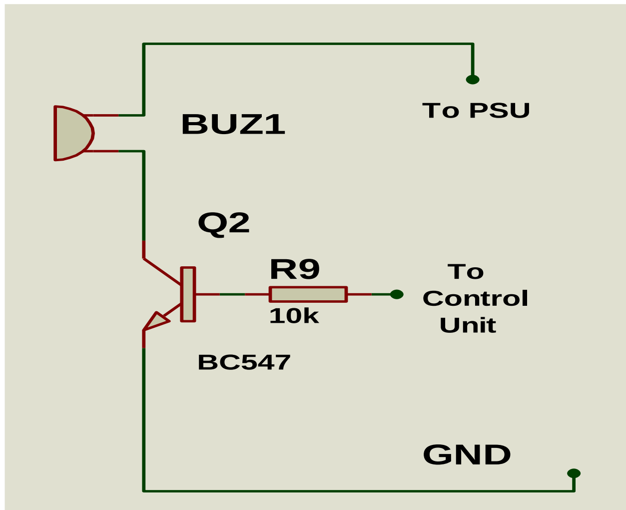

Figure 7: Circuit diagram of the output unitFigure 3: Image of HC - SR04 ultrasonic

3.2. System Software Section

The programming language used to write the codes for the Smart walking stick is embedded C language. The codes were written in IDE of Arduino application and compiled (converts C language into machine language). The converted hex file is written in ATmega 328P microcontroller's code memory. The Arduino IDE and sample written C language codes are shown in figure 8.

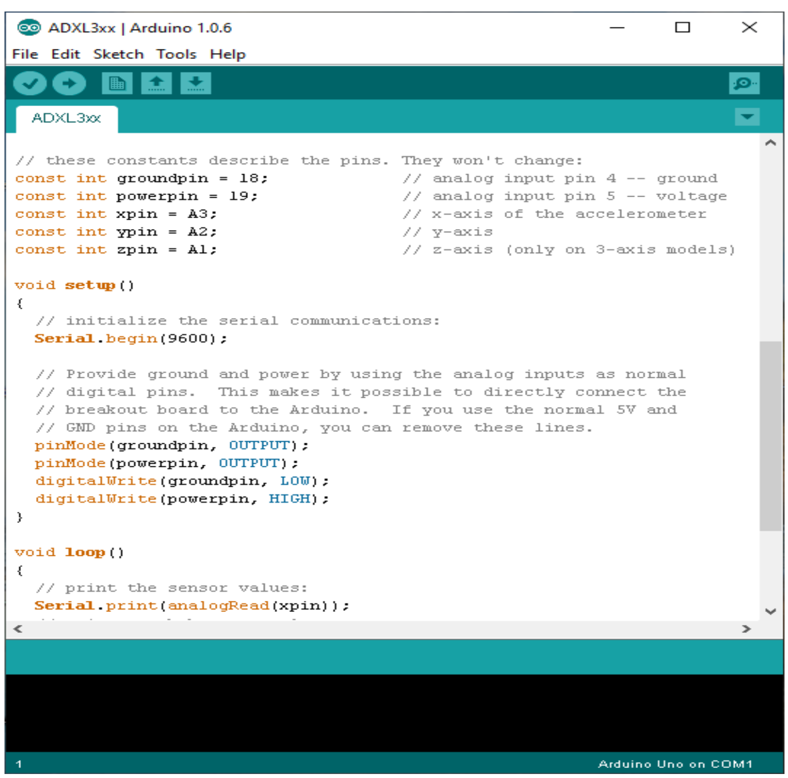

Figure 8: Sample written codes in Arduino IDE

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3.3 System Algorithms and Flow Chart

The system algorithm for smart walking aid for the blind with hand wearable remote locator is described in the following steps:

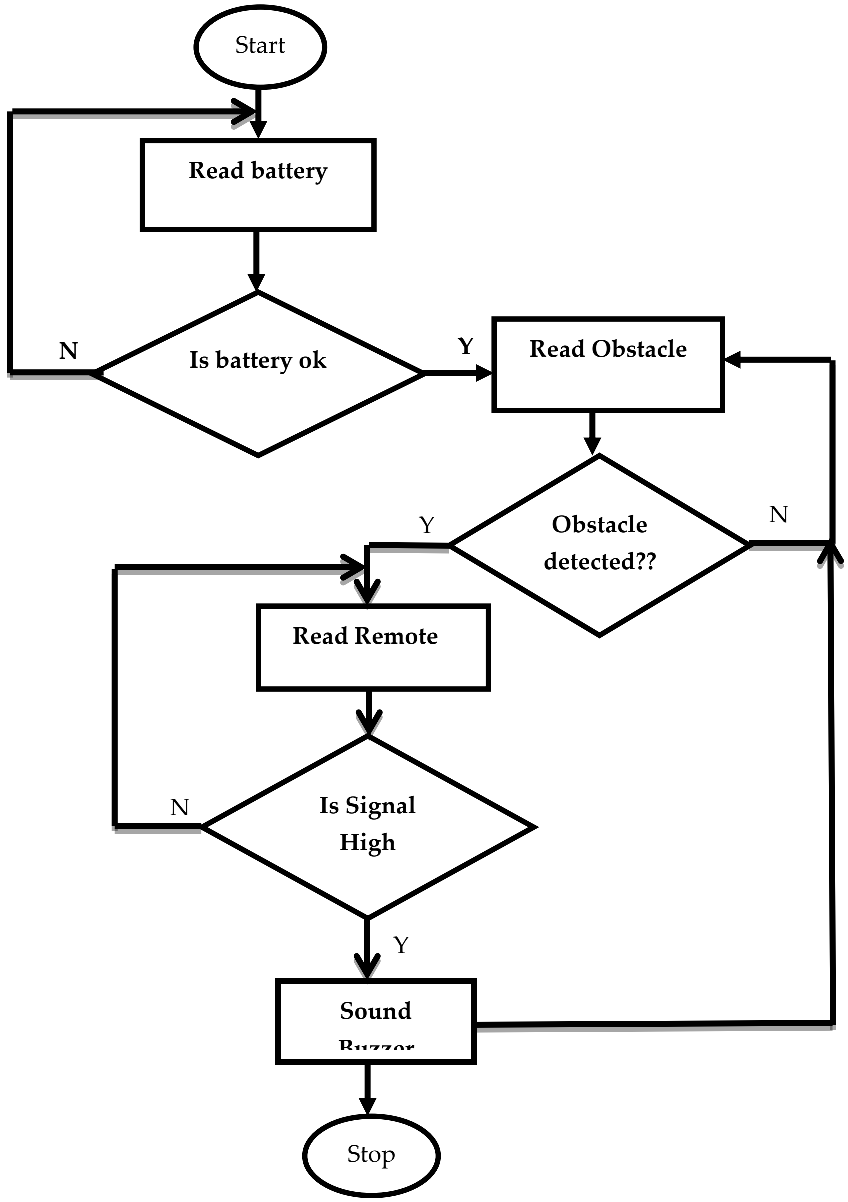

Figure 9: Flow chart of smart walking aid for the blind

Step 1: Start and initialize all variables
Step 2: Read battery voltage and check if battery is ok
Step 3: If yes, go to step 4
If No, go to step 2
Step 4: Read Obstacle distance and check if it's detected within selected mode range
Step 5: If yes, go to step 6
If No, go to step 4
Step 6: Read locator signal from remote and check if the signal is HIGH
Step 7: If yes, go to step 8
If No, go to step 6
Step 8: Activate buzzer to indicate presence of obstacle and go back to step 4

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Step 9: Stop

The flow chart used to realize the smart walking aid is shown in figure 9.

3.4 System Operation and complete circuit diagram

The operating principle of the smart walking aid with hand wearable locator is discussed .When the receiver unit is switched on; 10us signal is generated and sent to the HC - SR04 ultrasonic distance measuring module which in turn radiates 40 KHz beam of ultrasonic wave to scan ahead of the walking aid. This ultrasonic signal waves reflects back to the receiver (when it encounters an obstacle in its path) which converts the received infrared wave into a varying analogue voltage. An object reflects a short ultrasonic signal being transmitted at time 0. This is converted to electric signal by the sensor upon receiving it. The coming signal is transmitted when the echo fades away. The width of the echo signal corresponding with the distance measured is processed by the controller to determine if an obstacle is detected or not. The system outputs 38ms high level signal when no obstacle is detected. Once the detected range of the obstacle is within this range (less than 50ms), a signal is sent from the control unit to the output unit which switches ON the output unit to start sounding the buzzer.

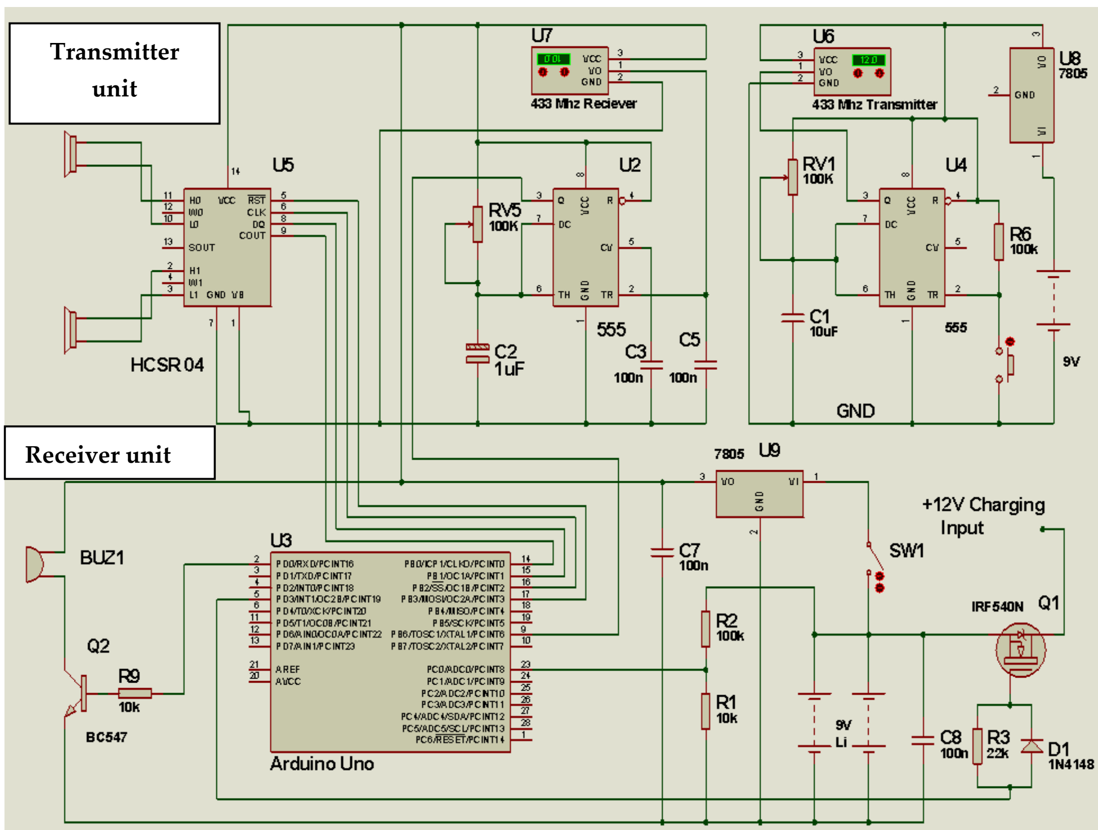

Figure 10: The circuit diagram of the smart walking aid and hand wearable RF locator

However, in case of absence of an obstacle along the pathway, the control unit receives nothing. Should in case a situation arise that the walking stick or proximity detector is carelessly kept and the blind person having difficulty in locating it, the button on the hand wearable remote unit should be depressed. This would generate and transmit a signal to the smart walking aid's control unit which would trigger the inbuilt buzzer to sound for about 5s. This would enable the visually impaired user to locate the walking stick through the produced sound back and continue walking. The circuit diagram of the smart walking aid with the hand wearable RF locator is shown in figure 10.

3.5. Packaged Smart Walking Aid with Wearable RF Locator

The packaging of the smart working aid and RF locator systems were successfully achieved. Plastic casing measuring 15cm in length, 10cm in width and 7cm height was used to package the control system of the smart walking aid with other components (receiver unit). Holes were made where necessary for sensors and buzzer components. The smart walking stick is a 1.3m stainless

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aluminum handle, connected with HC-SR04 ultrasonic sensor for obstacle detection. The transmitter unit (RF locator) was enclosed in a black plastic casing as wearable device. Figure 11 shows the picture of the smart walking aid with the wearable RF locator.

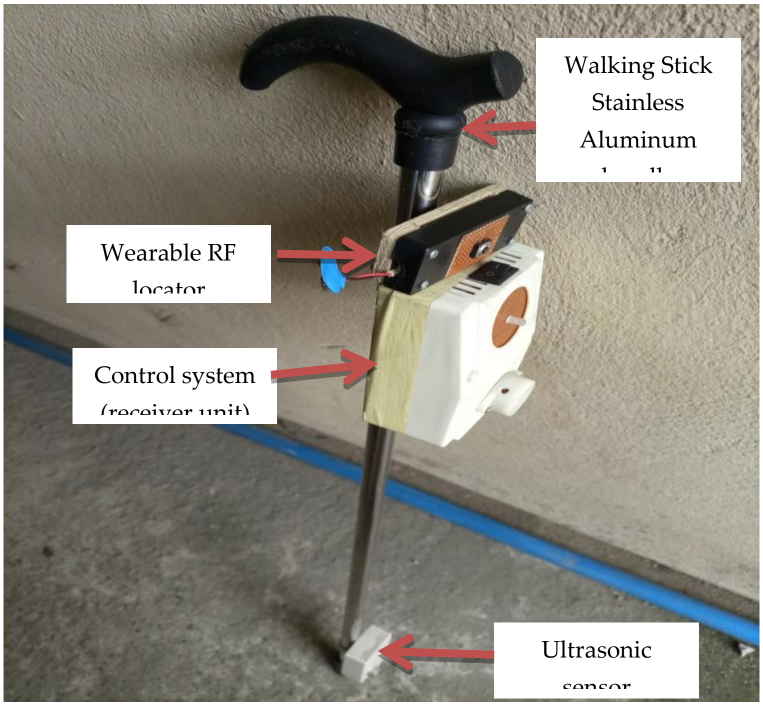


Figure 11: Packaged Smart walking aid with RF locator for the blind

4. RESULTS

The following tests were carried out and results obtained discussed.

4.1. Obstacle Detection Test

The ability of the smart walking aid to detect an obstacle in front of it was tested by switching on the system and moved it close to various obstacles. Various obstacles seen in the path were detected within a maximum distance of 15cm from the tip of the walking aid sensor.

4.2. RF Locator Test

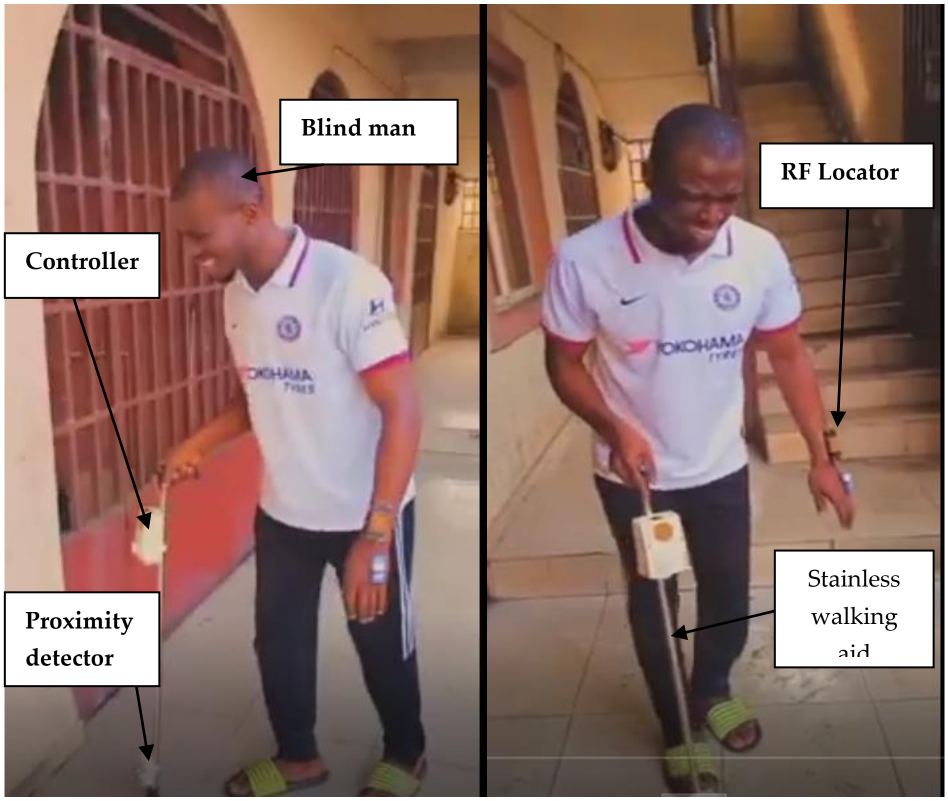
The remote locator system was tested by pressing the button on the remote transmitter device. A loud sound was heard from the buzzer of the smart walking aid device for about 10 seconds to locate the device. This really helped the visually impaired person to get it back from hidden place very fast without much struggle.

4.3. Recharging Test

The recharging feature of the system was also tested by connecting a 12v DC power supply adaptor to the charging port on the designed walking aid while the output charging indicator was observed. A red charging indicator LED that came ON when a 12v power supply was plugged into the socket showed that the system recharging feature is working perfectly.

4.4. Smart Walking Aid with RF Locator Test

The smart walking aid in stainless aluminum has control unit mounted close to the handle and ultrasonic sensor (Proximity detector device) mounted at the lower base of the walking aid. The visually impaired person put on the wearable RF locator on his hand and held the walking aid while walking as shown in figure 12. It was noticed that the smart walking aid always give an alerting sound any time the blind person approaches any obstacle on his path which helped him to change direction accurately. When the smart walking aid was taken away from him, he pressed the button on the RF locator on his hand and used the buzzer sound to locate back the walking aid.



5. CONCLUSION

The Smart walking aid with hand wearable RF locator for the blind has been designed, implemented and tested for use. This would enable people with impaired vision or sight disabilities to navigate their environments successfully without looking for any assistance. The guide stick or obstacle detector detects obstacles and transmits feedback of the obstacle detected through sound to the user. The smart walking aid system also has an additional hand wearable remote locator system which the blind uses to locate the walking aid if misplaced. The product can now be circulated to the entire visually impaired person because of its benefit and low cost. For future enhancement of this work, researchers are encouraged to consider ground holes and find a way of giving separate alert to the blind to escape from falling in the pit. Deep Neural Network learning algorithm can be deployed to optimize smart walking aid for better obstacle analysis and increase the walking process of any blind person.

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Conflict of Interest

The author declares that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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