Assistive Technology Strategy: Wearable Multi-Lingual Blind Technology for Persons with Impairment and Eye-Sight Disability Based on IoT and Cloud

Humayun Rashid, Aasim Ullah, Md. Mosaraf Hossain Khan, Md. Shahid Ullah, S. M. G. Mostafa, Mohammad Jalal Uddin, Abu Tayeb Noman, and Amran Hossain

Abstract People with challenged vision (both permanent and temporary) face several difficulties in their everyday life. A person having visual impairment may not differentiate between colors, which is an essential part of work in several industries such as Ready Made Garments (RMG) sector where sorting cloths based on color is essential. This work represents a more improved version of our previous work which was a demonstration of a talking color detecting device for blind people. Obstacle facing and fall occurrence are very important issues for visually challenged person that are addressed in this chapter. The proposed device uses the latest hardware components including upgraded Central Processing Unit (CPU) and sensors for IoT and cloud-based architecture that can detect color and obstacle efficiently. Moreover it gives notification regarding color and obstacle in multiple languages to visually challenged person. The device also sends fall notification through internet to the caretaker of the visually impaired user in case of fall detection, which is an added key feature of this work.

Keywords Alert generation · Cloud server · Color detection · Disability · Fall detection · IoT Assistive Device · Multilingual · Obstacle avoidance · Ready Made Garments (RMG) · Vision impairment

---

H. Rashid
Department of Electrical and Electronics Engineering, University of Turku, Turku, Finland
e-mail: hurash@utu.fi

A. Ullah (✉) · Md. M. H. Khan · Md. S. Ullah · S. M. G. Mostafa · M. J. Uddin · A. T. Noman · A. Hossain
Department of Electrical and Electronics Engineering, International Islamic University Chittagong, Chattogram 4318, Bangladesh
e-mail: aasim@kth.se

Md. S. Ullah
e-mail: shahideee04@iiuc.ac.bd

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2022
A. K. Pathan (ed.), *Towards a Wireless Connected World: Achievements and New Technologies*, https://doi.org/10.1007/978-3-031-04321-5_6

1 Introduction

Eye-sight impairment is a constraint in case of functioning of the eye. As mentioned in [1], the visual nerve system and persons having eye-sight impairment refers no vision in both eyes who has a visual acuity less than 6/60 or 20/200 in Snellen chart [2, 3]. According to a statistical research on blindness by WHO considerably more than 285 million people are struggling from visual impairment which includes blindness and low vision and unfortunately 87% of that total live in regions like Bangladesh [4].

The study also focuses on the opportunities of the visual impaired people that blind people usually regarded as burden to own family and to the outside world the disregard is out of world and unfortunately these people have extremely fewer possibilities to earn their very own livelihood. Generally this scenario has been observed in the underdeveloped countries while rich and developed countries provide at least more opportunities to them [5]. In case of children with visual impairment the sufferings are more noticeable as they are being excluded from the opportunity of getting education as well as other basic rights [6].

Color detection ability is an important privilege that seems not so important in a relative look which also can be a strength to some people in their daily life. Countries like Bangladesh, China, Vietnam, lot of people are gaining their livelihood through apparel along with clothing manufacturing garments in which cases visually impairment of a person can be a great hindrance while working, consequently making their livelihood. In these cases the opportunity to work in such a place reduces if they don't have the ability to detect and differentiate color. Also, color detection ability is benefited most for children for their education purposes.

Technological innovations have been becoming a hope for helping them in recent times in case of inability to color detection or even helpful for completely visual impaired person, although the concept of the assistive devices for the blind is actually not so traditional [7]. While reviewing the previously developed product, several blind assistive devices were found for color detection such as Color Talk [8], Coloresia [9], Colorino [8], Color Teller [8], Speech-master Talking Color with detection system [10], ColorTest 150 [8]. Some blind guidance systems have also been reviewed which are Sonar Glasses [11], iSonar [12], Smart walking stick [13], The GuideCane [14] and The NavBelt [15]. Some key limitation of these devices is not having speaking ability into multiple languages, IoT Connectivity and Wearability. Most importantly, no devices have been developed with both two features into one single wearable device with IoT connectivity. Also, there was no fall detection feature in any of the mentioned devices which is a very essential feature for any blind or disables assistive devices.

In authors' previous paper [7], a new architecture has been suggested in preceding research work [7] that can pronounce the name of numerous colors in both English and Bangla. This proposed architecture will help the blind people to recognize different colors in their real life and workstation. A new architecture has been proposed with current advancement of Internet of Things (IoT) and its wide variety of application in advance embedded system design. The suggested architecture incorporated with IoT and sensors to provide various features to identify 'fall' for the blind person. In addition, an obstacle avoidance unit has been added with proposed architecture to avoid collision and accident. The prime features of this proposed design is that all kind of warnings will be given as human vocal sound.

The book chapter arrangement has been organized in the following manners. The section discusses the architecture and methodology, the third and fourth section illustrates the software and hardware improvement, the fifth section represents the working principle and algorithm of the proposed system and the last two sections represent a comparison among earlier developed devices and the suggested system along with the conclusion following with the future scope of the work.

2 Review of Literature

Conducting activities of daily living for blind people, such as reading product labels and identifying currencies, can be difficult due to a variety of obstacles [16]. It demonstrates that a low-cost wearable device is accessible for anyone who wishes to take their phone with them. Dynamic multi-ability routing and an automated multi-lingual context are also in the works as are new innovations in dynamic routing [17]. Recent year research has also discovered that the relevant community is moving forward by providing new problems and scenarios ranging from multi-lingualism to driving. One may envision a blind person approaching an intelligent system who is knowledgeable in appropriate fields such as human–computer interactions, ubiquitous/wearable data processing, and so on, as depicted in [18]. Along with the growing diversity of wearable technologies, electronic food diaries and mobile applications enable users to keep a more detailed record of what they drink and eat. Yet there is a lot of scope for the future because of new technology in the health sector such as smartphone applications, smartwatches and sensors. Is the app accessible to disabled people (e.g., screen readers for blind people, closed captioning for deaf people) [19]. The current generation of smart assistants, which are embedded in home listening devices, smartphones and wearables, has developed over the last few years. The next generation of wearable devices straddles the boundaries between conversation and technology. Braille is a written language used by blind people to write and read, and it is similar to the language in which they communicate [20]. Recent technological advancements, such as deep learning-based speech identification, have enabled more accurate results to be obtained. The acoustic environment created by wearable gadgets was measured using a wrist-mounted device that was specially constructed for this purpose. As a result, both classifiers were unable to determine the group status of any of the participants [21]. Many surveys illustrate the relationship between humans (citizens) and computers (for example, wearables such as smartglasses). The survey allows users to connect to smart urban entities by utilizing augmented reality smartglasses (a sort of wearable computer). With these intelligent glasses, one could take his or her eyes off the road for a split second.

It is proposed that a variety of bus recognition systems be developed in the field of computer vision research, as well as in other domains; However, the majority of them employ sensors and active devices, such as RFID (Radio Frequency Identification), GPS tracking systems, Beacons, and so on. In the field of vision-based techniques, Wongta [8] developed a system that recognizes bus numbers by using MSER (Maximally Stable Extremal Regions). Instead than only finding the required texts in an image, their technique detects all of the texts in the image as well, for example the bus number. Guida et al. [9] developed a framework regarding bus route number that uses a number classifiers together including adaboost in order to determine any other items present at the very front of bus and some repairs are done to the recovered characteristics to get restored numerical value. The object is therefore transformed to Saturation, Hue, Value (HSV) colorspace, after which each numeric or digit value is partitioned.

At the end identification of digits was done via Optical character Recognition (OCR) and voice of the user is produced as the output. The proposed face detection framework by Viola and Jones [10] has three main contributions, namely integral images, boost and cascading classifiers, which is a simple and efficient way to detect faces from binary images. Bus detection system proposed by Pan et al. [11] helps the visually challenged people. It uses Histogram of the oriented gradients to extract features from bus images and for detecting the bus facade in frames of windows via a bus classifier a cascading Support Vector Machine model is implemented. To support the visually impaired person Tsai and Yeh [12] introduced a process for bus detection. The functionalities of that process contain detecting the moving bus as well as the detection of bus panel and also detecting text from the text region of the bus panel. The process showed high accuracy when features were extracted from different frames of the video as it uses the method of MAFD (Modify Adaptive Frame Differencing).

Bouhmed employed an ultrasonic sensor and camera in a walking cane to sense hazards in the path and communicate this information to the blind in [13]. The module creates output via voice. Zahir et al. [14] implemented a prototype of a wearable head-mountable device by adapting Virtual Reality glasses with ultrasonic sensors and HC-SR04 since it takes the least amount of time to detect and can discover hazards over a longer distance. Arduino is used to creating the prototype. Ani et al. [15] established a voice-assisted text-reading system that works with eyeglasses. A camera is incorporated into the eyeglass to obtain an image, and text is retrieved from the image using Tesseract-OCR. For TTS, Open Software E-speak is used. Khan and Khusro [16] presents a method for end-to-end real-time scene text localization and recognition, with "false positives" demonstrating the resilience of the suggested method against noise and poor character contrast. Murdoch et al. [17] introduces a Convolution Neural Networks (CNN) model for detecting English and Thai text from natural scene photos with higher accuracy than earlier approaches. Dengel et al. [18] describes an approach for extracting multi-script text from natural scenes that uses the collaboration of proximity and similarity rules to generate text-group predictions. Chawla et al. [19] investigates the topic of finding correspondences between two photographs taken from various perspectives. To support the blind, a variety of procedures and unique concepts have been offered. The majority of these systems are dynamic, which makes them easier to use in real-time. Our proposed solution is designed for real-time application and relies on video recognition rather than image capture. Because the bus arrival and waiting time are continually changing, every frame must be checked rather than just single image snaps, which would be less effective in detecting the bus and bus board. The suggested system can be connected with any existing arrangement with components that are nearly identical, or it can be constructed as a standalone system with any additional route number characteristics added.

3 Methodology and Architecture

The system has two main units. Each unit has several sub-units. The main two units are listed as:

1. Sensors and IoT section
2. Cloud server section.

A 8-bit micro-controller is used to develop the system in the previous design [7]. The design adopts simplicity in order to develop the efficiency. In latest studies [21, 22], several experiments are utilized with 8-bit based micro-controller. It is understandable why Atmega 328P is not worked as efficient device for the systems. As BLE and WiFi plays an important role which misses out in the chip. The missing features leads to no connectivity function with IoT base architectures. A supplemental Classic Bluetooth module is recommended in the study as well in order to use in previous research [7]. The purpose is to deliver the Bluetooth connectivity. Although it cause greater power consumption that cause a big negative aspect for any wearable device. 8-bit micro-controller has its additional supplemental constraint. It demands additional Wi-Fi module in order to supply Wi-Fi connectivity. The feature eventually enhances the power consumption along with the cost of the production. In this chapter, a micro-controller featuring Wi-Fi and BLE has been propositioned so that the elimination of an auxiliary Bluetooth and Wi-Fi module can be achieved as well as a gentle cut in the power consumption through the adaptation of this chip.

One of the significant challenges for visually impaired users is the perception of the colors that have been presented briefly in our earlier paper [7]. A color sensor had been suggested to not only recognize the colors but also to adapt the name of them in dual language from the pre-stored audio data in the storage of the system.

A color sensor with a similar concept has been utilized in this chapter to identify the colors and transcribe them in multiple languages with the help of various linguistic data packs stored in the cloud. The alternative language pack can be updated using a smartphone that will necessitate the participation of a caretaker but will allow users from other countries and languages to use the gadget in their native language. One of many significant features is the ability to listen to the audio using both wired and wireless headsets as well as existing sound systems.

Our earlier design could only detect colors with the use of a color sensor and had no other capabilities that could assist a blind person. When working on an earlier version of this chapter, the author suggested and created a blind assistive robot that employed an ultrasonic sensor to identify obstacles and allow blind people to walk beside the robot. A speech alarm, as well as vibration alerts, have been used to implement this obstacle avoidance system, which makes use of an ultrasonic sensor and a small motor driver in conjunction with the motor to create vibration.

Falling while walking or moving is a regular occurrence among blind people, and it can be observed in many different situations. Some falls can be dangerous, and recovering from them may necessitate support from others. As a result, those responsible for the care of blind people should be aware of their deteriorating condition. A fall detection feature has been introduced to this chapter, and the caretaker will be notified whenever a fall occurs. The basic block diagram of our suggested system is depicted in Fig. 1.

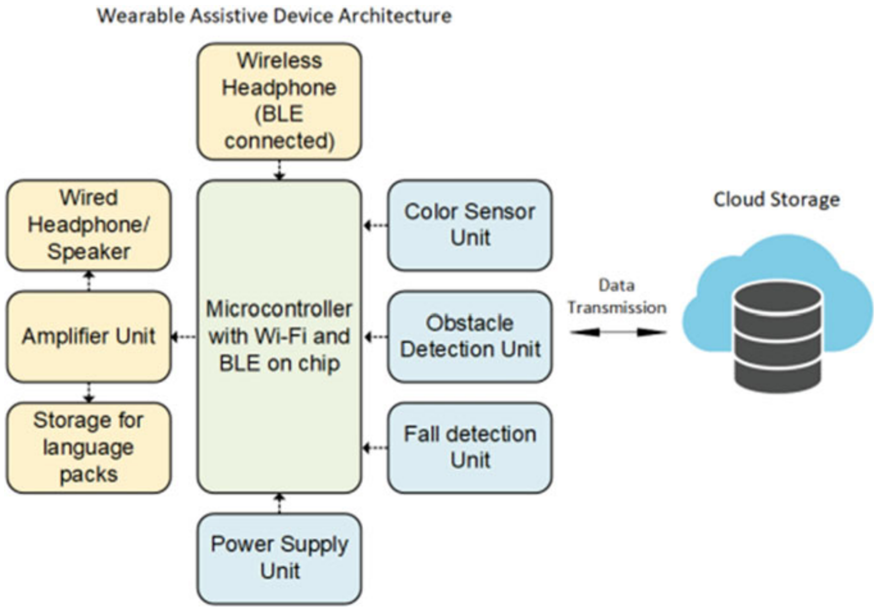

Fig. 1 The block diagram for the prospective system's architectures

4 Hardware Development

4.1 Microcontroller Unit

A 32-bit based micro-controller known as Node MCU ESP-32S has been proposed to be used as core micro-controller for our proposed system. NodeMCU ESP-32S is considered as a high-performance micro-controller for developing IoT based system as it is equipped with industrial grade specifications and able to perform efficiently for better integration, wireless transmission, lower power consumption and better network connectivity [22]. It is powered with ESP32 chip that is considered as a scale-able and adaptive chip. A principal feature of NodeMCU is that it has two CPU cores that can be controlled individually along with the capability to adjust the clock frequency from 80 to 240 MHz Another main feature of this micro-controller is that it can be operated without having any additional power supply unit and featured with ultra-low power consumption [3]. The module is also featured with traditional Bluetooth, Bluetooth low energy and Wi-Fi (802.11n @ 2.4 GHz up to 150 Mbit/s) along with other popular data transmission protocol of I2C, SPI, and UART that makes it very suitable to construct IoT based system.

4.2 Sensor Unit

Different sensorz require to be interfaced with the micro-controller unit to achieve different goal of the proposed concept. The three main goals are to detect colors, obstacle and fall. Assistive Navigation Application for Blind People using a White Cane Embedded System and sensor unit is also reported in [22].

4.3 Color Sensor

The TCS3200 colour is a Programmable colour light-to-frequency converter that has ability to convert light intensity to frequency and it allows optimized output range. The operating process of TCS3200 depends on Photodiodes which can detect colour when Light from the LED of the sensor is shone above the subject placed in front of the sensor. Three different values of red, green and blue colors are obtained by generating a square wave of 50% duty. Different logic permutations for three colors value are utilized along with various pulse provided from the micro-controller [4] to detect color. Similar color act with A finger wearable audio-tactile device using customized color tagging is reported in [23].

4.4 Obstacle Avoidance

HC SR04 is a ultrasonic distance sensor that need to be interfaced with ESP32 to detect obstruction in front of the user by with assistance of non-contact measurement functionality. The main feature of this sensor is that accuracy is up to 2–400 cm by utilizing Trig and Echo, but the ranging accuracy can be reached up to 3 mm by transmitting a ultrasonic signal and detect incoming output [5]. The sensor module is featured with additional control circuit to prevent inconsistent "bouncy" data that may cause false distance measurement.

4.5 Fall Detection

MPU-6050 is one of the first Motion Tracking devices that has been constructed with feature of low power consumption along with the ability to provide high-performance. It consists of 3-axis accelerometer, a 3-axis gyroscope and a motion processor that has capability to establish communication through I2C communication protocol. The main feature of this module is that it has capability to carry out complicated 6-axis motion detection that is required to detect the fall of the user [6]. A Fine-Grained Indoor Fall Detection System With Ubiquitous Wi-Fi Devices is found in [24], Contact-less fall detection for the elderly in [25]. Also, A Distributed Fall Detection Architecture Using Ensemble and machine Learning is mentioned in [26–28] (Fig. 2).

4.6 Alert Generation in Multiple Languages

The proposed system will have multilingual supports and the function to acquire the multilingual support requires to have a cloud server. The language files will be stored and updated to the clod server from where it required to be downloaded and and stored into a SD card storage that will be interfaced with the system.

The process to download and update the languages audio files requires the support of a an app that can be installed and run to an android powered smartphone. The app should have the capability to connect with hardware with the support of lowe power Bluetooth. Another approach can be developed to directly download the audio files to the assistive device with the help of built-in WI-FI of ModeMCU module. Also, a different methodology can be developed where audio language files will be downloaded to the smartphone with the help of the application first and sync up the assistive device with the latest audio files through Bluetooth. SD Card Module will be attached with the assistive device via SPI communication protocol [7].

Vibration alert will be generated when the assistive device will detect any kind obstacle and a vibrating Mini Motor Disc need to be utilized with ESP32 to achieve

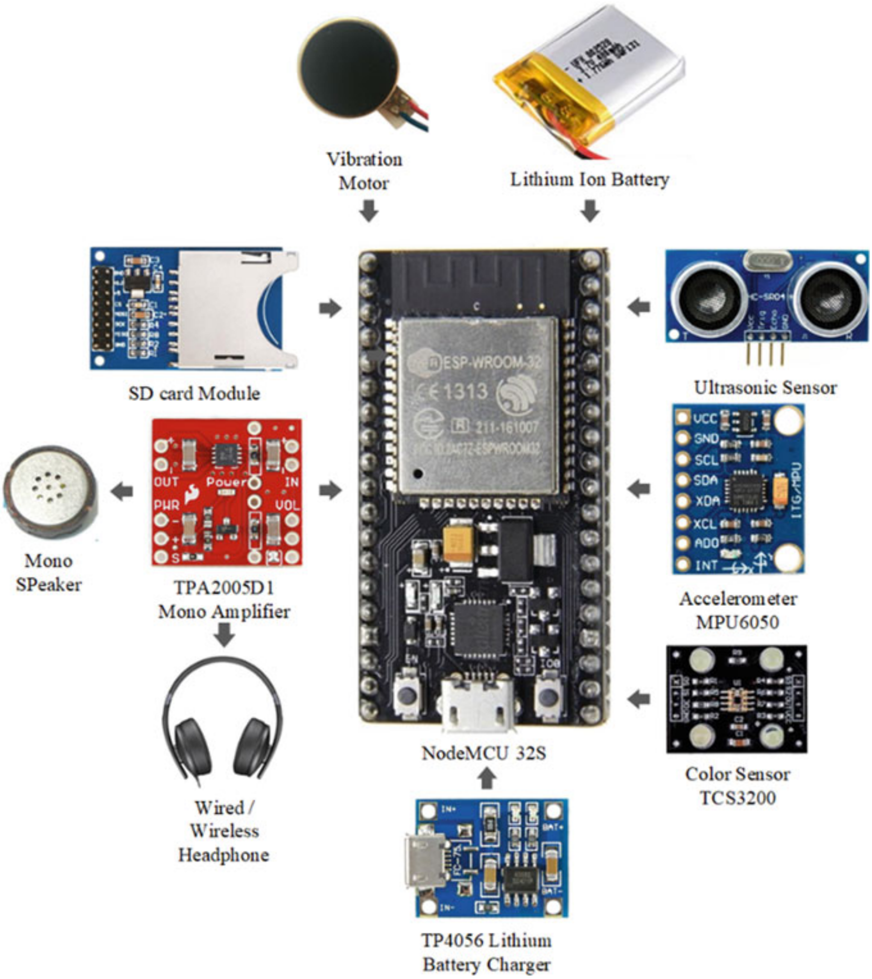

Fig. 2 The diagram of hardware settings for the proposed system

this goal. Low powered motor needs to be interfaces that can be operated with 2 V current (40 mA) to ensure higher operating time by the assistive device.

4.7 Power Supply Unit

lM7805 & LE33 were used to build the power supply unit for our previous development. But the need of using a separate power supply has been omitted for our current proposed assistive device as we are using NodeMCU featured with built-in power supply to convert 5 V into 3.3 V for different sensors and other components. A lithium changer module known as TP4056 requires to be interfaced to have projection against Dual Functions and recharge the battery.

5 Software Development

One of the significant features of using ESP32 based NodeMCU that different programming languages like Lua, Python, Java, Ruby can be used to program the device. To achieve our goals for our proposed system, the most convenient is to utilize C++ based Integrated development environment that is familiar as Arduino IDE. Arduino IDE has rich collection of libraries and modules for most of the available sensors and components. It removes the need to create additional library for each component from scratch. Another option is to use Micro Python an object-oriented powerful programming language based on Python for NodeMCU but it, but C/C++ based firmware can ensure faster compilation compare to Micro-Python for IoT based software development. Programming flowchart of the proposed system is demonstrated in the figure. The hardware requires to be initialized at starting to ensure the functionality of all components. Following the initialization process, the system requires to verify the selected policy by the user, which is determined through a select switch for choosing a specific policy among from several policies. The selected policy will run and determine the system functionality. The program requires to check and verify if the the policy has been changed by the users and in case no change is detected, the program will continue running the same policy. The program can change the policy based on the user selection. Policies are described below:

Policy 1: The policy 1 has been developed to run with full capability thus it utilizes higher power consumption. All the features are enabled that causes to run all the sensors and modules as weak as allow to enable all features. The user can detect color, obstacle, and fall. Performance efficiency of the proposed assistive device will be at the highest level although power efficiently will reduce significantly compare to the other policies. It can also be configured as the default policy when the assistive device system will be operated without any user's specific selection.

Policy 2: The policy 2 will be developed to have higher power efficiency by reducing power consumption through enabling selected features of obstacle avoidance and fall detection. The policy has been design with consideration for those users who don't requires to utilize the color detection always. This policy will allow to have lower power consumption compare to policy 1 as well the performance accuracy will be lower than he policy 1. Policy 2 will have higher operating time compare to policy 1.

Policy 3: Policy 3 will allow t user to use only color detection and thus it will have lowest power consumption compare to policy 1 and policy 2. The main reason to design such policy is to provide user flexibility to use only color detection with higher operating time. As the power consumption will be lowest, it will also have significant affects on performance accuracy (Fig. 3).

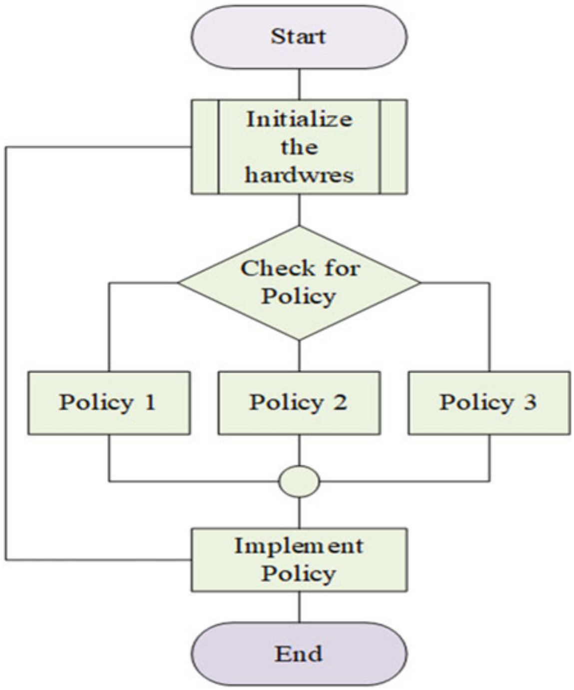

Fig. 3 The flowchart for the programming of MCU

The flowchart of the programming is illustrated in the following figure. In the initial stages, the hardware will be initialized. After the initialization procedure, the system will verify which policy has been chosen. There is a configurable selective switch for a different policy. According to the specified policy, the program will run the policy. During the process, the program will always check whether the policy has been updated or not. If it is not modified by the user, it will continue to run, or else if the policy change has been identified, it will alter the policy according to the user's choices.

Policy 1: In policy 1, all the components are active, and all the functions may be concurrently performed. The user may detect color, impediment and fall. Power consumption will be high but the performance efficiency of the device will be at the optimum standard. It will be also the default policy when the system would commence without any user's option.

Policy 2: In policy 2, only obstacle avoidance will be triggered together with fall detection. As perceived that users may not always wish to utilize color detection rather it is easy to use the device for obstacle avoidance and fall detection. This strategy would generate medium power usage combined with medium performance accuracy.

Policy 3: In this policy, the user will be allowed/permitted to Turn/switch on the color detection alone and the rest of the two features will be turned off. The user may activate this policy when he needs color detection just and does not require for other two features/functions. The policy will create reduced power consumption as the performance accuracy will also be relatively less compared to the other two policies.

6 Working Principle and Algorithm

6.1 Color Detection Algorithm

The colour sensor module is equipped with 8 × 8 array of photodiodes, where 16 photodiodes are having blue filters, 16 photodiodes are having green filters and 16 photodiodes are having red filters, and 16 photodiodes are having clear or no filters. Optical measurements is being executed utilizing small-angle incident radiation with assistance of an optical source. The basic principle of working functionality of a colour sensor is that it has capability to converts different colour into different frequencies. TCS3200 module is utilized to get the frequencies generated due to Green, Red and Blue filter of the object by allowing specific filter actives. Different logic and conditions have been developed to detect different colours. TCS3200 is featured with 5.6 mm lens that can operate with better functionality for the area of 1” and 1 1/16. There are two logic inputs known as S0 and S1 for controlling Output-frequency scaling that allows the output range to be optimized for a different kind of measurement method. The functioning procedure of TCS3200 module has been shown in Fig. 4. Duty cycle, time period and frequency are determined from the below-mentioned equation [4].

$$\text{The duty cycle of square wave T,}\ \ TH = TL \tag{1}$$

$$\text{Time Period, } T = 2\ TH \tag{2}$$

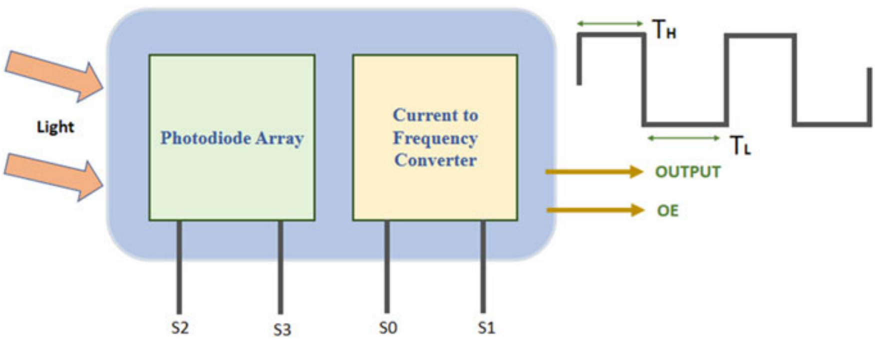

Fig. 4 The working principle of a color sensor (TCS3200)

$$\text{Frequency} = {}^{1}\!/_{2}\ \text{TH} \tag{3}$$

NodeMCU will detect the colour based on the logic created and the assistive device will find the selected language file and generate the sound of the name of the color in that selected languages. However, if the selected languages files are not available in the SD card module, the system will try to found it from cloud server through the application and if the sound file is found, it will be download it from the cloud server. The output audio sound can be heard into the attached wired or wireless headphone.

6.2 Obstacle Avoidance Algorithm

An ultrasonic sensor attached with the assistive system to transmit a high-frequency sound pulse to detect the distance between the user and the obstruction. The main working functionality depends on detecting the transmission time and receiving time of the ultrasonic sound. A short 10 uS pulse is required to enable the triggering of transmitting an 8 cycle burst of ultrasound at 40 kHz to detect the ranging. NodeMCU processes the timing of the echo and reflection of the sound for duration into a distance conversation. The processed value is compared with a pre-defined parameter to obtain the result with the help of following equation [19]:

$$\text{Distance} = (\text{high level time} \times \text{velocity of sound}(340\text{M/S})/2 \tag{4}$$

6.3 Fall Detection Algorithm

The algorithms for fall detection has been developed using a variation of acceleration and angular motion during fall occurs. Sum Vector Magnitude (SVM), the angle between x and z-axis and differential SVM (DSVM) are determined to detect if the fall has occurred (Fig. 5). The equation can be expressed as follow where *i* represent the sample number [11]:

$$SVM_i = \sqrt{{x_i}^2 + {y_i}^2 + {z_i}^2} \tag{5}$$

$$\delta = \arctan\left(\frac{\sqrt{{x_i}^2 + {z_i}^2}}{x_i}\right) * \frac{180}{\pi} \tag{6}$$

$$DSVM_i = \sqrt{(x_i - x_i - 1)^2 + (y_i - y_i - 1)^2 + (z_i - z_i - 1)^2} \tag{7}$$

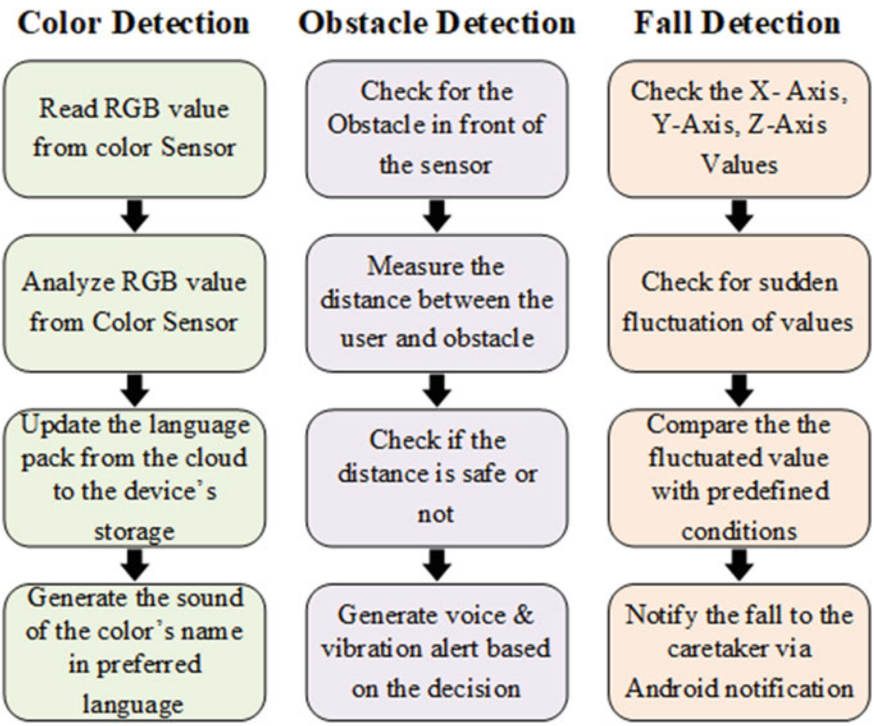

Fig. 5 Algorithm for color, obstacle and fall detection

6.4 Language File from Cloud Server and Notification to the Caretaker About Fall Detection

A cloud platform needs to be integrated with a android app to develop multilingual support and notification service. The development platform of the app is MIT app inventor that allows to develop an android smart app using drag and drop logic and functions. Multilingual support requires to have different languages pack stored in a cloud server. The concept of the notification is that a fall detection will generate a notification to the user's caretaker along with information of fall occurrence time and magnitude of the fall that will allow the caretaker to be able to find out the location of the user and arrange emergency services to reduce health hazard of the user.

6.5 Language File from Cloud Server

Several languages pack will be available to a cloud server. The languages file can be updated via system by the user. The user can select his own preferred language pack from the cloud and the language pack will be updated through the Wi-Fi of the device. Another approach is that the language file will be updated to the user's phone and where the system will be connected with the user's phone, it can update the features from the smartphone also. The app has been developed using MIT app inventor which offers an easy solution to build an android smart app using logic and functions.

7 Discussion

TCS3200, a color sensor is used to convert the color into frequency. In proposed model this TCS3200 module will be used to collect the frequency acquired with Green, Red and Blue filter of the object through enabling corresponding filter actives. In this case, several conditions are applied in order to detect each color. Generally, four white LEDs are attached at the front side of the TCS 3200 color sensor which effects in the spectrum by making a deviation whenever the sensor is initialized in the device, illustrated in Fig. 6 [11].

The Figs. 6 and 7 displays relative response vs. wavelength curves showing four different shades red, green, blue and black which plotted in the graph, represents four photo-diodes of red, green, blue and clear.

Three-axis data of x, y, z is collected from the Accelerometer which are pre-processed and analyzed with previously defined values to detect fall. Variation of Sum Vector Magnitude (SVM) and angle between x between z-axis with the processed

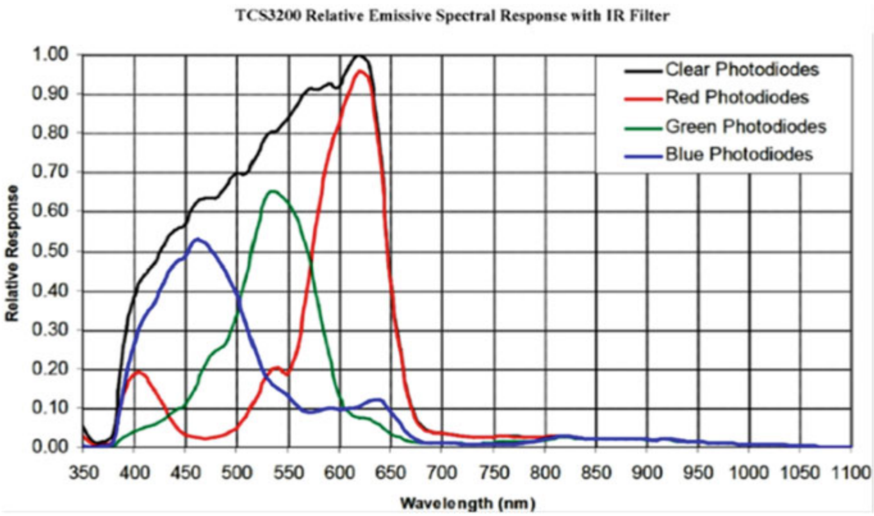

Fig. 6 The curve comparison of Relative response and Wavelength with IR Filter [9]

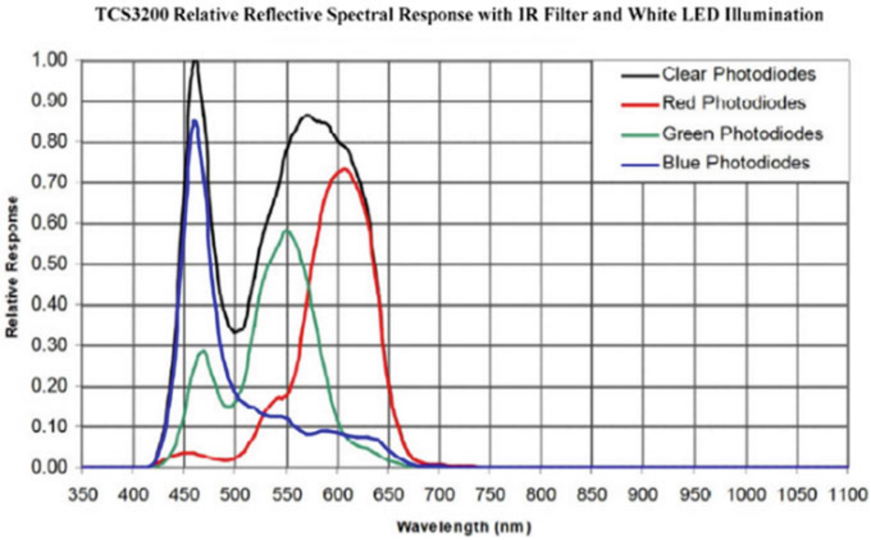

Fig. 7 Relative response versus Wavelength with IR filter and LED illuminations [9]

data can be shown as well to determine the threshold as well as a violation of threshold values which indicates a fall.

Different components have different power consumption that have been demonstrated in the table. When adopting a different policy, different power consumption has been noticed which has been documented in Table 1. The three different policy has been developed in a way that they can be employed for power efficiency. Table 2 has been showing the details of the three policy.

Table 1 Hardware specifications of proposed system

Components	Model	Operating voltage
Microcontroller	NodeMCU 32S	3.3–5.5 V
Color sensor	TCS3200	2.7–5.5 V
Ultrasonic sensor	HC-SR04	5 V
Accelerometers	MPU6050	3.3 V
SD card module	SparkFun microSD	3.3 V
Mono-amplifier	TPA2005D1	3.3 V
Vibration motor	Disk vibrating motor	−3.3 V

Table 2 Power consumption & performance analysis for different policy

Policy name	Color detection	Obstacle detection	Fall detection	Power consumption	Performance
Policy 1	On	On	On	High	High
Policy 2	Off	On	On	Medium	Medium
Policy 3	On	Off	Off	Low	Low

8 Comparison Study with Earlier Research

Table 3 illustrates the product functionalities that have been incorporated in the systems are given with the features and comparison of ten old products. The components are mainly categories according to some preferred terms such as- Obstacle Detection ability, Color Detection ability, speaking capability, Fall Detection ability, IoT Connectivity, and Wearability. From the contrast, it is quite clear that Color Talk [8], Colorino [8], Color Teller [8], Speech Master Talking Color [8], Color Test 150 [8] and Coloresia [9] are presenting same functionalities. All of these products can identify color and have the speaking capability. But these are not suitable for obstacle and fall detection, multiple language recognition capability or having IoT connectivity. Most significantly these components are not wearable either.

Obstacle detection is possible for Sonar Glasses [11] along with wearable functionalities. However, detection of color, detection of fall, IoT connectivity, speaking and multiple languages are not possible by this device [12]. The identical constraints have been found in Smart walking stick [10] and GuideCane [9]. In case of a blind assistive system iSonar is worth nothing if the above abilities are not found in this device. The NavBelt [11] has navigation capability and wearability by obstacle detecting unit. But it does not pose other features compared to the proposed architectures.

The architecture and the product which is suggested in this study is designed such a sensible way that all kinds of usable features including fall detection, color detection, obstacle detection, speaking ability, multiple language recognition ability are added in proposed product. As well as the most demanding 'wearability' has included for such case of study. The distinct feature in this proposed is that it can be linked and controlled through the Internet of Things (IoT) which is not available in the devices that are discussed above.

The market price of Coloring and Speech-Masters Talking Color is expensive enough. Obviously the suggested product will be economical comparatively other available devices in the market. The costs of proposed device are about $80 which is comparatively very low than the other available products. Additionally, the unavailability of all the mentioned features are present in the existing proposed devices.

Table 3 Comparison of previously developed system with our proposed system

No	Product	Color detection	Obstacle detection	Fall detection	Speaking Ability	Multiple language Ability	IoT connectivity	Wear-ability
1	Color Talk [8]	✓	X	X	✓	X	X	X
2	Coloresia [9]	✓	X	X	X	X	X	X
3	Colorino [8]	✓	X	X	✓	X	X	X
4	Color Teller [8]	✓	X	X	✓	X	X	X
5	Speech-master Talking Color [10]	✓	X	X	✓	X	X	X
6	ColorTest 150 [8]	✓	X	X	✓	X	X	X
7	Sonar Glasses [11]	X	✓	X	X	X	X	✓
8	iSonar [12]	X	✓	X	X	X	X	X
9	Smart walking stick [10]	X	✓	X	X	X	X	X
10	The GuideCane [9]	X	✓	X	X	X	X	X
11	The NavBelt [11]	X	✓	X	X	X	X	✓
12	Proposed Device	✓	✓	✓	✓	✓	✓	✓

9 Future Work and Conclusion

The Proposed device that we have discussed in this chapter overcomes major shortcomings of our previous designed system. A user ready version will be very beneficial for the consumer even though there is still plenty of scope for future improvements. By incorporating power efficient micro-controller with Bluetooth 5 and GPS Module, the current position as well as the directional navigation of the user can be accessed by the caretaker. By including more sensors with the proposed three sensors vital health status of the user can be monitored. The cheaper locally available sensors that are used here can be replaced with more efficient sensors for better performance. The color sensor and ultrasonic sensor can be replaced with a camera which can more efficiently detect variations of color and obstacles. The Proposed device interfaced with a machine learning algorithm to predict the user's priority and making the system more user-friendly will provide much better experience for the consumer.

References

1. A. Cashin-Garbutt, What is visual impairment? News-Medical.net (2012). [Online]
2. B. Punani, N. Rawal, *Visual Impairment Handbook* (Blind People's Association, India, 2000), pp. 1–10
3. Disability in Bangladesh: Prevalence and pattern, *Population Monograph of Bangladesh*, vol. 5 (2015)
4. World Health Organization, *Global Data On Visual Impairments 2010* (2012), pp. 1–17
5. Bangladesh fights to end blindness, *The Guardian* (2010). [Online]. Available: https://www.theguardian.com/world/2010/sep/28/bangladeshvolunteers-childhood-blindness-treatment
6. Help for the visually impaired in Bangladesh, Ft.com, (2016). [Online]
7. H. Rashid, A.S.M. Rabbi Al-Mamun, M.S.R. Robin, M. Ahasan, S.M. Taslim Reza, Bilingual wearable assistive technology for visually impaired persons, in *2016 International Conference on Medical Engineering, Health Informatics and Technology (MediTec)* (2016)
8. P. Wongta, T. Kobchaisawat, T.H. Chalidabhongse,An automatic bus route number recognition, in *2016 13th International Joint Conference on Computer Science and Software Engineering (JCSSE)* (IEEE, 2016)
9. C. Guida, D. Comanducci, C. Colombo, Automatic bus line number localization and recognition on mobile phones—a computer vision aid for the visually impaired, in *International Conference on Image Analysis and Processing* (Springer, Berlin, Heidelberg, 2011), pp. 323–332
10. S. Pattanayak, C. Ningthoujam, N. Pradhan,A survey on pedestrian detection system using computer vision and deep learning, in *Advanced Computational Paradigms and Hybrid Intelligent Computing* (Springer, Singapore, 2022), pp. 419–429
11. M. Vardar, P. Sharma,An optimized object detection system for visually impaired people, in *Second International Conference on Sustainable Technologies for Computational Intelligence* (Springer, Singapore, 2022), pp. 25–38
12. R. Priyatharshini, R. Senthil Kumar, M. Sanjay Sivakumar, A. Mathumathi, N.S. Johnson,A wearable assistive device for safe travel using transfer learning and IoT for visually impaired people, in *Advanced Soft Computing Techniques in Data Science, IoT and Cloud Computing* (Springer, Cham, 2021), pp. 3–26
13. E. Bouhamed, I. Kallel, D.S. Masmoudi, New electronic cane for visually impaired people for obstacle detection, in *Proceedings of the IEEE International Conference on Vehicular Electronics and Safety* (2012)

14. E. Zahir, K. Hossain, K. Balachander, C. Venkatesan, R. Kumar,Safety driven intelligent autonomous vehicle for smart cities using IoT. Int. J. Pervasive Comput. Commun. (2021)
15. R. Ani, E. Maria, J. Jameema Joyce, Smart specs: voice assisted text reading system for visually impaired persons using TTS method, in *IEEE International Conference on Innovations in Green Energy and Healthcare Technologies* (2017)
16. A. Khan, S. Khusro, An insight into smartphone-based assistive solutions for visually impaired and blind people: issues, challenges and opportunities. Univ. Access Inf. Soc. **20**(2), 265–298 (2021)
17. T. Murdoch, T. Pey, E. Brooks,A step towards truly independent access for everyone, everywhere. Assis. Technol. 1–5 (2021)
18. A. Dengel, L. Devillers, L.M. Schaal,Augmented human and human-machine co-evolution: efficiency and ethics, in *Reflections on Artificial Intelligence for Humanity* (Springer, Cham, 2021), pp. 203–227
19. S. Chawla, J.K. Sabharwal, B. McCarthy, R. Erhardt,Technology acceptance, social marketing and the design of a mobile health app to support active ageing amongst senior citizens in the Asia-Pacific region, in *Broadening Cultural Horizons in Social Marketing* (Springer, Singapore, 2021), pp. 239–261
20. D. Sayers, R. Sousa-Silva, S. Höhn, L. Ahmedi, K. Allkivi-Metsoja, D. Anastasiou, Š. Beňuš et al.,The Dawn of the Human-Machine Era: A forecast of new and emerging language technologies (2021)
21. B. Little, O. Alshabrawy, D. Stow, I. Nicol Ferrier, R. McNaney, D.G. Jackson, K. Ladha et al.,Deep learning-based automated speech detection as a marker of social functioning in late-life depression. Psychol. Med. **51**(9), 1441–1450 (2021)
22. L.-H. Lee, T. Braud, S. Hosio, P. Hui, Towards augmented reality driven human-city interaction: current research on mobile headsets and future challenges. ACM Comput. Surv. (CSUR) **54**(8), 1–38 (2021)
23. A. Mocanu, V. Sita, C. Avram, D. Radu, A. Aştilean,Assistive navigation application for blind people using a white cane embedded system, in *2020 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR)* (IEEE, 2020), pp. 1–5
24. C. Rui, Y. Liu, J. Shen, Z. Li, Z. Xie,A multi-sensory blind guidance system based on YOLO and ORB-SLAM, in *2021 IEEE International Conference on Progress in Informatics and Computing (PIC)* (IEEE, 2021), pp. 409–414
25. Y. Wang, S. Yang, F. Li, W. Yue, Y. Wang, Fall viewer: a fine-grained indoor fall detection system with ubiquitous wi-fi devices. IEEE Internet Things J. **8**(15), 12455–12466 (2021)
26. M. Nahian, M.H. Raju, Z. Tasnim, M. Mahmud, M.A.R. Ahad, M. Shamim Kaiser, Contactless fall detection for the elderly, in *Contactless Human Activity Analysis* (Springer, Cham, 2021), pp. 203–235
27. C.-C. Chang, Y.-C. Chen, B.-H. Sieh, Y.-M. Ooi,A distributed fall detection architecture using ensemble learning, in *2021 IEEE 4th International Conference on Knowledge Innovation and Invention (ICKII)* (IEEE, 2021), pp. 81–84
28. C.R. Kumar, M. Kaleel Rahman, E. Derrick Gilchrist, R. Lakshmi Pooja, C. Sruthi, Smart band for elderly fall detection using machine learning. NVEO-Nat. Volatiles Essential Oils J. NVEO 8269–8285 (2021)