International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 07 | July 2022 www.irjet.net p-ISSN: 2395-0072

ARTIFICIAL INTELLIGENCE BASED SMART NAVIGATION SYSTEM FOR BLIND PEOPLE

Dr.S. Mary Joans*, Aishwarya R[1], Meenu Sam[2], Sree Ranjane C[3], Subiksha S[4]

Department of Electronics and Communication Engineering,
Velammal Engineering College, Chennai-600066, Tamil Nadu, India.

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Abstract - *There are a huge number of blind and visually impaired individuals in this world who consistently need some assistance. These blind people find it difficult to go outside their homes without any help. Artificial Intelligence Based Smart Navigation System is a gadget intended to help guide the visually impaired by recognizing objects and depicting the data to them as an audio signal. This diminishes human exertion and gives better comprehension of the surroundings. Besides it likewise gives a chance for the blind individuals to move from one spot then onto the next without needing any help from others. The gadget can likewise be utilized in old age homes where aged individuals experience issues in their everyday exercises because of diminished vision. In this work, a framework is carried out that navigates the individual along his/her way. The object before the visually impaired can be recognized using image recognition with Artificial intelligence. The data about the object type before the individual can be conveyed by means of earphones / headphones. This will assist the individual in walking without any trouble.*

Key Words: Artificial Intelligence, Visually Impaired, Blind, Obstacle Detection, Recognition, Accuracy.

1. INTRODUCTION

As indicated by World Health Organization (WHO), there are over 1.3 billion individuals who are physically impaired across the globe, out of which about 36 million individuals are blind. India being the second biggest populated country on the planet, contributes about 30% of the total blind population. In spite of the fact that enough missions are being directed to treat these individuals, it has been hard to source every one of the prerequisites. It is truly challenging for blind individuals to roam openly in the outside world. Individuals with visual inability have a steady need of help with their regular routines. It can go from depending on others for help for basic needs to utilizing various Electronic Travel Aid (ETA) assistive gadgets whenever needed. They also use white canes and guide dogs. However, the limitation on the allowance of guide dogs in specific places and the short scope of white canes fill in as some of the disadvantages. Most of the ETAs have the disadvantages of being unreasonably expensive and wasteful. Keeping a tab on the different downsides of the conventional and normal techniques for helping the visually impaired and the blind individuals, we chose to create and plan our framework with a novel approach.

This era of brilliant advancements like Artificial Intelligence and Machine Learning implanted with appropriate equipment has life of visually impaired individuals simple and more secure. In the recent years, there is a wide-scale use of Artificial Intelligence going from scientific research, automated vehicles, national defence and space exploration. It is the need and obligation of the analysts to create such equipment for blind individuals to stroll around any region with the guide of smart navigation system that is built and most arising advancements, for example, Artificial Intelligence and Machine learning. AI has acquired big importance because of the huge amount of data and simplicity of calculation. Utilizing AI it is feasible to make these individuals' life a lot easier. The objective is to give an "optional sight" until they have an adequate number of assets needed to treat them. Individuals with untreatable visual impairment can utilize this to make their ordinary tasks less difficult.

In this paper, we propose a novel smart navigation system for blind and the visually impaired individuals. Some of the unique features of the system include:

1) A real-time and a camera-based system that is simple in design and also reduces the cost by minimizing the number of sensors.

2) A compact and a low-power design with an integrated voice alert system for outdoor and indoor navigation.

3) Processing of complex algorithm with a low-end configuration.

2. RELATED EARLIER WORKS

V.Kunta et al.[1] proposed a system that makes use of the Internet of Things (IoT) to create a bridge between the environment and the blind. Many sensors are used to detect obstacles, damp floors, and staircases, among many other things. The presented prototype is a basic and inexpensive smart blind stick. It is fitted with a variety of IoT modules and sensors.

A.A.Diaz Toro et al.[2] presented the methodology that can be used to build a vision-based wearable system which will assist visually impaired people with navigation in indoor atmosphere that is new to them. The proposed system helps the person in "purposeful navigation". The system detects obstacles, walkable spaces and others objects like computers, doors, staircases, chairs etc.

M.M.Soto-Cordova et al.[3] presented the design as well as the implementation of a helping aid for the blind. It is implemented using Arduino, ultrasonic sensors and some warning devices for obstacle detection and intimation based on the distance of the obstacle.

N.Loganathan et al.[4] presented a solution by implementing an ultrasonic sensor in the cane. The device can detect and perceive the obstacles at a range of 4 meters. The IR device will detect the nearby obstacles that approach the blind. With the help of a buzzer, the radio frequency transmitter and receiver are used to find the precise location of the stick.

J.Ai et al.[5] proposed a device that first acquires image information with a camera before converting the image to text with image captioning technology. Finally, the user is fed back with the text sequence using a voice signal.

D.Bal et al.[6] introduced a wearable system for the blind people that can be used for indoor navigation. It is a lightweight, portable and a user friendly solution which can also be mounted on a jacket. The system uses Raspberry Pi, vibration motors, a camera module, three ultrasonic sensors, emergency button, gyroscope and the android application 'Blynk'.

M.A.Khan et al.[7] designed an obstacle avoidance architecture with a camera and sensors, as well as advanced image processing algorithms to detect the objects. The distance between the obstacle and the user is determined using an ultrasonic sensor and a camera. The system contains an image - text converter and audio feedback, as well as an integrated reading assistance.

S.Dev et al.[8] demonstrated a smart device made using a Raspberry Pi that can perform tasks like object detection, navigation and gives audio feedback to notify the user.

D.P.Khairnar et al.[9] proposed a system that combines smart gloves with a smartphone application. The smart glove detects and avoids obstacles, as well as allowing visually impaired persons to recognize their surroundings. Various things in the neighbourhood are detected using smartphone-based obstacle and object detection.

Devi et al.[10] proposed a system that performs existing object observation and discovers the actions. The nearby location can be captured and given as a voice command. The proposed system effectively performs live observation of visually impaired and blind people and allows them to move anywhere without any help.

S. Barathi Kanna et al.[11] proposed a finding that allows visually impaired people and blind people to "communicate" with their surroundings in the Internet of Things (IoT) world. This prototype comprises an ESP8266, a power source for the development board and coin motors, as well as a smartphone App, making it more accessible to visually impaired people.

K. Patil et al.[12] developed a concept for a wearable device with a virtual assistant that would allow visually impaired and blind persons to accomplish simple tasks without assistance. The system is designed to provide voice-over assistance to visually impaired people who need help with their day to day life tasks.

3. PROPOSED SYSTEM

The Proposed system consists of a camera, AI processing, controller and voice alert. The ultimate goal of this smart navigation system is to detect the obstacles coming in front of the visually impaired person and to inform them about the object. AI processing is used to train the object images in the controller. If any objects/obstacles approach the blind person, then the controller alerts the person by a voice message. This can make the blind person more cautious and thereby lowers the possibilities of accidents. An automatic switch enabled with a voice assistant is also added to guide them in their private space. A camera is used to capture the indoor and outdoor images which help the smart navigation system to detect the obstacle.

The below flowcharts show the proposed system flowchart and the block diagram.

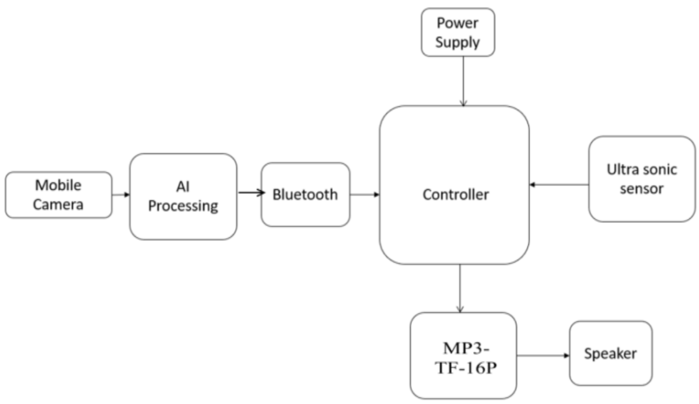

Fig-1: Proposed block diagram

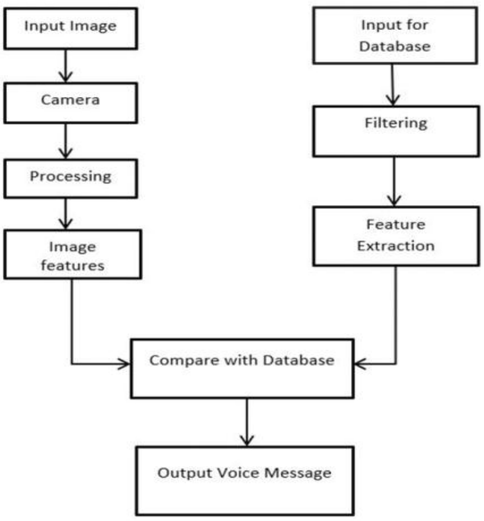

Fig.-2: Block diagram of AI processing

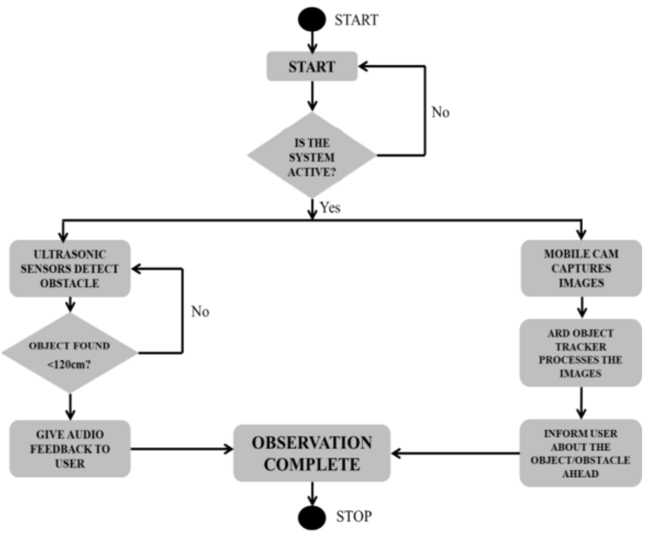

Fig-3: Proposed system flowchart

The flowchart of the proposed system is shown in figure 3. The hardware part consists of an ultrasonic sensor, camera, voice alert, and AI processing-based controller unit. These trained data have described the use of ultrasonic sensors integrating it with a controller for detecting the obstacles. The ultrasonic starts sending the signals with minimum delay and after that, the signal returns as an echo to the sensor receiver, and the controller estimates the time it takes to get the signal back from the sensor. Using the time taken, the distance of the object is calculated and is converted into speech and the feedback is given through speakers or headphones. The blind person will then be stopped from colliding with any object.

This assistive framework is built based on the idea of the Electronic Travel Aid (ETA), which plans to help the visually impaired and the blind people in strolling while at the same time staying away from obstacles. Let us consider a situation in which a chair is present in front of the visually impaired person. The person wants to sit and take a rest on the chair. In this case, the chair is not just an obstacle but a useful object. While using the Obstacle detection system, the user may not know what kind of obstacle is present in front of them but has to confirm it on their own. But on the other hand, if the user uses the Object recognition system, it helps to determine the object to be a chair and the user can claim a benefit. It is important to construct an assistive framework to detect and determine the objects around a visually impaired user.

4. SOFTWARE DESCRIPTION

4.1 ARD Object Tracker

This is an Android application that uses OpenCV libraries for computer vision detection.The ARD object tracker application can detect and track various types of objects from your mobile phone's camera such as lines, colour blobs, circles, rectangles and also people. Detected object types and screen positions can then be sent to a Bluetooth receiver device such as HC-05.

If using an appropriate micro-controller e.g. Arduino or Raspberry Pi users can analyze the detected objects for further projects.

Key Application Features:

1. Colour Blob Detect and Track

2. Circle Detect and Track

3. Line Detect

4. People Detect and Track

5. Rectangle detection.

6. Send detected object parameters wirelessly over Bluetooth.

- **Setting up Bluetooth:**

To connect an appropriate Bluetooth receiver, click the "Connect Bluetooth" button. If there is no button displayed you will need to double or single click the preview screen to bring up the options. The list shown provides the existing paired devices for your phone. If there are no items on the list, you will need to first pair your device within the Android Bluetooth settings options. Clicking on an existing paired device will attempt a connection to that device. If successful you will be taken back to the camera preview screen. Any errors will be displayed if not successful.

• **Configuration Settings:**

There are several configuration settings that control how the OpenCV computer vision libraries detect objects. These can be set by first clicking the "Settings" button. If there is no button showing on the preview camera screen, users will need to double or single click the preview screen to access the settings page.

• **Video Scale:**

This controls the image size that will be used for all image processing operations. A scale factor of 1 will use the phone's default image size capped to a maximum of 1280x720. If your phone's CPU is not fast, it is recommended to set this value to 2. Higher scale factors will result in faster image processing operations but can potentially result in instability or no object detections.

• **Tracked Object Persistence:**

Each tracked object is given a unique id. Tracked objects however can be missed on certain image frame updates and consequently re-appear on subsequent frames. To avoid issuing new ids, each tracked object is given a life persistence value. Increasing this configuration parameter will keep objects being tracked longer in the memory buffers.

• **BT Serial Tx Buffer Size:**

This configuration parameter controls how many detected object items are pushed onto the internal communication buffer for Bluetooth communication. The internal communication buffer is sampled 100 times a second (10ms). This should be sufficient to clear the buffer.

• **Bluetooth Data Transmit Formats:**

All data communication is sent as ASCII text in the following format:

"Object Type":"ID":"XPos","YPos","Width","Height"

4.2 Adaboost Training Algorithm

AdaBoost is an iterative algorithm that joins a new weak classifier in each round until a desired low error rate is reached. A weight is assigned to each training sample, indicating the possibility of it being included in the training set by a classifier. If a sample point is successfully classified, its weight will be reduced when building the next training set. On the other hand, if a sample point is misclassified, its weight will be increased. In this implementation, each sample has the same initial weight, thus we will choose sample points based on these weights for the k^{th} iteration operation, and then train the classifier. The weight of the sample that is incorrectly classified can then be increased, while the weight of the sample that is successfully classified can be reduced, based on this classifier. The modified sample set weights are then utilized to train the next classifier. This is how the entire training procedure is carried out.

Description of AdaBoost algorithm :

(i) Sample: Given the following training sample set:

$$(x1, y1), (x2, y2),..., (xn, yn),$$

where xi ∈ X, yi ∈ Y = {−1, +1}. (1)

(ii) Initialize the sample's weights:

- For positive samples, use the formula

$$W_1(i) = 1/2m \quad (2)$$

where m represents the total number of positive samples.

- For negative samples, use the formula

$$W_1(i) = 1/2l \quad (3)$$

where l represents the total number of negative samples.

(iii) Weak classifiers are trained by :

Circulate t = 1,..., T: where T represents training rounds.

(iv)
$$\alpha\, t = \frac{1}{2} \ln\left(\frac{1-\epsilon t}{\epsilon t}\right) \quad (4)$$

where $\alpha\, t$ represents the weight of weak classifiers and t represents the classifier's lowest error rate at the current level.

(v) If the sample is correctly identified, revise the weights with

$$W_{t+1}(i) = W_t(i) * \exp\left(\frac{-\alpha\, t}{Z\, t}\right) \quad (5)$$

If the sample is incorrectly classified,

$$W_{t+1}(i) = W_t(i) * \exp\left(\frac{\alpha\, t}{Z\, t}\right) \quad (6)$$

(vi) Final strong classifier = (Sum of weak classifiers) * (Individual weights of weak classifiers).

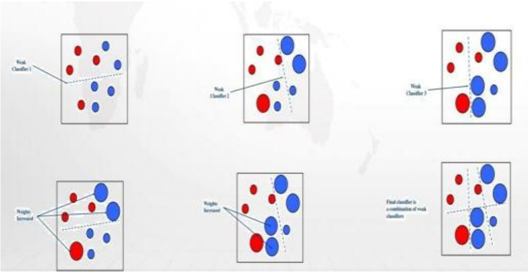

Fig-4: How weak classifiers work

Advantages of AdaBoost algorithm

- The AdaBoost algorithm offers the framework for multiple approaches to generate sub-classifiers, and the AdaBoost algorithm is a simple classifier with excellent accuracy.
- The estimated findings are simple to understand, and constructing a weak classifier is simple.
- There is no necessity for feature selection
- There is no threat of over fitting.

Improved Adaboost algorithm

The upper bound of the least error rate on the training set is used as a criterion for setting parameters in the traditional AdaBoost approach. However, this does not guarantee that the error rate will be reduced. As a result, the weak classifier is no longer picked as the lowest error rate in each training session in an upgraded AdaBoost approach. To tackle this problem, a weighting parameter of the weak classifier can be added to boost the performance of the improved AdaBoost algorithm. Furthermore, if the training set contains difficult samples and noise, the weak classifier's capability to generalize will deteriorate as the number of repetitions grows. "Degeneration" is the term for this condition. The weight expansion must be limited in this circumstance.

5. SIMULATION RESULTS

MatLab was used for carrying out simulation. The first test was carried out using 600 training sets which includes 400 negative and 200 positive samples.

200 positive samples 400 negative samples (complex)

Weak Classifiers No		100	200	300	400	500	600	700	800
Accuracy	Traditional	0.825	0.849	0.85	0.85	0.85	0.865	0.873	0.877
	Improved	0.835	0.853	0.86	0.875	0.89	0.907	0.91	0.925
Time(s)	Traditional	2.598	4.854	7.176	10.790	11.860	14.126	16.447	18.828
	Improved	2.618	4.953	8.171	11.011	11.834	14.407	16.594	19.019

Table-1: Accuracy and Time of 600 training sets

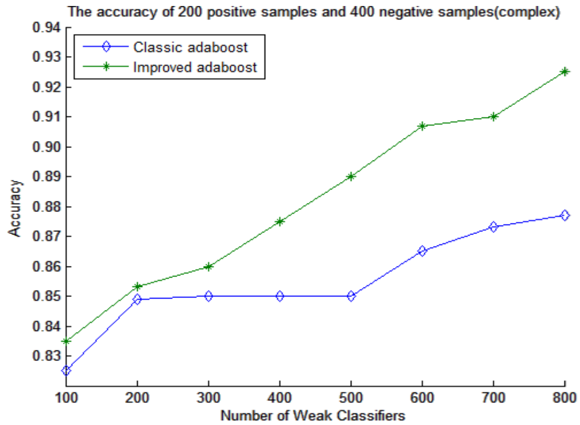

Chart-1: Number of weak classifiers vs Accuracy

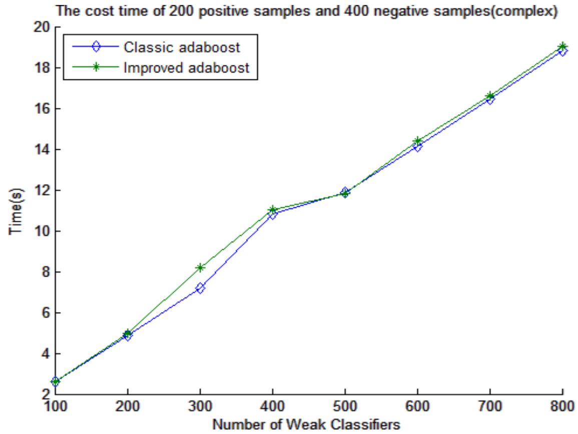

Chart-2: Number of weak classifiers vs cost time

From chart 1, it is understood that in traditional AdaBoost algorithm the accuracy is represented by the blue line whereas in improved AdaBoost algorithm it is represented by the green line. For 100 weak classifiers, the accuracy of traditional AdaBoost algorithm is 82.50% whereas for the improved AdaBoost algorithm is 83.50%. The cost time is observed as 2.5980 seconds for the traditional AdaBoost algorithm and 2.6180 seconds for the improved AdaBoost algorithm. It is also seen that the cost time for both the algorithms is similar.

It is also seen from the graph that the accuracy of the improved AdaBoost algorithm is increasing swiftly whereas for traditional AdaBoost algorithm the accuracy remains unchanged for the number of weak classifiers 200 – 500. When it is 500, the greatest contrast in the accuracy is seen. The accuracy of the traditional AdaBoost algorithm is seen to be 4% less than the improved AdaBoost algorithm. In can be observed that both the algorithm have almost the same cost time. In the traditional AdaBoost algorithm, about 700 weak classifiers have to be trained and the cost time is 16.4470seconds, however in the improved AdaBoost algorithm only 400 weak classifiers need to be trained and the cost time is 8.1710seconds, hence it saves about 8seconds.

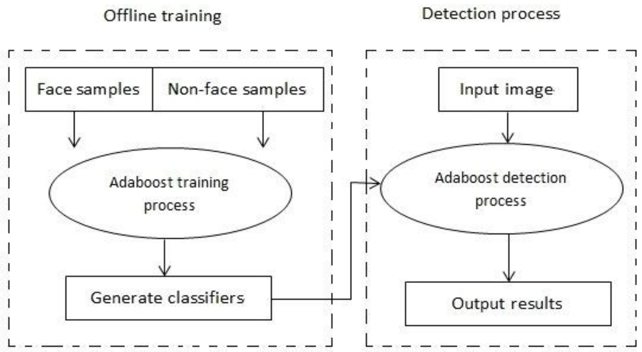

Fig-5: Adaboost Training and detection process

6. PERFORMANCE ANALYSIS

The below table shows the performance comparison of different AI algorithms used for different objects. The classifier based on AdaBoost produces more accurate results than the other classifiers.

Table-2: Performance comparison of different AI algorithms

S.no	Algorithm	Recognition accuracy
1	Random forest	89
2	Support vector machine	92
3	Neural network	92.3
4	Ada boost	95.6

The recognition accuracy comparison is shown in bar graph in the following figure.

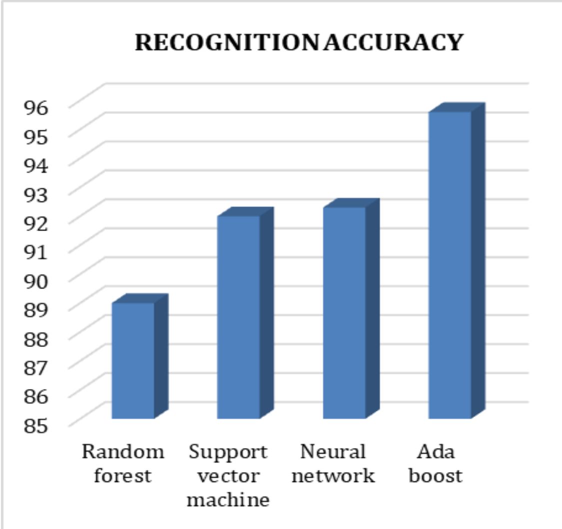

Chart-3: Recognition accuracy comparison

7. HARDWARE DESCRIPTION

- **Arduino Uno controller**

It is a microcontroller based on the ATmega328 that has 20 digital input/output pins, ICSP header, USB port, a power jack, reset button and a 16 MHz resonator.

Fig-6*:* Arduino Uno Controller

- **Camera**

A mobile camera or a webcam is used to record the images of the obstacles that approach the path of the blind person. For image detection, the clustering technique is utilized, with the image of the obstacles as input. To identify these inputs, they are compared to images recorded in the database. Then the output is given in the form of an audio signal if the input image matches with the database.

- **Ultrasonic sensor**

It is an electronic device that has a transducer which emits and receives ultrasonic sound waves to detect the distance to an object and provides information about an item's proximity.

Fig-7*:* Ultrasonic sensor

- **DF Player mini Mp3 Player Module**

The dfplayer mini is an easy-to-use, stable, reliable and compact mp3 module that can connect to the speaker directly. It integrates with MP3, WAV, and WMA hard-decision decoding. Tf cards with FAT16 and FAT32 file systems are also supported by this module.

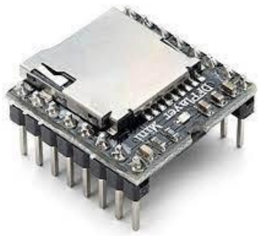

Fig-8*:* DF Player mini Mp3 Player Module

- **HC-05 Bluetooth module**

It is used to connect Arduino to other devices. The HC-05 is used to provide a wireless serial connection that is transparent. It operates on the 2.45GHz frequency band and requires a power source of 4-6V. The data transfer rate varies from 1Mbps to 10Mbps and is within a 10-meter range.

Fig-9*:* HC-05 Bluetooth module

- **Battery**

The smart navigation system's electrical power is supplied by a battery. In order to process the equipment connected to the smart navigation system, a 9 volt battery is used.

Fig-10*:* Battery

- **Speaker**

The speaker module that is used has a good performance and is generally used for all types of audio projects. 8 Ohm speakers consume less power compared to 4 Ohm speakers. They also emit less heat from the voice coil and deliver high-quality sound and can handle about 200 watts of power.

Fig-11*:* Speaker

8. IMPLEMENTATION RESULTS

The proposed system is implemented using an Arduino controller. The circuit connection and overall implementation of the proposed model are depicted in the figure below.

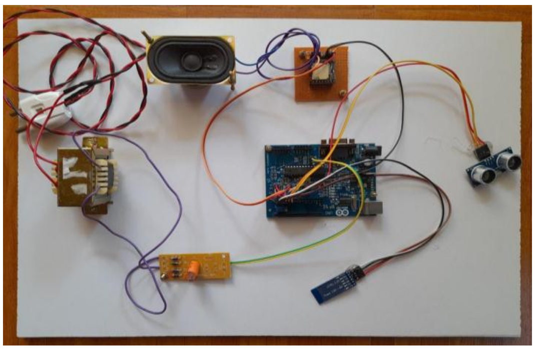

Fig-12*:* Overall implementation

9. CONCLUSION

The blind population may step in or out without any help while utilizing this smart navigation system as it has various functions including image processing, obstacle detection, and text to speech. Furthermore, our system does not need any input from the user, as it consists of ultrasonic sensors and camera modules that sense obstacles around the user and provide feedback to the user with the assistance of an audio device connected to the module. The system continually operates so that the visually disabled can get updates on the challenges at any point on the way. Consequently, with the aid of our project, blind people could perform their daily tasks comfortably without any trouble.

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