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Smart Stick for Blinds with advanced Face Recognition and Vehicle Detection using Machine Learning

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Abstract: ***Some infrastructure can be provided for the blind people so that they can feel safe while travelling. A smart stick can be proposed as an additional aid for the blind to improve mobility. The stick helps to sense obstacles and provide assistance to return to home safely. The stick helps to detect the vehicle coming towards the user by means of strong sensors employed in it. This enables the blinds user to cross roads without assistance. The Assistor works based on the technology of object recognition, image processing and human recognition and a navigation system. This model implements a camera on the hand of the stick. It captures the images of person approaching the user. Using convolutional neural network algorithm(CNN), the stick recognize the image and it returns the identity of that person. Ultrasonic sensors are used for obstacle detection. Three of them together helps to detect the vehicles passing by. Atmega328 microcontroller controls the activities taking place in the system. Feedback is given to the user through an audio earpiece using Bluetooth technology. The system employs GPS module for location tracking and navigation. GSM module installed in the stick sends emergency messages to the stored mobile numbers (Usually the numbers of people closer to the user) along with his current location.***

Index Terms: GPS, GSM, CNN, image recognition, vehicle de- tection, ultrasonic sensors, bluetooth module, emergency button.

I. INTRODUCTION

As stated by the WHO, the estimated number of people visually impaired in the world is 285 million, 39 million blind and 246 million having low vision; 65 all blind are 50 years and older.

There is a large group of people facing difficulties in carrying out their daily routine work due to eyesight lose. Their most dominant problems are in transportation, such as crossing roads, traveling in trains, or other public places, and also the inability to recognize people approaching them. They always require human assistance to do so. Visually impaired people needs assistance from others in an outdoor environment.

They may not know the presence of objects or vehicles in front of them or how close they are from an obstacle. This makes them vulnerable to accidents and other physical damages. The proposed stick detects the obstacles and vehicles with the help of ultrasonic sensors. Three ultrasonic sensors are employed in the stick to get a wider coverage and also the relative position of the obstacle. The blinds cannot recognize people approaching him. It leads to exploitation threat to his safety. This stick helps the user to recognize people approaching him.

The stick has a camera module that capture the front view of the user. The system will be trained to recognize the faces of people, those who are related with the user. Others are considered as strangers and an alert is provided whenever the stick finds a stranger in its way.

Another functionality of the system is the provision of nav- igation instructions so that the person will be able to go home with the help of the navigation instructions provided. Blind people can use this walking stick for safe navigation. The stick is embedded with microcontroller, GSM module, GPS module, vibrator, switches and a camera module. GSM module helps to send emergency messages and calls to the phone numbers of people who are related with the user. Microcontroller stores emergency contact numbers. The message includes current location of the user which can be retrieved using GPS module. The stick gives a fair idea about the obstacles, vehicles and humans with the help of audio signal provided through the ear piece. The user will be provided with details about the distance and location of any object in the surrounding/infront of it. The wireless connection between the stick and user's headphone has been established using Bluetooth technology. Once bluetooth pairing is done, the stick can provide voice instructions to the user.

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II. RELATED WORKS

Although similar ideas have been implemented before none of them were able to find an effective solution that enables the blinds to walk freely in an outdoor environment. Ayat Nada and Samia Mashelly proposed an effective fast response stick for blinds [2]. It consists of an ultrasonic sensor and IR sensor to detect the obstacles and changes in users terrain. It has got a lower coverage and the stick will not be of much help for transportation. But it is less efficient in terms of obstacle detection because it uses a single ultrasonic sensor which have lesser coverage to detect obstacles . The model [5] consists of three ultrasonic sensors , the stick cannot distinguish between moving and stationary objects. And vehicle detection is not possible in it.

Ashraf Anwar proposed A Smart Stick for Assisting Blind People [6]. The system consists of ultrasonic, IR, and light sensor. It has voice based navigation system with fire and light sensor which assist visually impaired people more effectively. In smart walking stick presented in [7], the object is detected with the help of a camera and the stick measures the distance between objects by using ultrasonic sensor.

The model in [8] uses voice commands through a Bluetooth earpiece and the stick consists of a water sensor, and other obstacle detection sensors. However, a panic button is not provided to help the user in emergency situations. The smart stick proposed in [9] consists of multiple ultrasonic sensors that provide a wider coverage. It contains a GPS and GSM modules to send 4 emergency messages. But the system cannot detect elevations or depressions in user's path. In the model Smart Stick for the Blind a complete solution to reach the destination [10] ,the system uses IR sensor, Ultrasound sensor and water sensor to detect the obstacle. However, this system just gives an alert if any one of the sensor is triggered, it uses a buzzer to alert the blind person. This system does not use any location identifier to track the location of the user. And this system is not very helpful for vehicle detection.

III. PROPOSED STICK

The block diagram of the proposed system is shown below. The system consists of three ultrasonic sensors, a camera module, water sensor, GPS and GSM module, Bluetooth module and an emergency button. The ultrasonic sensors finds the distance between the stick and obstacle. The values of distance data is read and processed and is sent to the microcontroller. The microcontroller sends respective voice message based on the relative position and distance of the obstacle. The user is provided with voice instructions through Bluetooth earpiece. Water sensor is also present in the system,4 cm above the bottom of the stick. Whenever water level reaches to that height, presence of water is alerted to the user. Obstacle detection is carried out using ultrasonic sensors. They sends signal continuously.

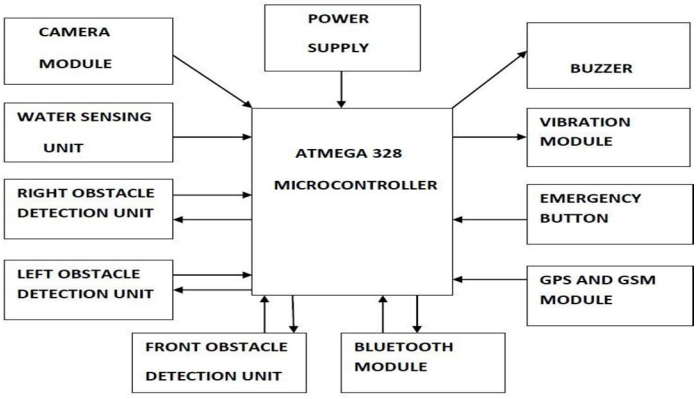

Fig. 1. Block diagram for the proposed stick

These signals strike on an object and reflect back. The time taken by the signal to reach back the source and also the speed of ultrasonic waves are used to find the distance between stick and the obstacle. Stick posses three ultrasonic sensors. Three of them are activated when the user is about to cross roads. The system works in two modes. First mode is dedicated for casual walking. The stick finds obstacles that are in its path. Only the front sensor is activated. Second mode is activated when user is about to cross roads. In this mode, three ultrasonic sensor are activated at a time. This helps in detecting vehicles that are coming from all directions. Audio messages corresponding to the relative position of the vehicle can be provided to the user.

$$D = v * t \qquad (1)$$

The camera module captures the front view image of the stick. Using Viola Jones algorithm , the stick detects the face from that image. The named identity of the people related with the user will be stored in the system memory.

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Once a face is captured, the system scans through the stored images to find a match. If a match is encountered, the system returns the named identity of the person whose face was captured. Otherwise, an alert will be provided to the user as 'a stranger is approaching, please take care'. Facial recognition is carried out using convolution neural network algortithm. The training data set consists of facial images of user's relatives and friends and also their labels (names).

GPS module is used for location tracking and navigation. The coordinate position of user's home location will be stored in the system. Therefore, wherever the user is, he can return to home safely using the voice instructions provided through the earphone. GSM module is associated with the emergency button. The microcontroller stores the emergency contact numbers of the user. Usually the mobile number of people closer to the user. When the user is in trouble and he needs assistance, he can press the emergency button. GSM unit installed in the stick sends emergency messages and calls to the stored numbers along with the location of the user. The location can be obtained from the GPS.

IV. MODULE DESCRIPTION AND WORKING

A. Obstacle detection

Three ultrasonic sensors are used for obstacle detection. One facing the left, other facing the right and the third one facing the front side. Sensors are positioned in such a way that it gets wider coverage and it can provide the relative position of the obstacle. Ultrasonic sensor sends ultrasonic signals continuously. These signal stikes on obstacles and refects back. Distance between the stick and obstacle is calculated and the presence of the obstacle is notified to the user. The time intervel between sending the signal to an obstacle and arrival of reflected signal back to the sensor is used to calculate the distance between obstacle and the stick. The ultrasonic sensors used in the stick have the coverage of 20m. This is a safe distance for the user to cross roads. Instructions are given as audio messages through earphone.

B. Moisture Detection

A water sensor is used to detect watery and muddy areas in user's path. The sensor is placed at a height of 4cm from the bottom of the stick. When the water level reaches at that height, the sensor alerts the user. This eliminates unnecessary alerts when stick encounter some water droplets. Feedback is provided through Bluetooth earphone.

C. Face recognition

A camera module is used for facial data collection. It captures the front view of the stick. Viola Jones algorithm is used to detect face from the captured image. In Viola Jones algorithm, the system will be trained using facial images and non-facial images. Once the training is completed, we can detect a face from any image. After training, the system stores features of the face in a seperate file. When a new input image is provided, the system will check the new image against features stored in the file. If the image pass through all stages of comparison, we can detect the face in that image. The system stores the facial images of people who are known to the user. Using CNN, the system will recognize the captured face. If the captured face matches with any of the faces that are already stored in the system, it returns the named identity of that person. That is the face which was sent from the camera is compared with the faces stored in the data set using the image processing. If no match is encountered, system will alert the user as 'A stranger is approaching, please take care'. If the face is identified, the system returns the identity (Full name) of that person.

D. GPS and GSM module

GPS module is used for location tracking. The coordinates of user's home location will be pinned in the system. This provides safe navigation to the user's home location. GSM module is used to send emergency calls or messages to the user's relativers whenever the user is in danger. The emergency message contain current location of the user which can be obtained from the GPS. A GPS system has two units, a sender unit and a receiving unit. The data sent down to earth from each satellite contains a few different pieces of information that allows your GPS receiver to accurately calculate its position and time.

E. Bluetoooth Module

The Bluetooth module communicates with microcontroller using serial port (USART). Bluetooth technology is used to provide audio output to the user. The output signal from the microcontroller is given to an audio amplifier circuit. The stick communicate with the user through a bluetooth device. HC-05 bluetooth module is used here. User wears an earphone which is connected to the stick via Bluetooth. The audio module provide voice commands as instructed by the microcontroller. It provides different audio messages for each functionalily of the system.

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F. Emergency Button

A panic button is placed at the handle of the stick. It is used in emergency situation. The microcontroller stores their contact number of user's close relatives and friends. When this button is pressed, GSM module sends an urgent message or call to these numbers along with the current location of the user. The location of user is obtained from the GPS unit.

G. Buzzer and Vibrator

To notify the user about the obstacle arriving on user's path, buzzer and vibrator is used which is operated by motor driver 8 L293D. The frequency of beep of the buzzer changes according to the distance of object. The closer the distance of obstruction, the more will be the buzzer beep frequency. The beep frequency is inversely proportional to the distance. Buzzer is also triggered when water sensor detects water.

H. Power Supply

12 V rechargeable Li-ion battery is used to power the stick. It is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging. One of the main advantages of this device is that the battery is rechargeable and can be replaced with a bigger battery at the user's convenience. Lithium-ion batteries have built in electronic controllers that regulate how they charge and discharge. They prevent the over- charging and overheating that can cause lithium-ion batteries to explode in some circumstances.

V. VIOLA JONES ALGORITHM

Camera module captures the front image of the stick. Identifying facial features from the image is carried out using Viola-Jones algorithm. In Viola-Jones algorithm, we train the classifier using facial images and non-facial images. Once the training is done, it becomes possible to detect a face from any image. After training the system using examples, the system stores facial features in a seperate file. When a new image input is provided, the system will check the image against features stored in the file. If the input image pass through all stages of comparison, it can be identified as a face. The steps are:

1) Initialize the weights for the training example, ie, for the image i;

$$W_i = \begin{cases} \frac{1}{2p} & \text{if } x = 1 \\ \frac{1}{2n} & \text{if } x = 0 \end{cases} \quad (2)$$

- p is the number of positive examples.
- n is the number of negative examples.

2) Apply normalization techniques on the weights.

3) Build all the features for weak classifiers and apply them to each image in the training set and find optimal threshold and polarity that reduce weighted error of classification.

$$h(x, f, p, \theta) = \begin{cases} 1 \text{ if } P\, f(x) < P\theta \\ 0 \text{ otherwise} \end{cases} \quad (3)$$

4) Weak classifier takes a single feature. To find the clas- sification of a training example, weak classifier use a threshold θ and a polarity parameter p.

- If p=1, weak classifier will give positive result when f(x) < θ
- If p=0, weak classifier will give positive result when f(x)> θ

5) Train all the weak classifiers.

6) Choose the best classifier from the trained set of weak classifiers.

7) Update the weight based on the error of selected weak classifier.

$$s = \min_{f,p,\theta} \sum_{i=1}^{n} W_i |h(x, f, p, \Theta) - y_i| \quad (4)$$

$$\beta = \frac{s}{1 - s} \quad (5)$$

$$W_i = W_i \beta \quad (6)$$

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- Where *s* is the error in selected classifier.
- Wi is the weight of training example i.
- e=0, If training example is classified correctly.
- e=1, Otherwise.

8) Repeat from step 2 to 7 until the desired number of weak classifiers are obtained. the frame.

VI. STEPS FOR FACIAL RECOGNITION

Once a face is identified using Viola-Jones algorithm, the system needs to recognize the image. For that, initially we store around 20 images of each person who are known to the blind user. Images are stored in system's memory. Correspond- ing to each image, the name of respective person will also be stored. Face recognition is carried out using convolution neural network (CNN) algorithm. CNN can detect principal features from an input without manual supervison. CNN is has more feature compatibility. Once a face input is provided to this algorithm, it checks the image against images that are already stored in the system. If a match is encountered, the face of that person is recognized. Hence, the name of that person is provided as audio output to the user . If no match is found, the face is not recognized. That person will be categorized as a stranger and a voice alert will be provided to the user as 'a stranger is approaching, please take care'.

The whole image recognition process can be categorized into facial data collection, face training and face recog- nition. The captured colour image needs to be converted into grayscale image. The conversion is carried out because grayscale images are simple and only less information should be provided for each pixel.

A. Facial data collection

1) Initialize the camera.
2) Take a snapshot.
3) Convert the RGB image to grayscale image.
4) Using Viola-Jones algorithm, detect the face region
5) Crop the face region.
6) Resize the image to 112 rows and 92 coloumns (112 x96).
7) Save the image into directory of a person.
8) Repeat the above steps for 20 images.

B. Face Training

1) Read all the face data of all the persons in the directory.
2) Train the images using CNN (7 Layers, Maximum training number=15, Learning rate=.0001)
3) Save the convolution network file.

C. Face Recognition

1) Initialize the camera.
2) Take a snapshot .
3) Convert the RGB image to grayscale image.
4) Using Viola-Jones algm, detect the face regions within
5) Crop the face region.
6) Resize the image to 112 rows and 92 coloumns (112 x92).
7) Classify the cropped image and we will get the label and score. If score is greater than 80◦ , display the person is idenitfied. Else display as Stranger.
8) Go to step 2 and repeat the same procedure.

VII. CONCLUSIONS AND FUTURE SCOPE

The smart walking stick, constructed with atmost accuracy, will help the blind people to move from one place to another without others help. This could also be considered a crude way of giving the blind a sense of vision. This stick reduces the dependency of visually impaired people on other family members, friends and guide dogs while walking around. It can detect the obstacles, changes in terrain etc and can alert the user efficiently.

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The device is efficient and unique in its capability in specifying the source and distance of the objects that may be encounter by the blind. It is able to scan areas left, right, and in front of the blind person regardless of its height or depth . It is a user-friendly device and can serve the purpose of potential beneficiaries. The stick can efficiently identify the people related with the blind and can alert him whenever a stranger is approaching. It can help the blinds to cross road without other's assistance. The system can provide safer navigation to the home location and can alert the user's relatives when he is in trouble. The system is a moderate budget mobile navigational aid for the visually impaired. Future scope for this project is to increase the benefits of the smart stick by allowing one stick to communicate with another smart stick (or mobile ,pc). In order to run this integrated set of hardware it is possible to use solar panels as an alternative to the battery. The stick can be improved with the help of image processing to find nearby zebra cross lines.

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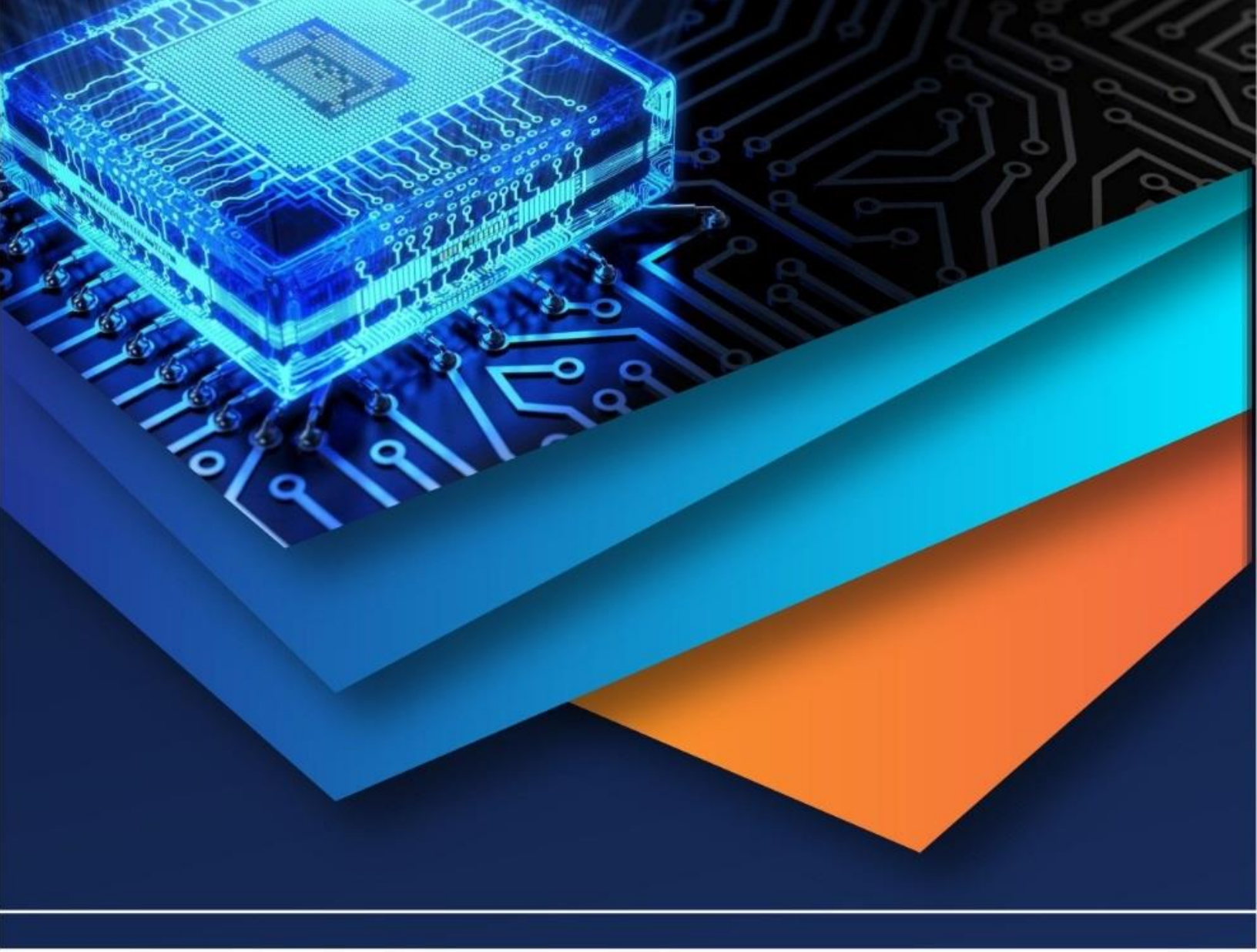

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