An Assistive device for Alzheimer's patients

Pubali Roy
Electronics and Communication
PES University
Bangalore, India
pubaliroy@pesu.pes.edu

Akshata Kumble
Electronics and Communication
PES University
Bangalore, India
akshatapraveenkumble@pesu.pes.edu

Priyanka H M
Electronics and Communication
PES University
Bangalore, India
priyankahm@pesu.pes.edu

Aishwarya Chandankeri
Electronics and Communication
PES University
Bangalore, India
aishwaryaachandankeri@pesu.pes.edu

Dr. Anuradha M
Electronics and Communication
PES University
Bangalore, India
anuradha@pes.edu

***Abstract*—Alzheimer's Disease(AD) is a degenerative neurological condition that results in the damage of brain cells and causes brain shrinkage. It is the most frequent cause of dementia, which is characterized by a steady deterioration in thinking, acting, social abilities and impairs a person's capacity for independent functioning. This project aims to design a smart device that can assist the Alzheimer's patient in remembering certain events, recognizing family member's identity and sending SMS to the family members when a distress call is detected. This is achieved through the use of machine learning models to perform tasks like face recognition and scream detection. We propose to develop an affordable and non-wearable device using Raspberry Pi to perform the required functions which can assist the AD patient thereby reducing their dependency on a caretaker.**

Keywords — *Alzheimer's disease, face recognition, SMS alerts, scream detection, interactive*

I. Introduction

As life expectancy increases, age related disorders increase, bringing great health and economic challenges. One of the most common age related diseases that occurs is Alzheimer's. Studies have shown that about one in nine adults over the age of sixty five years old in the United States are affected by Alzheimer's. It is estimated by 2050 that the projected number of individuals over the age of 65 affected by Alzheimer's in America will be 12.7 million, barring the medical breakthroughs to prevent AD.

Alzheimer's disease is a neuro-degenerative disease that worsens over time which causes the brain to shrink. This is the most prevalent type of dementia in older people. There is no cure for this disease that has been found until now and the damage caused to the brain is irreversible which may lead to death of the individual. It impairs the cognitive function of the patient, behavioural, social skills and mainly affects his memory retention capability. It is very difficult for AD patients to function independently.

The cost of nursing an Alzheimer's patient is economically taxing for the patient's family. It is estimated that an average cost spent on nursing an Alzheimer patient is approximately 8000 dollars. Alzheimer's patients require someone to attend them throughout the day, reminding their basic daily routines like meal reminders, medicine reminders etc. They often tend to forget the names of their close ones, hence the need to constantly remind them. They are very disoriented in general. Since this is a neurological disorder, it affects their balance and makes them very disoriented; hence they tend to fall very often. Someone needs to be there to make sure they are not hurt. All the above issues faced by Alzheimer's patients motivated us to come up with a solution to build assistive devices that will help the patient live a smooth life with reduced need of nursing and also an economically affordable alternative to the patient's family instead of hiring a full time caregiver.

This project aims at building an assistive device for Alzheimer's patients with the use of machine learning models which mainly focuses on features like face recognition, speech recognition and message alerts.

There are several assistive devices developed for Alzheimer's patients like smartwatch with fall and location detection which also has a reminder feature. There are robots that follow patients with limited movement that assist them in daily routine activities like telling them how to wash hands and also monitors them which is integrated with a watch and additional features like memory games, and cognitive activities. There are devices like collars that track the patient's location as they tend to wander off.

It is noticed that a general behaviour of Alzheimer's patients is that they are very fidgety and get irritated easily and remove irritable wearable on them. What we are aiming for in our project is to develop a non wearable device that assists them in remembering faces, reminding medicine and meal timings and also contact family in case of emergencies by detecting screams.

II. Literature Survey

[1] In this paper the approach followed is to do face recognition involves linear discriminant analysis which is combined

with PCA (principal component analysis). It extracts features including nose size, forehead and improves the rate of face recognition. [2] Aims to design smart glasses using Raspberry pi to assist a blind person in recognizing their family members. It takes in a video stream which is broken down into frames and matched with the database created. If a match is found, audio is sent to headphones saying the same. [3] A new face recognition method is proposed in this paper where input to the neural network are local features. The Neural network uses Back propagation networks and Radial Basis Function networks to perform face recognition. [4] Aims to build an assistance device like a collar that recognises people and tracks patient. It uses CNN to perform face recognition and includes location alerts. In [5] they have designed an intelligent wearable that is combined with an IoT application that assists Alzheimer's patients with daily task routines. The wearable design is built with the help of Node MCU . This has several sensors connected to receive input. It also includes a GPS module and pulse tracker. [6] Aims to build a robot with several electronic devices using ultrasonic sensors, PIR sensors, temperature sensor, motors, speakers etc. The robot monitors the health of the patient using several biosensors. It also includes voice interaction to guide the patient in conducting several tasks. [7] distinguishes between Distress Screaming and Joyful screaming by performing distinct acoustic features like level of intensity, compact MFCCs and high pitch analysis. [8] identifies three categories of illicit activities using scream detection. The model is tested on various ML models like Random forest and K-Nearest Neighbours and the Dense layers use ReLu activation for better accuracy. [9] Aims to detect distress in speech using phonetic and prosodic features. Speech is differentiated on the basis of the entire signal versus the sequences. In the global configuration, they segment the audio file into sequences, while the configuration in local space, the speech is segmented into concise time windows.

III. Proposed Methodology

The objective of our device is to develop a cost effective, user-friendly and multi-featured or functional, non wearable assistant to aid those suffering from Alzheimer's. This device provides the following functions: Virtual interactive assistance, Face recognition system and a Scream detection system with distress alerts. Fig1 represents a simple block diagram of our device depicting the connections between different components.

The device runs two tasks simultaneously which are mainly image processing and speech processing modules. The device is going to continuously monitor the audio from the environment, the audio is fed to the model that is run by Raspberry pi 4, if it recognises any queries asked by a patient it is going to reply with an appropriate response. If the model detects any scream it will send an alert message to a family member through SMS. The camera on the device is going to constantly capture video, frames are extracted which are then fed into our model and if it detects any visitor present in the data set it speaks out the person's name through a pair of speakers.

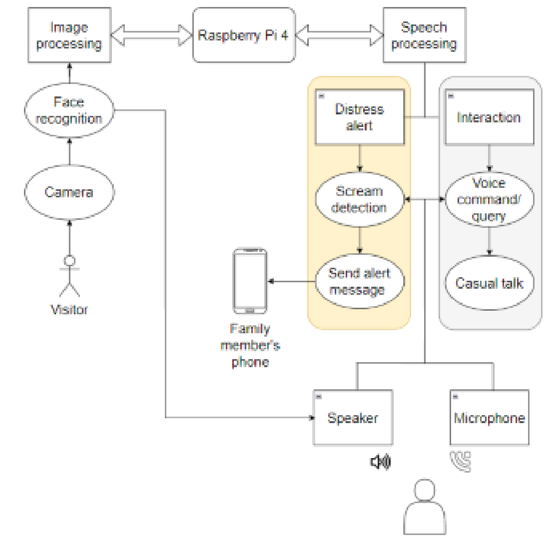

Fig. 1. Block Diagram

Hardware

The device is built using the following components:

1) Raspberry Pi 4: It is the underlying microprocessor that runs all the tasks efficiently.

2) Bluetooth speakers: It is the output device from which the patient receives replies or reminders from the assistant.

3) Microphone: It is the input component through which the patient can ask queries.

Software

All the tasks are coded using python 3.9. It is a high level programming language which emphasizes on code re-usability. The following libraries are used: tensorflow, opencv, numpy, twilio, pyttsx3, gTTS, pygame, speechRecogniser, librosa, matplotlib, sklearn, tkinter etc. These libraries provide efficient modules that help run tasks.

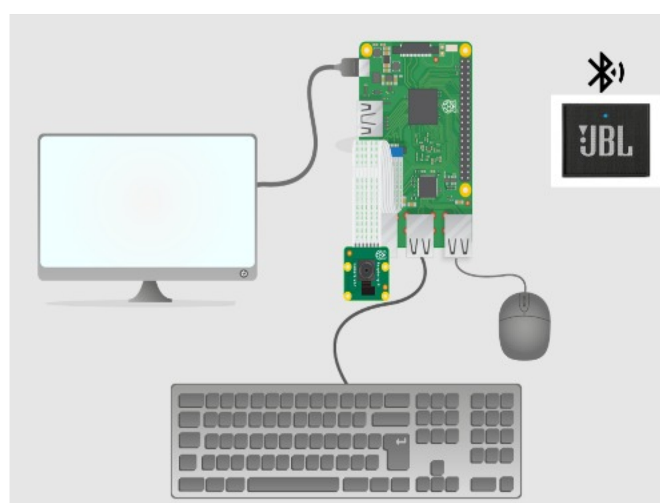

Fig. 2. Connection of components

Following are the ML tools used to perform different tasks of our device:

A. Haar Cascade Classifier

Faces can be located in still images or real-time video using this object detection method. The edge or line detection feature that this method uses was introduced by Viola and Jones in their 2001 work, ”Rapid Object Detection with a Boosted Cascade of Simple Features.” Both a large number of positive shots with faces and a significant number of negative photos without faces are provided to the algorithm during training. To achieve this, it is necessary to calculate the sum of all picture pixels in light and dark areas of Haar features and establish their distinction. The Haar value will now be close to 1 if the image contains an edge separating the light pixels on the left from the dark pixels on the right. In other words, the closer the Haar value is to 1, the more edges are detected. The four stages of the algorithm are:
1)Haar feature calculations: Collection of Haar features is the initial stage.
2)Creating integral images: Haar capabilities are calculated for every sub rectangle for each of which a reference of array is created.
3)Applying Adaboost: It helps select top features and trains the machine to produce strong and weak classifiers.
4)Implementing cascading classifiers: Combines weak learners into strong learners in the last stage using cascade classifier.

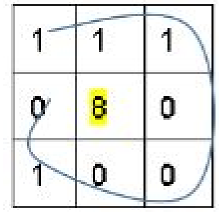

Fig. 3. Binary value for a square

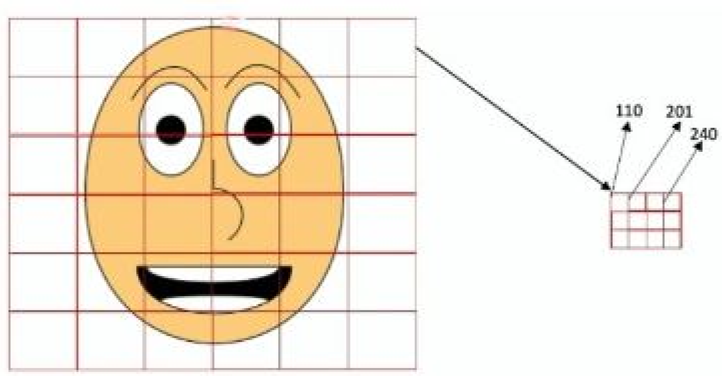

Fig. 4. Image representation in pixel format

B. LBPH Recogniser

Local binary pattern histogram(LBPH) is a face recognition algorithm that recognises a person’s face. It can recognise a person’s face from frontal and lateral view as well. An image is represented in the form of a matrix that is made up of pixels. It is going to apply a condition on a pixel where in the outcome of the surrounding cells is going to be one if they are more than the chosen pixel’s value else it is zero. It then takes a binary value from the matrix by traversing the above matrix from top left corner and goes around in a circular fashion. After converting the above binary value to a decimal value we get 256 which is going to be the value for that centre pixel. Let’s take an example with an actual image. The algorithm is going to partition the image into squares. Within each square it creates the previous explained matrix and applies the condition to each one of the pixels inside the square. Then it builds a histogram with the use of statistics which counts how many times a colour appears in every square. Figure 3 and 4 depicts the same.

C. Convolutional Neural Network

CNN stands for convolutional neural networks. CNNs are mainly used for processing images as they perform better than multi layer perceptrons. They have lesser parameters than dense layers. Since audio files can be treated as images, CNN was preferred. CNN layers obtain lower level features from the input data. Then further layers use these features to predict the output. Lower level features are combined layer by layer to form higher level features to give better output. CNN comprises mainly of 2 components:

ConvolutionLayer$\rightarrow$Conv2D(gridSize,stride,depth,no.Kernels)

Pooling layer $\rightarrow$ MaxPool(gridSize, stride, type)

There are no weights or bias units in pooling layers, for example, hence there are no learn-able parameters. For our model to detect scream we have built a sequential model with 5 layers- one input convolutional layer, three hidden layers all of which are using ReLu as the activation function and a final output layer that uses softmax as the activation function. The ReLU activation function is used to train the model faster and softmax is used to normalize the output and help in predictions. The three hidden layers are used for feature extraction and feature learning. The last two layers are used for classification(Flatten, Dense). Using this model we got an accuracy of 97.45%.

The data set contains 72 audio samples for each scream and no scream class.The model performs multi-class classification. The audio files are pre processed to remove external noise and extract 13 MFCC features which are used for mapping. The features are then stored in a json file which is fed into the model for training. It’s trained for fifty epochs in batch size of 32. Parameters like kernel size and pool size are varied to get the best results. The model is finally tested on real time audio to detect screams. In the case of screams a message alert is sent to a family member. Figure 5 depicts the CNN model summary.

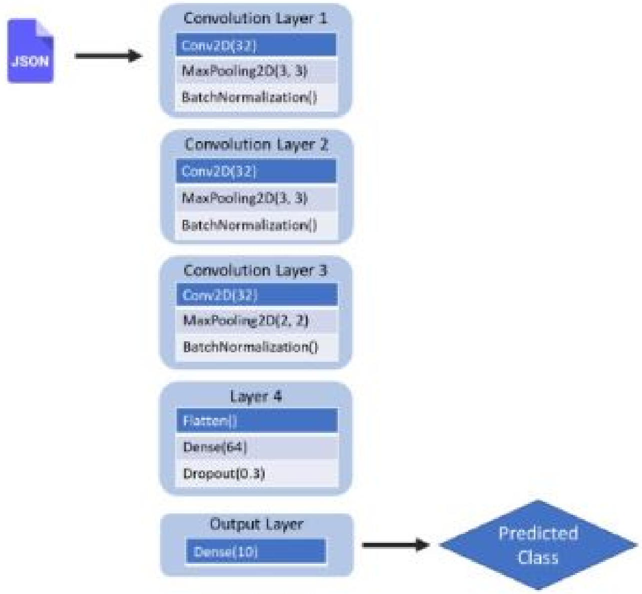

Fig. 5. Model architecture of CNN

IV. Results

We performed a comparative analysis of ML models to find which model gives the best accuracy for scream detection. CNN gave the highest accuracy among them and works accurately in real time. We have built a device where we integrated virtual assistance and scream detection. The device now replies to any queries asked by the patient and in case of any scream being detected an alert message is sent to the patient's family members through SMS. The device recognizes any visitor and informs the patient the name of the person at the door.

A. Image Recognition

In figure 6 as it can be seen the face is detected accurately and it speaks out the name as "The detected face is pubali" through speakers.

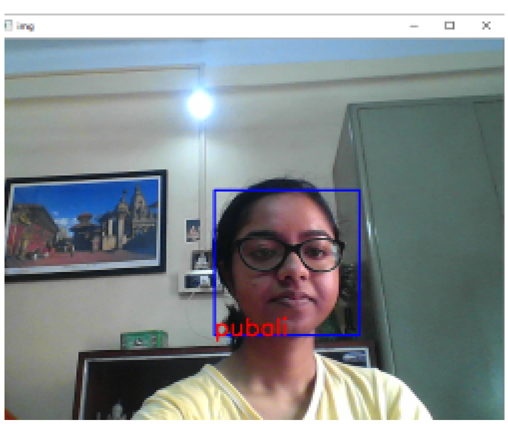

Fig. 6. Output of image recognition component

B. Virtual assistance

In figure 7 it is depicted that if a new user is detected for the first time, a GUI is created to take in the details of the patient.

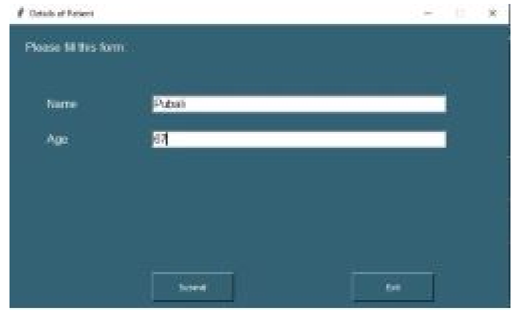

Fig. 7. GUI for patient registration

From the next time the name is stored and spoken. Friendly conversation can be made like "good morning", "how are you", and features are added through which music can be played or weather and jokes can be asked etc. as shown in figure 8.

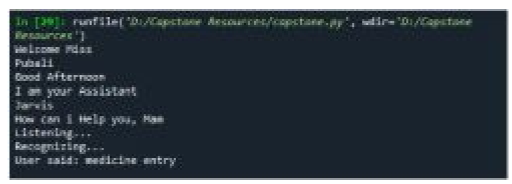

Fig. 8. Conversation between patient and the device

In figure 9 a GUI is created to take in the medicine entry from users; and accordingly the reminder is set, such that at that particular time, it reminds the patient to take the medicine.

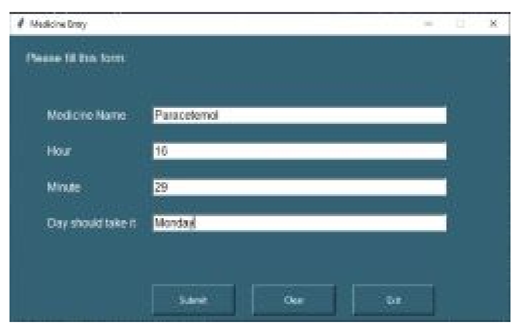

Fig. 9. GUI to add medicine to reminder list

C. Scream detection

Scream detection is also integrated along with the friendly chat, and message is sent to the family member whenever scream is detected as shown in figure 10.

V. Conclusions and Future Scope

In this project, we have successfully designed a virtual interactive device that helps patients suffering from Alzheimer's

Fig. 10. Output for scream detection

to be partially independent of any support from a caretaker. The doorbell camera was used to alert the user about the name of the person entering the house and a voice alert was produced. Also, LBPH recognizer combined with Haar cascade detector was used to efficiently process real time data to recognize faces. The device can effortlessly communicate with the user for medicine reminders, weather reports, casual talk, jokes etc. The device is also able to fire up with a wake up call. For alerting the emergency contacts about a probable event of distress caused to the patient, we have devised our own Convolution Neural Network(CNN). Every time a scream is detected by this model, a message is sent to the preset emergency contacts.

The model can also be implemented for dark lighting using IR cameras to recognize a person during night in the future. The Bluetooth model could be made better to ensure faster and more effortless communication between the user and the device. Better processing power can also be used to get faster results out of the model. Data set could contain larger set of customized queries and feedback for interaction. Since our distress detection works only based on audio input, it might create false positives. Another model for verifying falling of the user such as one that detects emotion or fall using video feed from the patient's room can help curb this issue.

Acknowledgment

We would like to extend our gratitude to Dr. Anuradha M, Chaiperson, PES University, Bangalore, India for her support during the design of the non-wearable assistive device for Alzheimer's patient.

References

[1] S. Sharma, M. Bhatt and P. Sharma, "Face Recognition System Using Machine Learning Algorithm," 2020 5th International Conference on Communication and Electronics Systems (ICCES), 2020

[2] M. T. Islam, M. Ahmad and A. S. Bappy, "Real-Time Family Member Recognition Using Raspberry Pi for Visually Impaired People," 2020 IEEE Region 10 Symposium (TENSYMP), 2020

[3] N. Jamil, S. Lqbal and N. Iqbal, "Face recognition using neural networks," Proceedings. IEEE International Multi Topic Conference, 2001. IEEE INMIC 2001. Technology for the 21st Century., 2001

[4] R. Chokri, W. Hanini, W. B. Daoud, S. A. Chelloug and A. M. Makhlouf, "Secure IoT Assistant-Based System for Alzheimer's Disease," in IEEE Access, vol. 10,2022

[5] S. N. Siri, H. B. Divyashree and S. P. Mala, "The Memorable Assistant: An IoT-Based Smart Wearable Alzheimer's Assisting Device," 2021 IEEE International Conference on Computation System and Information Technology for Sustainable Solutions (CSITSS), 2021

[6] M. Venkatesan, Z. Shaikh and A. Shaikh, ""Robocare for Elderly": A Personal Assistant Robot for Elderly People," 2021 IEEE Pune Section International Conference (PuneCon), 2021

[7] D. Handa and R. Vig, "Distress Screaming vs Joyful Screaming: An Experimental Analysis on Both the High Pitch Acoustic Signals to Trace Differences and Similarities," 2020 Indo – Taiwan 2nd International Conference on Computing, Analytics and Networks (Indo-Taiwan ICAN), 2020

[8] R. Mathur, T. Chintala and D. Rajeswari, "Identification of Illicit Activities and Scream Detection using Computer Vision and Deep Learning," 2022 6th International Conference on Intelligent Computing and Control Systems (ICICCS), 2022

[9] Y. Alkaher, O. Dahan and Y. Moshe, "Detection of distress in speech," 2016 IEEE International Conference on the Science of Electrical Engineering (ICSEE), 2016

[10] K. Cho, B. van Merrienboer, C. Gulcehre, F. Bougares,H. Schwenk, and Y. Bengio, "Learning phrase representations using RNN encoder-decoder for statistical machine translation," in Empirical Methods of Natural Language Processing, Oct. 2014.

[11] A. Graves, A.-r. Mohamed, and G. Hinton, "Speech recognition with deep recurrent neural networks," in ICASSP. IEEE, 2013, pp. 6645–6649.

[12] Y. Sun, B. Xue, M. Zhang, G. G. Yen and J. Lv,"Automatically Designing CNN Architectures Using the Genetic Algorithm for Image Classification," IEEE Transactions on Cybernetics, vol. 50, no. 9, pp. 3840-3854, 2020.

[13] Z. Balogh, M. Magdin, G. Molnár, "Motion Detection and Face Recognition using Raspberry Pi, as a part of, the Internet of Things," Acta Polytechnica Hungarica, Vol. 16, No. 3, 2019

[14] Manish Assudani, Kamran Quamar, Palash Pramod Dhongde, Pawan Sanjay Thakare, Ritik Vijaykumar Yadav, Sayyed Tarique Hasan A Rahim, "AI Based Virtual Assistance on Raspberry PI", International Journal of Advanced Research in Science, Communication and Technology, pp. 381, 2022.

[15] "A prototype of smart virtual assistant integrated with automation", Inventive Research in Computing Applications (ICIRCA) 2021 Third International Conference on, pp. 952-957, 2021

[16] Nivethaa M, Pavithra N, Priyanka, Palaniappan Sambandam, "Speech Emotional Recognition Using CNN Algorithm", Electronics Computing and Communication Technologies (CONECCT) 2021 IEEE International Conference on, pp. 1-5, 2021.

[17] K. N., R. V., S. S. S. and D. R., "Intelligent Personal Assistant - Implementing Voice Commands enabling Speech Recognition," 2020 International Conference on System, Computation, Automation and Networking (ICSCAN).

[18] R. S. Sai Dinesh, R. Surendran, D. Kathirvelan and V. Logesh, "Artificial Intelligence based Vision and Voice Assistant," 2022 International Conference on Electronics and Renewable Systems (ICEARS),2022,IEEE pp. 1478-1483, doi: 10.1109/ICEARS53579.2022.