International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930

HUMAN PRESENCE BASED LOAD CONTROL USING MACHINE LEARNING AND IOT

[1] C M VINAYKUMAR , [2] Ms ASHWINI C

[1] Student, Department of master of computer application ,UBDT college of engineering,

Davangere,Karnataka, India

[2] Assistant Professor, Department of master of computer application,

UBDT college of engineering, Davangere,Karnataka, India

ABSTRACT:

For maintaining comfortable living conditions within a home/office. Least interaction with the system makes the system easy to use and uncomplicated. Faces can be used as the key to the room/office for automation of the devices and peripherals. When the person walks into the room/office the devices preselected turn on without having the user press any button inside the room/office to switch them on. Users can preselect what devices users want to be switched on during the process. Users need to train their faces to be recognized. This system represents the application of IoT for Automation system using smart techniques which includes a Esp32 module as a processing unit for data which is extracted from camera and a Graphical User Interface for program control.

Keywords: Machine Learning, IoT, Automation, Computer Vision, Appliances,Esp32 module

1.INTRODUCTION

Idea about Room/office Automation is not fresh. It began to gain popularity in the late 1990s and early 2000s as internet technology developed incredibly fast and smart homes suddenly became a more affordable option.To give it an upgrade this system using face detection for Automation. In previous systems, a user uses his mobile phone or some device to control the appliances. This system changes it to 'Face'. Person First has to register himself/herself from the UI which is made in tkinter ; A library available in python to create GUIs[20]. He / She must Upload photo or more video to the UI with some details of what appliances the user wants to be turned on. After registration users must click the Train button for updating the Database. Once this is done the user is good to go. As soon as the person walks into the room the camera detects the face, then the image of the face is sent for recognition. Figure 1 shows how faces detected look like with a visual interface. If the face matches from ones in registered, then the Configuration is loaded and applied to the appliances. The appliances will turn on. If the user wishes to exit the room, the user just needs to press one button to reset the Configuration. Apart from this admin can delete a profile, get a list of users and train the model. Users can update their profile whenever needed. The program can even get better over time for recognizing faces and it uses the concept of active machine learning. Once the user enters the room, his picture will be sent again for the model training. Then the model is trained again and becomes better. More images make the model accurate. If this process is repeated the model will get better and better over time. Accurate face detection will reduce the error rate.

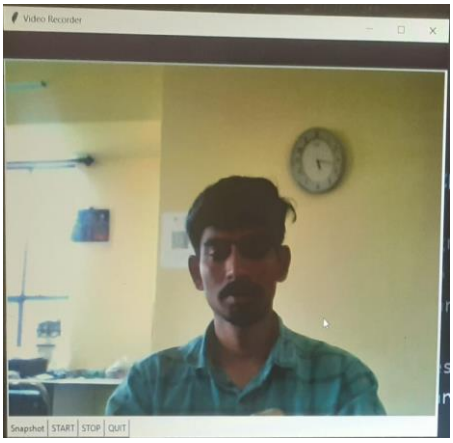

Figure 1. Face Detection

2.PROBLEM DEFINITION

Automation being the key to Smart home functionalities has been incorporated in this work using IoT and Machine Learning techniques. To be able to use Human Facial Patterns for switching home appliances forms the basis of my work. Currently covering four Appliances and scalable to any number of applications by enhancing the hardware is the tactical approach proposed.

3. EXISTING SYSTEM

A. Overview

Current systems work in a typical way where the appliances must be turned on via Bluetooth or WIFI with an application in a mobile phone with a specific device [1]. These use the same concept as the present system i.e. using relay circuits to turn appliances on or off. The Relay Circuit acts as a switch which can be turned on or off with an electrical signal. Security also be comes an issue[2].Due to easy access more and more IoT devices make their way into the tech world, deployed uncontrolled, complex environments, securing IoT systems becomes a challenge and raises safety issues. IoT has some serious challenges ahead of it. Anyone can tap into the user's Bluetooth or WIFI connection and sabotage the network or do some changes without the will of the user. Thus automating this task and making it completely free of human involvement will make it more safer and secure which was an issue in the previous systems.

B. Literature Survey

Paper1: "Research Paper On Home Automation Using Arduino"[1]

Advantage: Arduino being open source is cheap and easily available. Programming code is in C language.

Drawback: Arduino when purchased comes as a blank slate so programming is required,Not ideal for everyone. A mobile app is used which creates problems for people not possessing a mobile phone. Bluetooth has Vulnerabilities.[2]

Paper2: "Interfacing of MATLAB with Arduino for face detection and tracking algorithm using serial communication"[11]

Advantage: Arduino being open source everyone can get hands on experience with it for face detection.Hardware required for this is cheap.

Drawback: Matlab is not free for everyone. Face detection experience with Arduino is not that great.

Paper3: "IoT Based Home Automation Using Raspberry Pi"[12]

Advantage: Used Raspberry pi instead of Arduino. Uses Wi-Fi instead of Bluetooth. ZIGBEE wireless technology to build home internal networks. Can be controlled remotely

Drawback: Not utilizing the full potential of Raspberry Pi and its components. Using Wi-Fi makes it vulnerable to attackers. Raspberry Pi is expensive in comparison to an Arduino and makes it hard for everyone to get their hands on it

4.PROPOSED SYSTEM

Let's take a look at the working of the system. A brief idea can be obtained with a look at figure 2. The camera of this system rolls as long as power is provided to the system and the detection is done along with that too. When a person walks into a system assigned area the camera, the camera sends the stream of digital data to the raspberry pi via a ribbon cable. The data is then used for face detection. Face detection is not just one step. It is further divided into 3 parts and they are converting an image into grayscale image which can be done with a simple command, then feature extraction along with face division and then creating a box around the image to highlight the face. Clearly the last step is not necessary but is worth mentioning. Features are nothing but things like the surface of skin, contour of the eye sockets, nose and chin and these are in pixels. Examples for the types of features are given in figure 3. These types of features are clubbed to create one major part of the face which can be understood by the computer. We can learn about face detection in section V i.e. Methodology. Once the face is detected successfully now we need to identify the face. The first step in face recognition is to crop the image to the area of interest i.e. the face only and removing the background completely. Then the face recognition is done by creating a 3D model of the face. This model is created by considering the distances between the eyes nose and all the other features of the face. After the model creation it produces code for all distances of features for example the distance between the eyes, depth of eyes, width of nose, etc. which can then be compared with the ones in the database. There is a possibility that some distances might match with multiple people data, for that algorithm makes a list of people having the same distances. Then it checks for the persons data having maximum matches and labels it as a recognized face. We can even do it with geometric features, they operate as one and the same however, the 3D method is much better. Once the face is recognized that means it is a registered user, now the system finds details for the particular user in the database. The details are nothing but the data for the relay circuit switching. It contains which relay circuits need to be on and which need to be off. Then input pins are used to activate relays. These are user defined pins that can be programmed to do almost anything a user can desire. The system sends a signal through the pins to the relay circuit via jumper cables which turns the relay on allowing current to flow to a particular appliance. The relay circuits marked by the user get the signal and only those allow the electricity to pass creating a personalised environment for the user. All technical details of the system are cited in the section i.e. Methodology.

5. METHODOLOGY

Steps involved in the procedure methodology are represented in figure 2. Each step is explained in the following sections. Video Stream: Video is a medium which can be used electronically for the recording, copying, playback,

broadcasting, and display of moving visual data, for example a video captured by the digital camera. Every single frame in the video is a picture itself. The program operates on the images only so what we need to do is to extract the frames of the video continuously and feed it to the program. This video will be provided by the camera which will be at the door. Every image then will be processed to get the important bits and pieces out of it.

Face Detection: Face detection is a technology being used in computers for a variety of applications can identify human facial patterns in digital images[3][4].OpenCV(Open Source Computer Vision) is a popular computer vision library started by Intel in 1999[18]. The OpenCV now comes with the latest Face Recognizer class for face recognition. Even after detecting and recognizing faces daily, We don't really know how our brain encodes all this information. We recently discovered that our brain has specialized nerve cells responding to specific ocal features of a scene, such as lines, edges, angles or movement[16][18]. Our brain somehow manages to put all this information all together and develop a pattern out of it which helps us in detecting and recognizing. Face detection is kind of a specific case of object-class detection. Haar Cascade is a object detection algorithm used to identify objects in an image or video and based on the concept of features proposed by Paul Viola and Michael Jones in their paper "Rapid Object Detection using a Boosted Cascade of Simple Features" in 2001 and can be used of faces as well [5][14]. Initially we need a lot of images having the positive and negative results i.e. images with faces will be considered positive and images without faces will be considered negative to train the classifier. Then we need to extract features from it. This is done by haar feature extraction[14]. Algorithms used for the local feature extraction are Gabor Wavelets, Discrete Cosinus Transform and Local Binary Patterns. Each feature is a value obtained by subtracting the sum of pixels under white rectangle with the sum of pixels under black rectangle as mentioned.

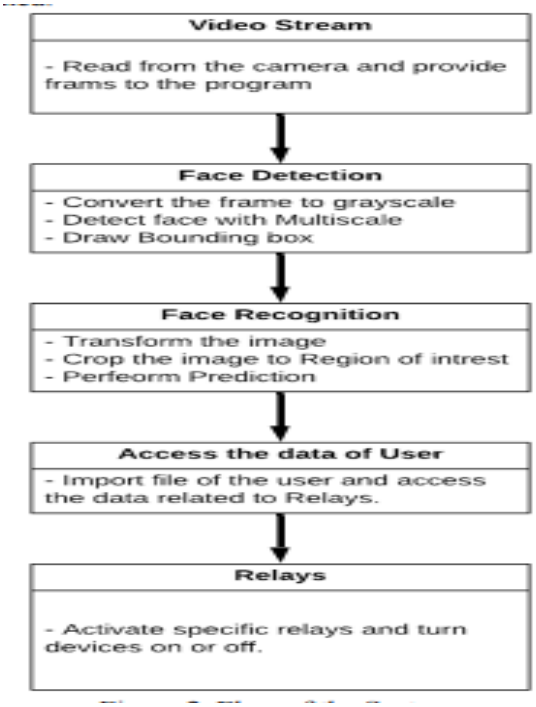

Figure 2. Flow of the System.

Among all the features extracted most of them are not pertinent. To get the best out of the image we use Adaboost that applies all the features on every single training image and then creates a best threshold which will classify the faces to positive and negative[15].These features are also called as weak classifiers. After finding the features, we use a weighted combination of these features to determine that the frame has a face or not. These work better rather than randomly guessing the features. Each weak classifier is important in detection no matter how small weight it has.Output of the weak classifier is binary if it has identified a part of the face or not. A strong classifier is built on the linear combination of the weak classifiers.

Strong classifier=linear sum of weak classifiers

$$F(x) = \sum (\alpha_i * f_i(x))$$

here α_i are corresponding weights to each weak classifier

$f_i(x)$ [15]

There are always some errors and miscalculations which are not required. But we select the best features out of the all. Some papers even say that 200 features provide detection with 95% accuracy. But how to select the best features? Here we can use some math to solve our problem.For every feature we calculate the following:

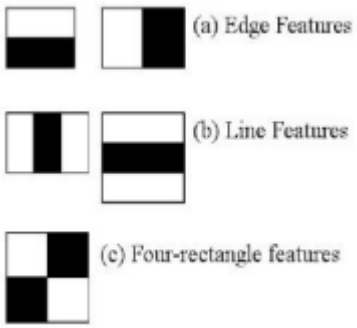

Figure 3. Types of Features.

All this is done on a gray scale image only. So if the image being used is a color image then we have to convert it into a gray scale. Then detection is done with the Multi scale method which is mentioned is the paper Multi scale

Face Detection: A New Approach to Robust Face Detection which was published by M. Aghagolzadeh, H.Soltanian-Zadeh, B.N. Araab in 2006 [6]. The algorithm has two stages: in the first stage, a face is detected in a unique scale and in the second stage, only the faces that are situated in the neighbour scales are taken as real faces. For the sake of the user we draw a boundary around the face detected so that the user can see the result the user was expecting.

Face Recognition: As we discussed earlier, the brain has a unique way of getting a pattern out of the angles, edges and much more. Since we don't see the world in scattered pieces, our mind's visual cortex will have to somehow combine the different sources of information into useful patterns the same way as our brain does. Automatic face recognition is extracting those important features which are needed from an image and then put them into a useful depiction and performing some kind of classification on them for prediction. Face recognition based on the geometric features of a face [7].The former systems used to calculate the euclide an distance between feature vectors of a probe and reference image to perform recognition. So at this current point in time we have 2 main algorithms for recognition namely Eigen faces and Fisher faces[8]. The basic idea is to minimize the variance within a class i.e. less spread on graph, while maximizing the variance between the classes at the same time. This is help full when plotting the image results on the graph. Recently various methods are being combined to create an efficient way to perform tasks. To avoid the high-dimensionality i.e. size of image of the input data only local regions of an image are described that are relevant to us, the extracted features work better against partial occlusion, illumination and small sample size. This basically means that we performance crop operation of region of interest i.e. Face. After the prediction we get confidence and the name of the image or we can say the label of the images. The confidence is how much the algorithm is sure about the prediction.

User Data: Next step includes getting the correct information corresponding to the user which has been recognized by the program. The information mainly contains the relay numbers which need to be activated.

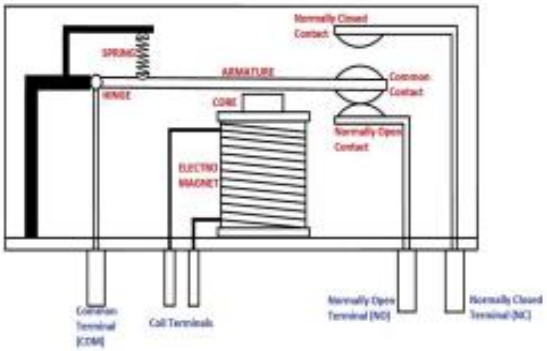

Figure 4. Relay Internal Diagram.

Activating Relays: Relays are switches that open and close circuits electro-mechanically or electronically. Relays control only one electrical circuit by opening and closing contacts in another circuit which are arranged in series [9].Relays are either electromechanical relays or solid-state relays. In electromechanical relays (EMR), contacts are opened or closed by a magnetic force which is created by electromagnets. In solid-state relays (SSR), there are no contact points and switching is totally electronic. Figure 4 and Figure 5 represent an EMR. The live wire needs to be connected to the 'Common terminal(COM)', And the appliance should be connected to the 'Normally Closed(NC)' with a wire. 'Common Terminal(COM)' is always connected to Common Contact. When a signal or current is applied to the coil it creates an electromagnetic force which pushes the common contact currently connected to Normally Open(NO) to Normally Closed(NC) allowing the current to flow. When the signal or current to the coils stop, the electromagnetic effect stops and then spring pushes the Common contact which then breaks the contact and stops the current flow. These are widely used in many world applications and were used in this system as well. Transistors can be used instead of Relays as well. They work the same when compared to Relays but they do have limitations as well. The circuit diagram of the actual system is shown in Figure 6. The relays are activated by pins on the Esp32 [19]. A great feature of the Esp32 is the cluster of (input/output) pins along the bottom edge of the Pi board. Esp32 can be easily used for Home/office automation systems. One of the examples can be found on[13].23-pin in Esp32. Any of the pins can be assigned (in software) as an input or output pin and used for a wide range of purposes and applications.

Figure 5. Relay Circuit Board

Figure 6 shows Pins on the Esp32module which connect the relays. This individual relays will act as a switch for a single device. LEDs in the above diagram represent a device which will be connected to the main power supply line. However for the representation purposes we are using LEDs as our indicators/Devices. The button on the right is the exit button. The user will need to press that button when he wants to exit the room. That button resets the relays and turns of all the devices in the room.

6. RESULTS AND ANALYSIS

The system was made with Python Programming language which is one of the best languages for machine learning and image processing[17]. Esp32 module was the base and it made IoT applications a lot easier. The pins can be used for a lot of applications and the system can be easily upgraded. The average Confidence or accuracy was around 80% - 85%.

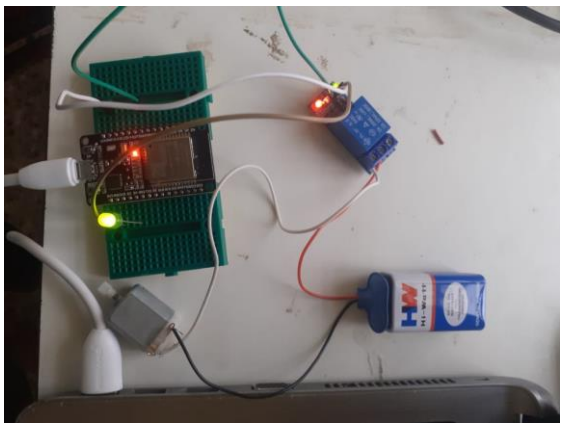

Figure 6. Circuit Diagram of the system.

This will increase by every day use as the model also learns on the new images. When the Registered person enters the room/office with all the settings perfectly set the devices preselected change the state as desired and was the motive of this entire system. If no face is detected or the face is detected but not recognized then the person has to manually change the state of the devices as we do in traditional approach. Figure 7 shows the working of the system.

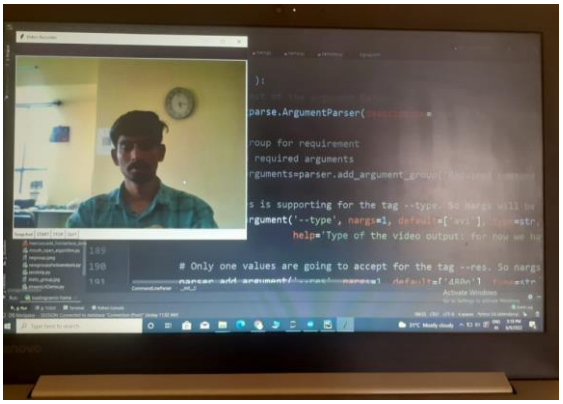

Figure 7. Working of system

7. CONCLUSIONS

In the proposed work, around 1800-2000 images were used for initial testing which yielded in the result of 80-85% accuracy. The Feature Extraction of the face using Haar-Cascade was done with utmost perfection to meet the demand of the current industry. The Esp32 model was used for all the purposes in this entire project. It has a processor clocked at 160 or 240MHz coupled with 320 or 448 kiB RAM which took around 10 minutes to train the model for a user.

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