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INTERNET OF THINGS BASED IMAGE PROCESSING USING OPENCV-PYTHON AND ITS APPLICATION IN SMART BUILDING

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Abstract

The nation's buildings and dwelling places where people spend about more than ninety percent of their valuable times are destined to be smarter. A smart building adopts automated control systems that automatically control the different operations like air conditioning, lighting, ventilation, security and other systems. Commercial buildings extensively use electricity to power lighting, heating/cooling systems and are manually operated. Most of the times energy spent on lights, fan, air conditioner go as waste. Thus energy saving is most important for developing an integrated system that makes buildings to be operated more intelligently and help reaping the benefits in terms cost savings on electricity billing. Internet of Things based image processing using OpenCV-python and its application in smart building can be used to conserve energy. As the project is envisaged to be for a specific application of image processing to identify presence of human being through supervised machine learning algorithm, it is proposed to use OpenCV (Open source computer vision) library for image processing. The objective is to identify presence of human being and then use it in IOT control application. Once the presence of human beings is detected, temperature is needed to be monitored; if it's very cold then air-conditioner need not be switched on. This temperature setting can be made programmable. Ambient light needs to be measured based on which lighting system to be switched ON/ OFF. The data is then sent to cloud. Through cloud, it is possible to control the appliances manually through phone. Cloud makes it possible to monitor the appliances remotely. As importance is given these days for energy conservation and also as it involve huge recurring cost, this project envisages to prototype a solution to operate these devices only if needed, which would then not only save energy but also the recurring cost.

Index Terms— Internet of Things, OpenCV-python, smart building, Image processing

1.INTRODUCTION

The "Internet of things" (IoT) is a fast growing technique that finds wide range of applications in different fields. The "Internet of things" is poised to generate a huge impact on the way human beings live in this planet.

Owing to the continuous decrease in the cost of bandwidth and fast evolution in internet technologies, the usage of internet reached phenomenal milestone in the recent years. The rate of connectivity of devices to the internet has been growing tremendously. Wi-Fi capabilities and advanced wireless internet connectivity has enabled sensors and other independent modules to continuously communicate with integrated systems in real-time with greater accuracy and precision. The growth and development in the internet together with evolution of devices capable of communicating seamlessly in real-time has created a perfect platform for the IoT based systems.

IoT can be simply considered as the technique that enables the connecting any device having an ON and OFF switch to the Internet. IoT system can be applied across different electrical appliances like lighting system, air conditioning system, ventilation, smart phones, electronic devices like washing machines, food processor, headphones, wearable devices, etc. The building operating cost and energy spending on utilities can be greatly minimized by employing Internet of Things (IoT) based platform. Such efforts also enhances the efficiency of the buildings by making them more sustainable by bringing down maintenance costs drastically. It is estimated that HVAC and lighting costs around 59% of commercial energy use. A research by Texas Instruments found that advanced HVAC and lighting IoT solutions were capable of minimizing the energy use up to 40% through optimized sensor control.

Through automation processes by employing IoT platform, it is possible to enhance the building energy efficiency, better temperature control, improved security features and quality of sanitation system operations.

According to an estimation by the analyst firm Gartner, “By 2020 there will be over 26 billion connected devices”. Other report speculate that this estimate could even reach 100 billion. This indicates that there will be lot of connections as IoT is a giant network of connected "things" including people and things around. The interactions between people-people, people-things, and things-things will generate huge volume of useful data.

I. SCOPE OF THE WORK

Machine learning is extensively used for image processing. For image processing, python language is used extensively used with appropriate add-on libraries like Google Tensorflow or Open source Computer Vision (OpenCV).

Tensorflow is resource intensive and heavy as it has many features. As the project is envisaged to be for a specific application of image processing to identify the presence of human beings through supervised learning algorithm, it is proposed to use OpenCV library for image processing. OpenCV is not heavy can be installed in LINUX based IOT devices like Intel Edison or Raspberry Pi or beagle bone. OpenCV has been designed and developed for better computational efficiency. In addition, OpenCV has a strong focus toward real-time applications. Developed using an optimized version of C/C++ language, OpenCV library takes advantage of the multi-core processing. Application of OpenCV includes interactive art, mines inspection, stitching maps on the web or through advanced robotics. The scope of the project is to identify presence of human being using face detection algorithm and then use it in IOT control application. Commercial building extensive use electricity to power lighting, heating/ cooling systems particularly in a large commercial complex like IT tech park, malls etc. these systems are manually operated and since its dependent on human being most times energy spent on lights, fan, air-conditioner go as waste.

The objective of this project is to detect the presence of human in the building bay through machine learning by OpenCV. The sensors and API may analyze the environment variables and turns on the necessary appliances after identification of the object to be human. If the human leaves the room or the absence of human object turns off the appliances.

MQTT is used to control the lighting and the HVAC system. The system can be manually controlled through Google assistant by Voice or through Adafruit dashboard.

II. RELATED WORKS

A. Automation using NODEMCU

The Internet of Things (IoT) is framework that helps interconnecting several physical devices, objects, appliances, modules in vehicles that are embedded with sensors, electronic circuits, software systems and network connectivity and enabling the individual objects to gather, interact, store and exchange data.

In educational establishments, dedicated human labor is required to carry out routine tasks like turning ON, turing OFF the appliances like lights, fans, AC in the laboratories and classrooms in order to save electricity wastage. This in turn adds to the additional labor cost to the educational institutions.

In order to automate the entire process related to the powering of electrical appliances like lights, fans and AC’s, this project proposes an IoT based system [1]. The proposed system can effectively reduce energy wastage by efficiently managing the consumption of power in the classrooms by employing advanced electronic system based on embedded control system. The proposed system can effectively control the parameters for maintaining ambient environment, along with effective energy consumption management and overall security management. This module can also controls the operation of switches by automatically turning on and off the lights, fans and other electrical appliances and prevents unwanted wastage of power.

In the proposed system, power management system was designed using Passive InfraRed (PIR) sensor which are capable of sensing the motion [6]. PIR transmits “HIGH” signal to Arduino microcontroller once it senses any movement in the room. Arduino controller has been programmed to turn “ON” the electrical appliances in the room like fans, lights once it receives a “HIGH” signal from the Passive InfraRed (PIR) sensor. Similarly, PIR sends “LOW” signal to nodeMCU in case no motion is detected in the classroom. As a result, Arduino turns “OFF” the respective appliances in the room as it has received “LOW” signal from the PIR sensor. It is important to note that for each motion in the classroom, the time is approximately extended to about five minutes. In case, if no motion is detected for five minutes, nodeMCU is automatically activated and it switches “OFF” the power supply. The proposed microcontroller based system is useful in minimizing the consumption of power in small as well as large scale environment. Instead of detecting a motion, the presence of a human can be detected for controlling the home system because the motion can be produced by any living being not necessary for the motion to be produced by a person or people.

B. Controlling IoT Using MQTT

One of the major problems confronted by developing economies in the world is Energy crisis. According to an estimate by the Central Electricity Board of India, 6.7 TWh of power is required for public lighting, incurring approximately an whooping amount of 500M USD annually. It is widely believed that the technology like Internet of Things (IoT) can provide an optimal solution in handling the public lighting system in a sustainable manner. IoT enables monitoring and control of electronic devices remotely via the internet medium. Thus, power consumptions in the public lighting system can be effectively managed and power consumption can be decreased through continuous monitoring of the brightness in the surrounding and altering the intensity of light using advanced protocols like MQTT [2].

For storing the large volume of data, online platforms (cloud storage) can be used. Data processing encompasses operations like data acquisition, storage and data analysis.

In this project, online platform namely adafruit.io was used for performing simple data connections. IO has client libraries that are compatible in processing protocols like Message Queuing Telemetry Transport (MQTT) and API. In this work, MQTT protocol which is an ISO standard used for sending and receiving information was implemented. MQTT is a lightweight protocol which is suitable for useful when there is low bandwidths and has very low memory requirements.

The purpose of the publish module is measuring the light intensity in the environment and transmit the data to the adafruit.io server. Light Dependent Resistor (LDR) sensor is used to measure brightness of the surroundings. The light sensor has a resistor in which the value of the resistance varies inversely in proportion with the variations in the intensity of the incident light. Thus, whenever there is an increase in the exposure of light, there will be a corresponding decrease in the resistance of LDR resulting in increasing conductivity. On the other hand, when there is darkness, conductivity decreases. The subscribe module which is also connected with the adafruit.io server houses the main circuit that controls the operation of lights. The function of the module is extracting data from the server constantly and comparing with predefined set of values in order to arrive at decisions about surroundings (bright or dark). Based on the surrounding light intensity of the surrounding environment, the intensity of the streetlight is varied. The light intensity is altered by adjusting the current flow into the lighting device. In this module, provision has been made through manual mode by controlling from the server to perform operations like “switch-on” or “switch-off” the streetlights. In case, when the light intensity in the surrounding is brighter when compared with the daylight, the streetlights are automatically turned-off. The Google home or Amazon Alexa can be connected to the MQTT to control the devices remotely through voice [10].

The working of MQTT protocol is as follows: Clients associate with the broker (Adafruit.io) in order to establish communication between the publisher and subscriber [8]. When the publisher transmit data to the broker, it collects the data, store it and process the data and then forward the data to the intended clients who have already made requests for the particular data. This process enhances the efficiency as larger volumes of information can be instantly monitored and controlled. The function of MQTT is mainly centered around distributing the information in an efficient, scalable manner. In addition, MQTT is capable of updating information in a shorter time duration and thus reducing the development time. MQTT can also be used for integrating the smart phone, Adafruit dashboard and Raspberry Pi.

C. HAARcascade for Face Detection

HAARcascade is face detection algorithm that uses several different methods for identifying and detecting the human face. Haar algorithm [3] and Local Binary Pattern based algorithm (LBP) are important face detection methods. Haar algorithm based Face Detection uses machine learning based approach in which a cascade function is trained from a database consisting of large number of positive and negative images.

The face detection module includes Raspberry Pi board as the core processor. The operating system compatible with the raspberry pi board is loaded in the SD card. A Picamera which has been interfaced with the Raspberry Pi board was used to capture the human face.

Viola and Jones [3] have developed the concept of using Haar wavelets and used Haar-like features [3]. Haar-like feature includes considering adjacent rectangular regions at a specific location in a detection window, summing up the pixel intensities across each region in the surrounding and computing differences among these sums. This difference is then used for categorizing the subsections of an image file. For example, for an image database consisting of human faces, it can be observed that regions surrounding eyes is darker when compared with those region around cheeks. Therefore, Haar feature for face detection [9] uses two sets of adjacent rectangles that lie above the eye and the cheek region. The position of these rectangles are defined on the basis of the detection window which functions like a bounding box for the target object.

The Haar cascade files are supported in OpenCV which comes with a trainer and a detector. In this work, OpenCV was used as detection module for Haar cascade files. The XML files are stored and compared for performing detection operation using inbuilt functions

(cv2.cascadeclassifier). Haar Cascade algorithm has been applied to detect the presence or absence of humans in a given region based on which the appliances can be turned on/off.

D. Automation Using PIR sensors

In the last decade, the majority of the developments in the Information and Communication Technology (ICT) are focused on the upcoming technology like Internet of Things (IoT). Services based on IoT technology are capable of improving the domestic environment in a real-world scenario, and are applied in different applications including Home automation.

In home automation application using IoT, all the electrical and electronic home appliances can be networked together and operated without human interference. This motivated the authors to develop a novel application for managing and controlling the operations of different home appliances including like light, fan, door using advanced sensors like LM35, IR sensors, LDR module, Node MCU ESP8266 and microcontroller like Arduino UNO.

The proposed system uses the sensor [5] to detect the human motions. In this paper, the conventional home automation system has been enhanced by incorporating advanced wireless sensor network (WSN) based system. The proposed smart home system can integrates different modules including electrical and electronic appliances and automate the different modules them with or without user interventions. The proposed smart home system can monitor various environment variables and associated modules continuously to enable proper functioning as per the user specifications. In addition to automating the appliances and modules in home on a continuous basis, a smart home system notifies the user about the electricity bill regularly and facilitates automatic bookings. For example, in case the LPG level used in home cooking reaches below the threshold level, it can automatically make bookings with the respective gas station. This Smart Home System was developed and tested in this work using Internet of Things technologies. From the results, we proved that developing an effective, low cost and energy efficient smart home is possible for the better and greener future. A strong motion is required for the PIR sensor to detect the motion. It cannot analyze if the motion is produced by a human or any other object.PIR sensor may not work in places where the normal temperature is more than 35 C.

E. Automation Using Arduino Mega

In Internet of Things based Home Automation System or Smart Home Project, every networked module, device or appliance is assigned an IP address. Each unit can be monitored and controlled from anywhere at any time remotely.

The user need not require to operate the electrical appliances manually [4]. For example, the proposed system was programmed in such a way that as soon as user enters the room, the light will automatically on. On the other hand, if the user leaves the room, the light goes off automatically. In addition, provision has been made for a user to control the switching using his/her smart phone based application. Interestingly, the level of brightness of the lamps can also be altered so that the power consumed can be minimized.

In this project, Arduino Mega is used as the main controller as it is cost effective, supports cross-platform operations, require simple programming, open source and extensible software. All the appliances modules and sensors output are connected with the appropriate pins of Arduino Mega. Arduino board read the inputs and process the information to produce desired output. Arduino uses serial mode of communication for receiving and transmitting data, triggering an interrupt on a low value, providing 8-bit PWM output and more. The Wi-Fi Module (Model: ESP8266) has 8 pins which are connected to the Arduino Mega. ESP8266 has been chosen because it is cost effective and has better features making it an ideal module for IoT applications.

Arduino Mega can work as a microcontroller. It does not have the processing power of a Raspberry Pi. Arduino cannot process images like a Raspberry Pi. It does not have an inbuilt wifi module. Arduino is not suitable for projects with face detection.

F. Face detection using MATLAB

In the proposed model, Arduino [7] has been interfaced with Matlab environment to enable operations like face detection and tracking. The aim of this paper is to develop a real-time face detection system and tracking technique using hardware devices like Webcam as the input device and Arduino board with Microcontroller as the output device.

The face detection algorithm proposed by Paul Viola and Michael Jones using Haar features was implemented on the MATLAB platform. The face detection is accomplished using different parameters of the image and tracking of the detected image. Haar feature based system has been used as it operates much faster than the pixel based system.

The webcam captures the face image and transmits to the MATLAB which in turn detects the face in the captured video. The detected image data is transmitted to the Arduino. Arduino performs tracking of the face region by altering the orientation of the servo motors attached with webcam. In general, three types of features are considered for face detection namely, two rectangle features, three rectangle features and four-rectangle features. The features are computed based on the difference between sum of the pixels

in white portion to the sum of the pixels in the black portion. For example, a four rectangle features calculate the difference between the sum of the diagonal pairs of rectangle. On the other hand, a three-rectangle feature computes the difference between the sum of the edges of the rectangle to the middle one. Finally, a two rectangle feature calculates the difference between the pixels among two rectangular regions which can be oriented either horizontally or vertically adjacent to each other and generally has the same shape and size. AdaBoost classifier has been used in this algorithm as it can enhance the performance of weak algorithm. AdaBoost algorithm boostis the performance of proposed algorithm by training the classifiers and enabling selection of small set of features from a large number of features.

The disadvantages of Matlab are its cost of License and the time taken for execution. It is very costly for the user to buy each and every module and pay for it. It can be slow, and poor programming practices can make it unacceptably slow.

III. SYSTEM ANALYSIS

Internet of Things Based Image Processing Using Opencv-Python and its Application in Smart Building incorporates the advantages of the previous systems and proposes solutions to eradicate the backlogs of the previous systems. The face detection is done using Haar Cascade Algorithm in OPENCV PYTHON. The problem with the image representation is that the images are in high dimensionality. Hence, the image must be converted to gray scale.

Once the presence of a human is detected, the ambient light and temperature is measured and the necessary system is turned on. The ambient light is measured to turn on the lights and temperature is measured to control the HVAC system.

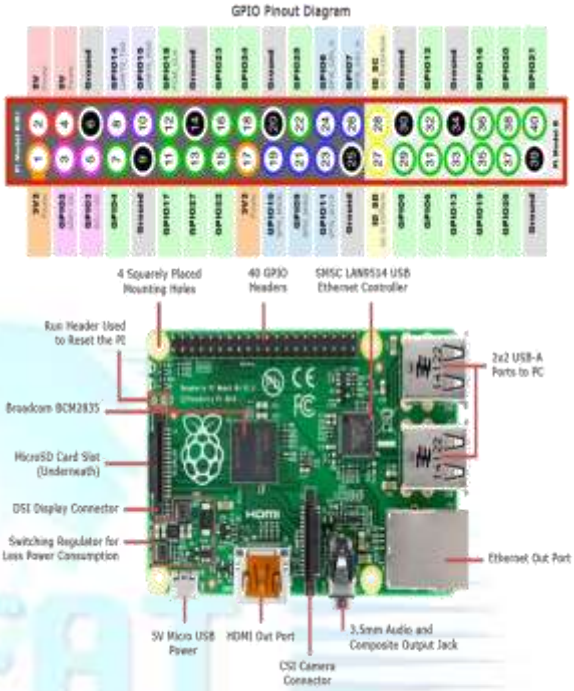

Fig 1 Raspberry Pi Architecture diagram

The HVAC and the lights can also be manually controlled by voice and through the Adafruit dashboard. The changes in the HVAC and the lighting system are updated in Adafruit. The timing when the appliances were turned on or off can be analyzed in Adafruit. The current temperature and ambient light is updated in Adafruit dashboard.

ADVANTAGES

The proposed system is likely to have the following advantages:

- The smart building system can be controlled through automation as well as manually.
- For automation, the proposed system uses Haar Cascade Algorithm for face detection; this is more efficient than using motion sensors to detect human beings.
- The environment variables are analyzed and only then the required systems are activated.
- The system can be manually controlled through voice using Google assistance and Adafruit dashboard.
- The appliances can be analyzed in the Adafruit cloud.

The automation system has been integrated with voice control.

IV. SYSTEM ARCHITECTURE

The Architecture for the process of internet of things based image processing using OpenCV-python and its application in smart building is illustrated in the Fig below

The MQTT broker is central system for any publish/subscribe protocol. Based on the implementation, a broker can handle several concurrently connected MQTT clients. Here, the MQTT clients include the Adafruit dashboard, Google Assistant and Raspberry Pi. The broker is responsible for getting all messages, filtering the messages, defining who is subscribed to each message, and transmitting the message to these subscribed clients.

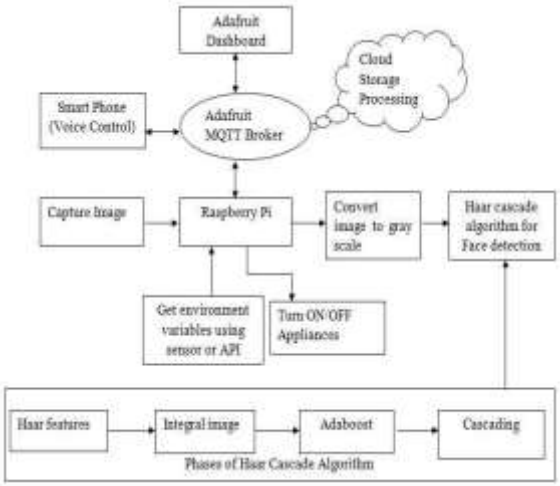

Fig 2 Smart building using Image Processing Architecture

Auto control is chosen by the user, and then the automation is activated. When an object enters the room or hallway, the webcam is used to detect if it is a human face. The human face can be detected using the Haar Cascade algorithm. Using machine learning, only human object is taken into consideration. The webcam is connected to the Raspberry Pi. If the object is a human, the sensors and API detect the environment variables which include luminance, temperature and analyze them. Light Dependent Resistor is used to analyze the ambient light and required API is used to get the current temperature. Different lighting has different luminance value. If the lighting is not adequate, then the required lights may be turned on. A temperature greater than 25 C turns on the required HVAC system. On analyzing the variables, the necessary appliances may be turned on or off. If there is no human object or the last person present in the room leaves, all the necessary appliances may be turned off. Raspberry Pi is connected to the cloud storage for processing. The changes in the environment variables are updates in the Adafruit cloud.

MQTT broker continuously monitors the clients. If voice control is given through Google Assistant, the lighting and HVAC system can be controlled manually. If voice control has been activated, automation must be deactivated. Appliances can be manually controlled through the Adafruit Dashboard as well. Any changes must be continuously updated in the Adafruit dashboard.

A.CIRCUIT DIAGRAM

The circuit diagram for the internet of things based image processing using OpenCV-python and its application in smart building is illustrated in the Fig 4.2 below

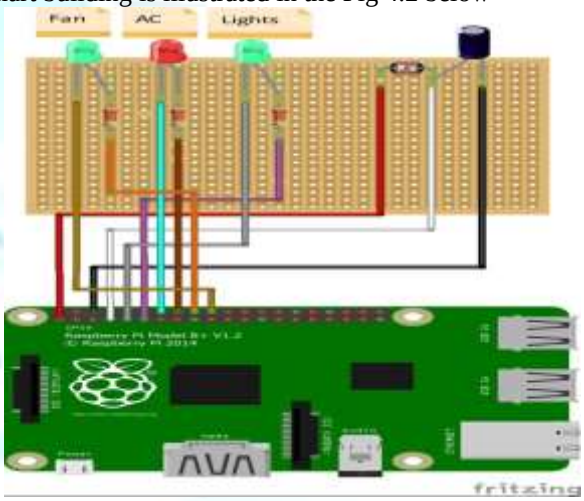

Fig 3 Circuit Diagram for Smart Building using Raspberry Pi

GPIO stands for General Purpose Input Output. Raspberry Pi consisted of two rows of GPIO pins connected between the Raspberry Pi and the real world. Output pins can be considered as the switches that can be turned on or off. But are able to transmit a signal to other device. Input pins can be considered as the switches used to turn on or off from the outside world.

The positive end of the three LEDs is connected to GPIO 24, GPIO 23 and GPIO 17 which represents the fan, Air Conditioner and lights respectively and the negative end is grounded. A Light Emitting Diode (LED) emits light when an electric current is passed through it.

A Light Dependent Resistor (LDR) is used to analyze is the ambient light. Often, LDR is connected in series with the capacitor. The positive end is connected to GPIO 4 and the negative end is grounded. One end of the LDR is connected to the 3V pin. The LDR is used to measure the ambient light. The Raspberry Pi has digital I/O pins whereas LDR is LDR is analogous. Hence a capacitor is connected in series to the LDR. The capacitor charges quickly when resistance is low and charges slowly when resistance is high. LDR produces

low resistance when light falls on it and produces high resistance when it is dark. In this way, the ambient light can be measured using LDR.

The mobile communicates to the Raspberry Pi through MQTT which is shown and the overall automation process flow is explained in the Fig 4.6 given below. Activity diagram determines the state of the application. The initial stage include the mobile activating the automation and ends with cloud storage. All the states involved in the smart building automation process is explained through this diagram.

Fig 4 State Flow Diagram for the events that occur in Automation

V. SYSTEM IMPLEMENTATION

A. Subscribe to MQTT broker

Adafruit MQTT broker is used in this project. The Raspberry Pi, Adafruit dashboard and the Google assistant publishes and subscribes to this broker. Therefore, Raspberry Pi, Adafruit dashboard and the Google assistant act as the client. The Raspberry Pi subscribes to the MQTT broker; it needs either the dashboard or the Google assistant to publish automation to the broker. Once automation has been published in the MQTT broker, the Raspberry Pi activates the face detection algorithm. If manual control has been published in the MQTT broker, then automation will be deactivated and voice control through Google Assistant is activated. The devices to be controlled manually are published inMQTT broker and the Raspberry Pi which has subscriber to the broker may control the required appliances.

B. Face Detection

Haar Cascade classification algorithm has been employed for face detection. In this work, cascade function is trained using large set of positive images (images of faces) and negative images (images without faces). Then, the important features are extracted from stored images. Haar features shown in the Fig 5 has been used. They are analogous to convolutional kernel with feature having a single value obtained by subtracting sum of pixels under the white rectangle from sum of pixels under the black rectangle. Even a 24x24 window can generate over 160000 features. .

To solve this, they introduced the integral image. However, among all these features calculated, several of the features are irrelevant. The first feature selected is based on the property that the region around human eyes are darker than the region around nose and cheeks regions. The second feature is selected on the basis of the notion that region around eyes are darker when compared with the bridge of the nose region. However, the same windows when applied to other regions like cheeks or any other place produces irrelevant results. Adaboost has been used to select the best feature. For this, each and every feature is applied on all the training images. For each feature, the optimum threshold value that can classify the faces to positive and negative is generated. The features with minimum error rate are identified, as it accurately classify the face and non-face images.

The final classifier is obtained as a weighted sum of the different weak classifiers. It is called weak since it alone cannot be able to classify an image. However, when combined with others classifiers, it becomes a strong classifier. As most part of the image consists of non-face region, it is always to use a simple method to determine if the selected window belongs to face region or not. If the selected regions is not face region, it can be discarded at once and need not process again. Subsequently, other regions containing face can be focused.

Thus, as opposed to applying for all the 6000 features on a window, the features can be combined across various stages of classifiers and applied one after the other. For example, in case a window fails in the first stage, it can be discarded. In this way, the face can be detected based on which the sensor and API starts to collect data.

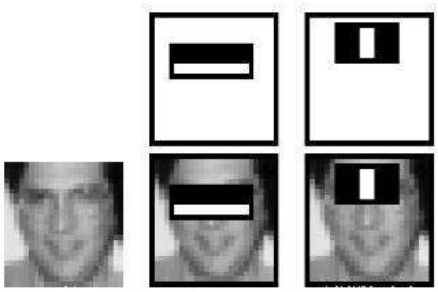

Fig 5 Haar Cascade Algorithm for face detection

C. Analyze variables through API and Sensor data

The face has been detected successfully as a human. Now the API and sensors must detect the environment factors. Various environment factors like luminance, temperature are noted. The factors can be detected using sensors and API.

An LDR is used to analyze is the ambient light by placing a capacitor in series with an LDR. The capacitor will charge at different rate depending on whether it is light or dark. When the value matches the daylight value, the lights need not be turned on; else the lights need to be turned on.

The next factor to be measured is the temperature. The temperature needs to be measured to control the HVAC system. IPstack API is used to locate the longitude and latitude of the current location. This longitude and latitude is provided to the temperature API to find the current temperature. OpenWeatherMap is used for finding temperature. If the temperature is below 25 C, no cooling appliance needs to be turned on. A temperature of 25 C and above, results in the fan being turned on. Temperature above 35 C switches on the air conditioner. The temperature must be monitored periodically and must be used to control the appliances.

D. Cloud Storage processing and Turning on appliances

The necessary home appliances are turned on. The ambient light and the temperature are measured periodically to turn on/off the necessary appliance. The current temperature and ambient light must be updated in Adafruit. The time when the lights and HVAC system were turned on can be analysed in the Adafruit cloud. After turning on the appliance, the camera must be periodically detecting the presence of a human. If no human faces can be recognised, all the appliances must be turned off.

The duration of the appliance being turned on/off can be monitored through the Adafruit cloud. The data can be analyzed to conserve energy. The ambient light and temperature is continuously updated in the cloud. This data can be viewed from anywhere. Based on the data, the users' can control the appliance remotely through Google Assistant and Adafruit dashboard.

The data must be updates periodically in Adafruit dashboard. Suppose a person wants to turn off/on the appliances, it may be possible through his/her smart phone. This is an alternative method to control the appliances manually. MQTT broker subscribes to the smart phone. If the user provides the required voice command, the appliances can be turned on/off. The lights and the HVAC system can be controlled manually through the Adafruit dashboard and voice control. Google Assistant is used for voice control. Once the user wishes to automate the building's appliances again, automation can be activated. Raspberry Pi which has subscribed to the MQTT broker will activate the automation again. The face detection will be initiated. The data will be sent to Adafruit cloud. The Raspberry Pi may publish the data in Adafruit dashboard through the Adafruit MQTT broker.

VI. CONCLUSION

The proposed system will successfully use image processing for smart building automation. Message Queuing Telemetry Transport (MQTT) has made it easier for the Raspberry Pi to be controlled remotely. The automation system has been integrated with voice control and Adafruit dashboard through MQTT. The data can be monitored from any location through Adafruit cloud. The proposed system uses the Haar Cascade algorithm to detect the presence of humans instead of using sensors. Further, the system uses the LDR to find the current ambient light value and the temperature API is used to find the current temperature based on which the appliances can be turned on/off. This helps to conserve energy which is the key scope of this project. The data is brought to cloud which the user can monitor to control the devices manually in case of any necessities. The devices can be controlled manually through the Adafruit dashboard or Voice control through Google Assistant.

VII. FUTURE WORK

The proposed system focuses on automation of buildings. Further the system can include a security alert system. The same system which is used to detect the presence of humans can be used to detect intruders in a building when required. When all the people have left the building for the day, the intrusion detection system can be turned on. On detection of intruders, an alert message can be sent to the security department. A stronger security and privacy system can be implemented. A maintenance system can be implemented which reminds the owners when the appliances need to be serviced.

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