Real time Machine Learning Approach for a Smart Door Unlocking Using Face recognition System

Rayavel Pa, Sivakumar Ab, Gopirajan P Vc, Surenderanath Sd, Rathnavel Pd

Abstract: This proposed framework goes about as a home security framework for both Person location and gives security to entryway access control by utilizing facial acknowledgment for the home climate. The more peculiar's face is distinguished inside a home climate accomplished by catching a picture from a web camera and handling will be done on caught pictures. The web camera catches the arrangement of pictures when the individual comes before the entryway. The caught picture is analyzed utilizing our face acknowledgment calculation model. In the event that the individual is the approved one, at that point the entryway is opened. Then again, if the individual isn't the approved one, the picture of the individual is shipped off the power in the event that he perceives the individual and wants to open the entryway. He can distantly get to the entryway and permit the individual in.

Keywords: Face recognition; Image processing; Convolutional Neural Networks; Machine Learning; Smart-home.

1. Introduction

Lately, human identification strategies, are with progress applied to a few retail stocks in business sectors like advanced cameras, great telephones, or police examination frameworks for police work people faces [1, 2]. Inside the arranged framework, face location is received for human ID, the face identification is utilized as a result of the essential solution [3]. Along these lines, face identification work is depicted by face recognition instead of shape location. Investigations of face recognition will be arranged into four assortments [4], to be specific, the information based, the component based, and the model coordinating based approach. Inside the underlying technique, the face was recognized by the spatial features and pixel variation between eyes, nose, and mouth [5]. Recognition was effectively measured by the direction and lighting conditions of facial features.
Facial feature alternatives square measure made from the insights of the areas in the face and consequently the separations present in the organs such as nose, eyes and so on [6–9]. Commonly, face recognition is carried over with its coordinating areas, comparative choices and shading color data in pre-prepared models. The discovery pace of this approach is more beneficial than the past one, notwithstanding, the presentation could essentially be impacted with commotions, lighting, and shadow that arises with the lighting [4]. Prototyped coordinating systems utilize a pre-prepared, trained facial model for coordinating. A face is realized once the geometrician separation between the ROI and thusly the model is a more modest sum than an express limit cost [10]. It was reported that facial feature recognition proportions and identification was all around created inside the specification and has the closest connectedness to human attributes, so it's pleasant for people recognizable proof. So, when an individual pixel feature is recognized inside the Region of Interest (ROI) points, movement of individuals face was caterpillar-followed and finally examined by an applied mathematical analyzer to ascertain the comparing added substance probability, and can be utilized due to the assessment of the goal [11].

Since there square measure scope of works is done abuse raspberry pi models in computerized picture measure field. Like picture catching procedure in partner degree inserted framework with Raspberry Pi. Particularly the biometric frameworks such as finger print, iris recognition, voice recognition were fundamentally treated as a primary source, acknowledgment of the input voice signal, solutions of arcane frameworks, independent face acknowledgment system [12], and so forth all abuse Raspberry pi. moreover, the face acknowledgment framework square measure turned out profoundly for the wellbeing reason and police examination and computation of different boundaries like bogus dismissal rate and bogus acknowledgment rate square measure done as a feature as artificial input materials like plastic cards, personal identification numbers, scratches square measure utilized for authentication[13]. Thereupon the presentation, irregular speed, and so on elective boundaries square measure principally based with pertinence the equipment style of Raspberry pi. Conjointly Raspberry pi is thought at its ability and cost with significant show modules [14].

Over the long haul general society uses the Raspberry Pi in light of the focal module and concentrates the outcomes. Inside the year 2017, a group upheld a character's face recognition algorithmic standard abuse 3 frail classifiers just as Haar course classifier. Skin shade bar graph, Eye location, and Mouth discovery square measure the 3 classifiers received by this procedure. This yields adequately high recognition. The arranged philosophy creates an edge forecast value (PPV) to with respect to 78. 18% - 98.01%. this will be revised to locate human faces exclusively of various races and cut back the postponement for police work and perceiving various appearances among totally changed pictures of people with variety in a lightweight and foundation conditions[15]. Inside the year 2017, a group actualizes a face identification framework by examining with Haar course classifiers and edge direction coordinating. Edge direction coordinating algorithmic guideline and Haar-like component decision joined course classifiers square measure the 2 strategies used in this technique. This algorithmic standard creates a more grounded coordinating anyway the discovery speed is generally less[16].

"Haar-Cascade calculation" to spot human faces that are coordinated in Open CV by Python language and "Neighborhood parallel example calculation" to recognize faces. Gathering with elective existing calculations, this classifier creates a high acknowledgment rate even with variable articulations, prudent element decision, and a low variety of bogus positive alternatives. Haar include based course classifier framework uses exclusively 200 choices out of 6000 choices to yield an acknowledgment pace of 85-95% [17]. The circle of AI has taken a sensational contort as of late, with the expansion of the false Neural Network (ANN). These naturally intrigued machine models square measure ready to so much surpass the presentation of past kinds of figuring in like manner AI errands. One of the chief terrific kinds of ANN configuration is that of the Convolutional Neural Network (CNN). CNN's square measure essentially won’t to unravel intense picture driven example acknowledgment assignments and with their exact all things considered, the simple plan offers a disentangled approach of acquiring began with ANNs [18].

This biometric recognizable proof entryway open framework could be a technique which can locate the facial features by distinguishing among face inputs. Total pixel average of face features having varying sorts of face feature points, in this outstandingly their square measure a few particular faces that square measure totally unique in relation to each other that intrigued the United States of America, from that thought this strategy has been set up. The primary intend to shape a decent entryway framework to a house. That framework should authenticate the members of house and should provide access to handle individual home appliances. This study aims at setting-up a live web camera in the entryway, show screen was installed both in door way and inside the house. This web camera streams
the live display to the administrator, the framework was also embedded with a voice recognition system to record voice of the person who is standing in front of the camera [20].

This examination plans to propose a fresh out of the box new warning framework abuse face location partner degree acknowledged to advise the house proprietor [guests | of tourists | of occasion makers]. In case of any abnormal entry, an alert email will be sent with the help of SMTP containing the login information of these guests. Apart from recorded information, present information collected from the camera will also be sent to the admin [21].

2. Methodology

Current setup was made with the hardware components such as Raspberry Pi 4 configured with GSM module, 1.5 GHz ARM Cortex-A72 Quad Core processor, 4 GB RAM and VideoCore IV graphics; Web Camera, Stepper engine, Display device and a Door alarm. Raspbian OS was used for implementing this complete module. The Raspbian OS has inbuilt support for implement with python.

The arrangement of Raspberry pi4 was finished with Windows 10 IOT as appeared in Fig.1. It is interfaced with a showcase to the processor specified. The web camera was interfaced by means of port with the processor, this web cam captures the picture of the anonymous entering the home, the GSM module embedded in the Pi helps in sending messages of the abnormal activity. IR sensor collects the number of people enters the home, which encourages the proprietor to get the details of persons entering home. The framework will likewise give a live streaming cycle through the application and furthermore encourages the proprietor to forever bolt the entryway until interfaces information over cloud through the application. Raspberry Pi was designed to consistently check the live streaming and put away in the cloud which causes the proprietor to watch the home entry details. On the off chance that an interloper attempts to enter the home it will make an impression on the proprietor of the house and rings the chime.

Fig 2 shows the internal architecture of this system. Its working details were explained below:

A. Input Unit (IU): IU Collects facial pixels by face recognition mechanism and picture outlines for character discovery were caught through the advanced resolution web camera enter contraptions individually.

B. Processing Unit (PU):
Measurements which is accumulated from the Input unit this is caught Image enter is taken care of into the preparing unit wherein the handling or estimations are cultivated at the proposed individual identification and entryway lock gadget, Here the processing unit is Raspberry Pi board, together with code

![Architecture with Processor](image)

**C. Enrollment Module:**

In this enrollment module shown in Fig. 3, the records which amassed from the input camera means character face photo is stored within the database. Before storing the image it's going to use characteristic extraction means it's miles transformed in Haar Feature-based Cascade Classifier

![Enrollment Module](image)

**D. Authentication Module:**

In this module appeared in Fig. 4, we perceive and stagger on the enter pix. This module is appended to the external side of the entryway, where the caught photo changed over into Haar Feature-principally based Cascade Classifiers. Also, coordinating this choice extraction picture with the information base.
E. Application Module:

The Application-explicit unit appeared in Fig. 5 comprises of an electric entryway strike, it's far identified with the entryway lock machine module of the validation module and it starts working reliable with aftereffects of the module to convey outside lock open/close activity dependent on Face Recognition.

3. System Implementation

The proposed framework goes about as a security framework for home with both individual location and gives security to entryway access control by utilizing facial acknowledgment for the home climate. The savvy entryway open framework comprises of raspberry pi with information base availability. The information base comprises of pictures of experts for whom the entryway open admittance to be given.

3.1 HAAR CASCADE

Cascading inside a picture is acceptable based on the ROI values. Based on the ROI, the facial features can be grouped and compared with two images.
The initial step is to gather the Haar Features. A Haar work considers bordering rectangular zones at a particular spot in a recognition window, summarizes the pixel forces in each locale, and ascertains the distinction among these totals. Fig. 6 shows the case of HaarCascade work.

![Fig.7. HaarCascade Feature Set](image)

Essential Images are utilized to make this extraordinary quick. However, among every one of these highlights we determined, the greater part of them are insignificant. For instance, recall the photo underneath. The top line shows two great abilities. The main capacity chose appears to acknowledgment on the property that the spot of the eyes is routinely more obscure than the spot of the nostril and cheeks. The subsequent trademark chose depends on the resources that the eyes are more obscure than the scaffold of the nostril. Yet, the equivalent home windows utilizing on cheeks or some other district is unimportant. Fig.7 and Fig. 8 shows the HaarCascadeAdaboost and list of capabilities.

![Fig.8. HaarCascade Adaboost](image)

So how would we choose the great capacities from 160000+ capacities? This is refined by the utilization of an idea alluded to as Adaboost which each chooses the pleasant highlights and prepares the classifiers that utilization them. This calculation develops a "hearty" classifier as a direct total of weighted simple "defenseless" classifiers.

During the identification stage, a window of the objective size is moved over the information photograph, and for each subsection of the picture and Haar capacities are determined. This distinction is then in contrast with a discovered limit that isolates non-objects from objects. Since each Haar work is best a "weak classifier" (its location uncommon is marginally in a way that is better than arbitrary speculating) an enormous assortment of Haar capacities are essential to depict an article with enough precision and are in this way set up into course classifiers to shape a powerful classifier.
3.2 Cascade Classifier

The course classifier incorporates an assortment of stages, where every degree is a group of helpless students. The defenseless rookies are simple classifiers called choice stumps. Each level has prepared the utilization of a strategy called boosting. Boosting presents the capacity to prepare an exceptionally precise classifier by taking a weighted normal of the decisions made with the guide of the weak novices.

Every level of the classifier names the zone characterized utilizing the contemporary spot of the sliding window as one or the other positive or horrendous. Positive proposes that a thing was resolved and negative demonstrates no articles were found. In the event that the name is terrible, the class of this district is finished, and the locator slides the window to the resulting place. In the event that the name is high-caliber, the classifier passes the spot to the ensuing level. The finder audits an article situated at the current window area when the absolute last stage orders the region as brilliant.

The degrees are intended to dismiss terrible examples as fast as could reasonably be expected. The supposition that will be that the tremendous greater part of windows do now exclude the object of interest. Then again, genuine positives are extraordinary and worth setting aside the effort to confirm.

- A *authentic high quality* occurs while a fine sample is correctly labeled.
- A *false fine* takes place whilst a poor sample is mistakenly labeled as nice.
- A *false negative* occurs while an effective pattern is mistakenly categorized as negative.

3.3 Hog representation

This segment gives a framework of our element extraction chain, which is summed up. Execution subtleties are postponed till x6. The strategy is predicated on assessing very much standardized local histograms of picture values with the directions of slope during a dense environment. The principal plan was to enforce local item look and structure to be normally be described very well by the circulation of local feature points. Application of the system can upheld by extracting the ROI pixel as a separate window to slight deliberation districts (.cells.), in each cell gathering a region 1-D bar outline of the gradient comportments over the pixels of the image. For higher constancy of enlightenment, shadowing, and so forth, it's conjointly useful to differentiate standardize the local reactions prior to misusing them. This should be possible by gathering a live of local bar graph .energy. Over some angular reflection areas (.squares.), abuse the results to regulate the entirety of the ROI blocks inside the square. The standardized descriptor blocks represents as a Histogram of Oriented Gradients (HOG) details. Covering the location window with a thick network of HOG feature set and misusing the joined component direction during the commonplace SVM based image classification gives human recognition concept. Fig.9. shows the implementation of HaarCascadeAdaboost.

![Fig.9. HaarCascadeAdaboost](image_url)
application [12,14]. The framework [1] contemplated dissimilar cells and square structure, but stomach muscle initio abuse exclusively edge picture component checks while not the direction histogramming that delivers the delineation along these lines successful. The accomplishment of those dainty component based pictures has to show some degree of differences via hidden capacity and simplicity of HOG’s as dense pixel points. Present general examination can encourage to redress this, particularly, our casual examinations counsel that even the best current keypoint based generally approaches are without a doubt to have bogus positive rates at least one or significant degrees more than our thick matrix approach for human identification, essentially because of none of the keypoint sights that we keep an eye on are mindful to identify outline structures constantly. The HOG/SIFT demonstration has numerous benefits. Edge feature or angle structure was captured as normal for native structure, related it will along these lines during a local outline with a just reasonable level of constancy to local mathematical and estimation changes: interpretations or pivots make almost no differentiation on the off chance that they're a great deal of more modest than the local spatial or direction container size. For human identification, a fairly coarse reflection testing, direction inspecting, and robust local approximation stabilisation appear as the optimal methodology, possibly due to its grants appendages and organisation of the constructed sections to fluctuate look and transfer from feature to aspect for serious ton in particular on the off chance that they keep up a generally upstanding direction.

3.4 Face encoding
The training technique was demonstrated with 3 similar faces simultaneously:
1. Known persons facial image was loaded and created as a training set
2. Upload the similar image to the training set
3. Upload an image of a very different man or woman
Calculation was made with a glimpse of the training set and test set at the estimations it's far by and by delivering for all of these 3 input faces. Algorithm itself capable of changing its neural structure to makes positive decisions from the image #1 and #2 which are scarcely closer while ensuring the estimations for #2 and #3 were scarcely correspondingly disconnected.

At this stage, dataset was created with multiple images, the neural structure data finds out how to reliably create 128 estimations of dataset for every individual images collected. Among the dataset, ten diverse images were chosen for training a similar image with various facial expressions. Fig. 10 shows the working of a solitary trio preparing strategy.

Control administrators trained the system with 128 feature sets of each face and embedding. Reducing confounded crude measurements similar to the image keen on a posting into the computer system created numbers comes up a great deal with machine learning. The precise strategy implemented for faces recognition was developed in 2015 by Google, however numerous comparative systems were also exist.

3.5 Convolutional neural network
CNN's works with the three layers namely convolutional, pooling, and completely related layers. These layers when framed perfectly leads to good CNN design.

I. Info Layer: The quantity of neurons present in this layer is equivalent to the overall amount of highlights in the present system developed (a wide assortment of pixels on account of a photo).

II. Hidden Layer: Result obtained from the Input layer was fed into the specific tunnel. Individual shrouded layers can have unmistakable numbers of neurons which may be normally more prominent than the capacity of facilities. All the layers output was figured with the guide of lattice augmentation of first layer yield with learnable loads of that layer and afterward by utilizing the expansion of learnable predispositions noticed through actuation work which makes the organization nonlinear.

III. Output Layer: Output from the previous layer is then taken directly into a calculated element like sigmoid which changes on output of individual class to the likelihood measure.

Further, information was taken care by the model and output from individual layers was gained this progression is known as feed forward, we at that point figure the slip-up the utilization of a blunder trademark, some typical mix-
ups highlights are going entropy, rectangular misfortune mistake, and so on. From that point onward, the results were back-propagated to the model using ascertaining the subordinates.

**A single ‘triplet’ training step:**

- Picture of GD
- Test Picture of GA
- Another Picture of GA
- 128 measurements Generated by neural net
- 128 measurements Generated by neural net
- 128 measurements Generated by neural net
- Compare Results
- Tweak neural net slightly, so that the measurements for the two GA pictures are closer and the GD measurements are further away

Fig.10. A single triplet training method

**Fig.11. CNN Hidden Layers**
As appeared in Fig.11, Convolution Neural Networks were the neural organizations that form exact boundaries. Envision you have an image. It was similar to a cuboid with fixed length, width (image size), and image features (as photographs regularly have red, green, and blue channels).

![Fig.12. Image Dimensions](image)

CNN concepts were implemented on the image taken as training set, with state, k output, and was treated vertically. This study implements the neural networks with various dimensional and multi-feature images, thus, the result achieves another multi-feature photo. Apart from R, G, and B values, multi-feature data width and stature of images were also considered for calculation. In the event that fix length is equivalent to that of the picture it will be a standard neural network. As a result of this little fix, we have less loads. Fig.12 shows the measurements and RGB boundaries of the picture.

![Fig.13. CNN Patch](image)

Presently we should talk about a lump of math that is included inside the entire convolution measure.

- Layers of this convolutional model comprise of a fixed self-learn channels as appeared in Fig.13. Each channel out has little width and top and an indistinguishable profundity as that of entering amount (three if the enter layer is picture enter).

- For instance, on the off chance that we need to run convolution on a photo with size 34x34x3. The conceivable size of channels might be axax3, where 'a' possibly three, 5, 7, and so on however little when contrasted with photograph measurement.

- In the first phase, each slide of the channel was slide over entire enter amount grade by grade where each progression is known as step (with approximated value of 2 or 3 or 4 multi-dimensional images) further, dab items were processed among provided loads of channels to fix entering amount.

- As the channels were slide, 2-D output was derived for each channel were stacked together accordingly, output value was achieved to a profundity indistinguishable from channel assortments. Selected community images were trained successfully with the help of channel.
3.6 Convolutional layer

These portions were limited in spatial dimensionality, nonetheless, the approximations were widespread with the information. When convolutional layer was begun, present layer convolves with each channel provided through available spatial dimension over passageway to deliver 2D enactment map. Available initiation guides can be approximated, as found in Figure 3. As we float by means of the information, the scalar item is determined for respective cost section. Obtained results makes the network contemplate into pieces that 'Glow' after they witness a specific identification over entry.

Each bit could have a comparing actuation map in the event that you need to be stacked close by the profundity estimation to shape the volume of output from the convolutional layer. The criticalness of the availability through the force is quite often indistinguishable from the profundity to enter. The input image having R64×G64×B3 resolution responsive zone size was set to 6 × 6, through convolutional layer 108 loads were developed and to sum up finally, there were 12, 288 ANN samples created. Convolutional layers likewise can recognizably diminish the unpredictability of the model through the streamlining of its yield. These are advanced by means of 3 hyper-parameters, the force, the step, and putting zero-cushioning. Zero-cushioning is the basic arrangement of cushioning the outskirt of the info and is a successful way to deal with give other than control concerning the dimensionality of the yield volumes. It is essential to catch that through the use of those methods, we can change the spatial dimensionality of the yield of the convolutional layers.

3.7 Pooling layer

The pooling layer's motivation to steadily diminish the dimensionality of the portrayal, and in this way correspondingly decrease the level of edges and the multi-feature model.

This layer influences over the available dimensionality information and its actuation level to the "Extreme" feature. This layer also converts the multi-feature set to 2X2 spatial elements. Further the pixel information was reduced 25% with the actual results stored. These results were created using pooling neurons which are in a situation to complete a huge number of typical tasks alongside L1/L2-standardization, and normal pooling. In any case, this instructional exercise will fundamentally zero in on utilizing max-pooling.

3.8 Creation of ConvNets

A CovNets is a chain of layers, each layer of this ConvNets converts one volume to another through variable capacity.
1. Input Layer: Input image with width-32, stature-32, and profundity 3 was taken as input.
2. Convolution Layer: output of this layer works with processing spot item among all channels and photo fix. If 12 channels used, then the output measurement degree would be 32 x 32 x 12.
3. Activation Function Layer: Component cunning enactment highlight to the output was applied from convolution layer. Some ordinary enactment highlights were RELU: max(0, x), Sigmoid: 1/(1+e^-x), Tanh, Leaky RELU, and so forth. Unaltered data produces yield degree and can have measurement 32 x 32 x 12.
4. Pool Layer: CovNets incorporates this layerfor the principle highlight reduce size of the calculation function and produces exact curve. In other way, when 2 x 2 channels were taken with step 2, the resultant degree leads to 16x16x12 output as appeared in Fig.14.

Fig. 14. Image slice matrix
During real-time implementation, this study has the provision to accept various input face features. Moreover, the existing OpenFace methods were implemented with this current dataset. Methods implemented by authors Brandon Amos et al were also compared with this 128 valuations for each face as appeared in Fig. 15. Here are the estimations for our check photo:

![Image of input image and measurements]

**Fig. 15. Measurements generated from the input image**

Important care was taken when considering similar facial feature values by comparing with the 128 training set created.

**4. Results and Discussion**

As shown in the Fig. 16, a door was created with all the specification mentioned.
When a person comes in front of the door the camera starts to capture a series of images and process it and compare it with the images in the database as shown in Fig. 17.

![Face Detection](image17.png)

*Fig. 17 Face Detection*

For facial recognition, we use CNN (Convolutional Neural Networks) algorithm, so that the accuracy will be high.

![Face Recognition](image18.png)

*Fig. 18. Face Recognition*

After recognition, if the image captured recognizes the images in the database the door unlocks. Otherwise, the authority will be alerted regarding this activity. Fig. 18 shows the screenshot of a simple warning message.
Fig. 19. Door Unlocks

As shown in the Fig.19, Afterimage is recognized if the image captures do not match the images in the database the authority will be alerted regarding this activity.

Fig.20. User Alert through Email

For sending this ready we are utilizing the GSM module. In the event that the individual attempting to get to the entryway is a known individual the authority would remote be able to get to the entryway and make it to open. Else if the individual is an obscure individual the alarm will be sent like "Nobody is at home". On the off chance that the obscure individual plays out any abnormal movement the alarm will be shipped off the authority as appeared in Fig.20.

5 Conclusion and future enhancement

In this proposed machine entryway get admission to the machine by utilizing the utilization of face acknowledgment and close by the SMS ready machine has been introduced. This gadget has been utilized with home entryway locks to gain admission to power dependent on the face notoriety approach through confirming enlisted facial pictures. Concern people could be educated effectively around the character recognition by means of SMS ready ages along the edge of subtleties joined. Face notoriety is one of the few procedures for spotting individuals. A few methods can be utilized for that reason. One of the most not abnormal is the utilization of PCA or Eigen faces. The Haar Cascades calculation is one of these calculations. As we show Haar Cascades has awesome execution and perhaps exceptionally exact.

Our model will have a few issues during the message transmission on account of sign problem in certain circumstances and places. In that case, our future work will resemble in the event of any unlawful exercises promptly record might be despatched to crisis numbers that work with no sign or even without sim cards. An ongoing talking right hand might be conveyed to make the gadget more client well-disposed and effective. Exceptionally secure conventions which incorporate Transport Layer Security might be conveyed to ensure there is no security break.

References

[1] Rahman, M.T.; Kehtarnavaz, N. Real-time face-priority autofocus for digital and cell-phone cameras. IEEE Trans. Consum. Electron. 2008, 54, 1506–1513.
[2] Zuo, F.; With, P. Real-time embedded face recognition for smart home. IEEE Trans. Consum. Electron. 2005, 51, 183–190.
[3] Zeng, C. Robust Head-Shoulder Detection by PCA-Based Multilevel HOG-LBP Detector for People Counting. In Proceedings of the IEEE International Conference on Pattern Recognition, Beijing, China, 23–26 August 2010, pp. 2069–2072.

[4] Yang, M.H.; David, J.K.; Ahuja, N. Detecting faces in image: A survey. IEEE Trans. Pattern Anal. Mach. Intell. 2002, 24, 34–58.

[5] Yang, G.; Huang, T.S. Human face detection in complex background. Pattern Recognit. 1994, 27, 53–63.

[6] Yow, K.C.; Cipolla, R. Feature-based human face detection. Image Vis. Comput. 1997, 15, 713–735.

[7] Mckenna, S.; Gong, S.; Raja, Y. Modeling facial color and identity with Gaussian mixtures. Pattern Recognit. 1998, 31, 1883–1892.

[8] Hsu, R.L.; Abdel-Mottaleb, M.; Jain, A.K. Face detection in color images. IEEE Trans. Pattern Anal. Mach. Intell. 2002, 24, 696–706.

[9] Lanitis, A.; Yaylor, C.J.; Cootes, T.F. An automatic face identification system using flexible appearance models. Image Vis. Comput. 1995, 13, 393–401.

[10] Jie-Ci Yang et. all An Intelligent Automated Door Control System Based on a Smart Camera

[11] Suma. M.O, Rashmi. H.N, Srinidhi B Seshadri – “ Standalone Face recognition system using component principle analysis “

[12] Pankaj R. Bhusari, Vrushali G. Raut – “ Real Time Face detection and Recognition System “

[13] Edward Iglesias and Arianna Schlegel – “Using Raspberry pi as a versatile and inexpensive display”

[14] Li Cuimei, Qi Zhiliang. “Human face detection algorithm via Haar cascade classifier with three additional classifiers”, 13th IEEE International Conference on Electronic Measurement & Instruments, pp. 01-03, 2017.

[15] Kushsairy Kadir, Mohd Khairi Kamaruddin. Haidawati Nasir, Sairul I Safie, Zulkifli Abdul Kadir Bakti.” A comparative study between LBP and Haar-like features for Face Detection using OpenCV”, 4th International Conference on Engineering Technology and Technopreneuship (ICE2T), 2014.

[16] Senthamizh Selvi. R , D. Sivakumar, Sandhya. J.S , Siva Sowmiya. S, Ramya. S , Kanaga Suba Raja. S Face Recognition Using Haar - Cascade Classifier for Criminal Identification

[17] Keiron O’Shea and Ryan Nash An Introduction to Convolutional Neural Networks

[18] M Vamsi Krishna, A Bhargav Reddy, V Sandeep Facial recognition enabled smart door to unlock system

[19] Ahmed Abdul Qader Al-Bakeri, Abdullah Ahmad Basuhaill Notification System Based on Face Detection and Recognition