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Home Automation Security System Based on Face Detection and Recognition Using IoT

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Abstract. In the modern world security is one of the major issues. As technology is getting advanced many security issues are arising. The existed developed security methods have some flaws and they can be hacked. The proposed system for resolving the security issue is based on face detection and recognition using Internet of Things (IoT). The face of a person is captured by the camera and compared with the acquired database. The authorized user can also utilize mobile application to give access to the premises to any unregistered person. In the case of unauthorized/unknown access, the face image of the person will be captured and notified to the concerned authorities through an email. An Alarm will be generated in the case of unauthorized access. The proposed system produced accurate results in both cases: authorized and unauthorized access. The introduced system provides a low-cost solution for monitoring and controlling the houses, different organizations like banks, universities, etc.

Keywords: Biometrics · Face detection and recognition · Digital image processing · Raspberry pi · IoT

1 Introduction

Face recognition is important not only because it allows us to use our face as a key but also because systems like face identification can read our expressions in real time. As IoT grows, different devices are being developed and face recognition is emerging rapidly. Now-a-days, security is the major issue for every person. People get harassed in their house and old security methods have failed to provide a high level of security. Different electronic devices, such as mobile phones, laptop and ATM, used some type of biometric authentication or passcode but these can be easily accessed by thieves by any means which is not safe.

According to United Nations Office on drugs and crime statistics [1], 5723500 theft cases were reported in the year 2015 in United States of America. However, in Pakistan 38902 cases were reported. The Statistics are given in the Table 1.

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Table 1. United Nations statistics on drugs and crime

	Theft case reports at national level							
	2012		2013		2014		2015	
Pakistan	Count	Rate	Count	Rate	Count	Rate	Count	Rate
	49,148	27.62	45,494	25.04	42,747	23.04	38,902	20.54
United States of America	6,168,874	1968.78	6,019,500	1907.70	5,809,100	1828.38	5,723,500	1788.99
Robbery case reports at national level								
	2014		2015		2016		2017	
	Count	Rate	Count	Rate	Count	Rate	Count	Rate
Pakistan	18,107	0.18	15,164	0.15	13,088	0.13	12,458	0.12
United States of America	322,900	3.23	328,100	3.28	332,800	3.33	319,400	3.19

So, to solve these cases face recognition will help as face is unique identity of every person. Facial recognition combined with IoT will be much more secure than any other biometric systems.

The term "Internet of Things" consists of two sections i.e. first section is "Internet" and the second section is "Things". IoT is referring to the idea of things, especially everyday objects, that are readable, recognizable, capable of being addressed through different sensors and can be controlled via the internet [2]. IoT has totally transformed the technology, as it has capability of connecting multiple devices together on one platform which can be accessed and modified according to our needs.

The proposed home automation security system, utilized face detection and recognition features. The prototype system consists of a raspberry Pi module with attached camera, programmable stepper motor, relay circuit and an internet link. At first, we will install Linux based operating system in raspberry pi and stepper motor will be mounted on the door so that it can be automatically unlocked. The captured face by camera is compared with the database and if the person is recognized the door will be unlocked otherwise the system will send an email to the concerned person. The unregistered person access can be granted by using the mobile application by the owner. Similarly, if light is too low then door can be unlocked by using application via the internet.

2 Literature Review

The authors [3, 14], have proposed the face detection framework using Principal Component Analysis (PCA). The system is fast and efficient, but algorithm was run on MATLAB which uses very high memory and processing power. So, it is costly and also having low processing speed. We use Linus Base Operating System that is more efficient. Senthilkumar et al. [4], implemented the embedded images taking system via raspberry-pi. In this work, they took the picture and contrasted it with database, but have the problem of inefficiency the low light state. We Compared the Particular picture with 500 Database and results are 95% accurate. Sowmiya et al. [5], proposed the system of based on IoT. In this framework, they used PIR (passive infrared) sensor and camera. PIR sensor was exploited for identifying individual and camera utilized for

capturing the video of the individual who comes at the entrance. But their proposed model did not give the ability of sending messages to the concerned persons. We will develop a system that will not only send message via Email but also send message on Number. Karri and Daniel [6, 7] proposed SMS based system using GSM, which send notifications via SMS to the house owner replacing conventional SMS. Jayashri and Arvind effectively implemented finger authentication for unlocking of doors. This system prevents unauthorized person and this can be monitored. This system includes extra protection features like leakage of smoke and gas detection. Fingerprint scanning may be costly and costly to some extend. Some experts think it's not a wise decision to rely only on fingerprint seniors because it's easy to replicate them, this can be overcome by addition of PIN password, voice detection or any other technique.

Dwiet et al. [8], have proposed the system of face recognition which used MyRIO 1900 controller. The controller has the program for detection of face. Personal computer is used to display the output and LabVIEW is used for programming. But the problem is that the MyRIO module is very costly. We used Raspberry Pi which is very cheap nd easy to use. Kodali et al. [9], have proposed a system of home security by using TI-CC3200 Launchpad board which uses Wi-Fi and internet to control and manage home appliances. But the limitation is that TI-CC3200 Launchpad board has limited memory, processing power and features than that of raspberry-pi. The earlier face recognition systems used nose, mouths and eyes for identification. These systems used classifier based on use of faces and datasets. These methods were not producing good results due to its low quality and low amount of information [10]. Ramanan et al. [11], proposed a system based on Algorithm of support vector machine (SVM). The algorithm for face scanning and detection upon functioning of static face image or color image. For color image, the colors of image increase in size of data available while mapping on pixels which efficiently reduce processing speed.

Dalal et al. [9], developed a system that was based on linear discrimination analysis (LDA). LDA is used to form an idea of an amount of significance of facial attributes. The datasets divided into different classes each of them has images of the same person, but in different ways, like different frontal faces and facial expressions. It assumed all images have one facial region that is of equal size. But this technique was the old one and makes the processing too slow. The earliest face recognition systems used nose, mouths and eyes for identification. These systems used classifier based on use of faces and data sets. This method was not producing good results due to its low quality and low amount of information. Moghaddam and Poggio [12] addressed the high dimensionality problem by using PCA to linearly take out significant modes of the face. They proposed statistical density model that was based on Eigen faces. But this system did not model for non-face patterns. Kartik et al. [13], developed two systems, One based on GSM and other on camera for scanning or detection. Which is controlled by PC with the help of Internet. It gives sound alarm when the intruder comes in front of the house. Second system based on GSM sends an SMS to the owner, but using this system the owner can monitor only, but can't control his door when he is away from his house. We intend to design an automated door lock system based upon IoT that uses face recognition for its operation. The use of IoT in our home automation system is in line with advancements in modern security technologies which shall dominate all aspects of postmodern life. The microcontroller is used for a robust design that will introduce simplicity and flexibility in the system.

3 Proposed System Architecture

The proposed system for real-time face detection and face recognition is shown in Fig. 1. It can be categorized into five sections: Face Detection, Creation of a dataset of the individuals, Training the classifier, Recognition of the face in the stored dataset and the IoT. The complete working flow of the proposed system is shown in Fig. 2.

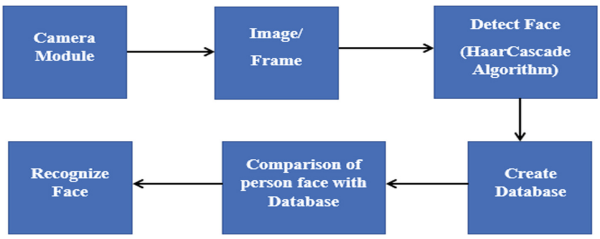

Fig. 1. Block diagram of the proposed system (Color figure online)

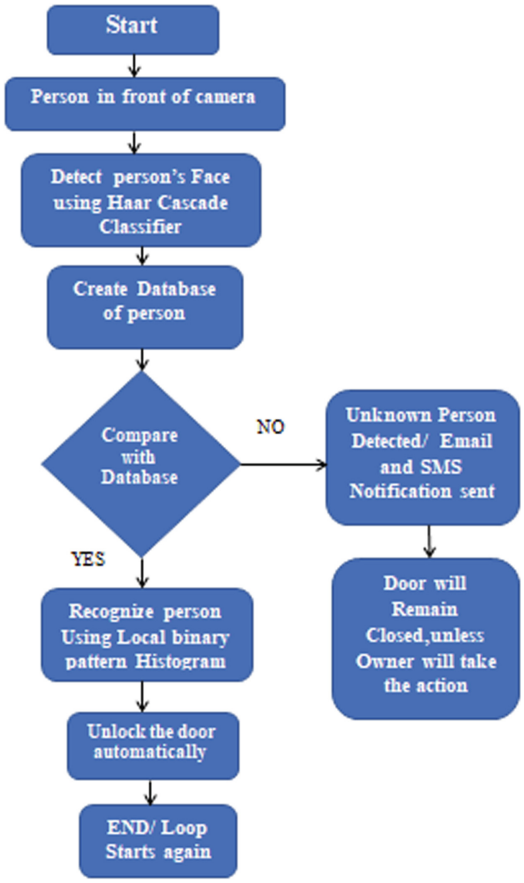

Fig. 2. Flowchart for the proposed system. (Color figure online)

3.1 Face Detection

In this section, we will first test the camera. A person comes in front of the camera. The camera will capture the particular person's frontal face. Then the person's face is detected by using the algorithm. The algorithm we use is Haar Cascade [15, 16]. This classifier is used to detect the objects for which it has been trained before. It is an effective object detection method. A cascade is instructed from a group of positive and negative images. It is needed to take out the features from it. This algorithm covers four stages: Haar feature, creation of integral images, adaboost training and Cascading classifier. First step is to gather Haar feature. Haar features include edge feature, line feature and rectangle feature. It examines adjoin rectangular fields, ranges at special placing in discovering window, sums pixel intensity in each division and calculate the difference. Integral images are the sum of all pixel values present before the current pixel at any location. Adaboost selects the best features among 160000 features and trains them. It provides a huge number of potential features. Cascade classifier is collection of stages in which each stage groups of weak learners. Weak learners are the decision stumps. Each stage is trained by boosting technique which trains highly accurate classifier by taking a weighted average of decision. During the detection distinct period, a window will go in a specific direction over input image and Haar features are calculated. The threshold separates non objects from the objects. To achieve detection's accuracy, we have set number of stages, feature types and other function parameters. The features extracted for face detection are: Gray scale, scale factor, neighborhood connectivity, and size of image, eyes detection and face detection. Gray image is obtained by conversion of the RGB image to Gray image. This scale factor specifies the smoothness and identifies how much image's size lessen at every image scale. The neighborhood connectivity identifies how many neighbors should be shown in the particular person's image. In our project, the neighbor is zero. The size of the image is identified. It defines the size of the rectangle around the picture. The dimension of the rectangle is 640*480. The eyes detection feature is added for more accuracy in the proposed system. Then, the frontal face of the particular person is detected with dimensions. The image is shown is a rectangle which is of 640 * 480's dimension. The images are marked as a blue rectangle.

3.2 Creation of Datasets of the Individuals

In this section, we will create database of each person, each person's id and number of images in grayscale that is used for face detection. The images of the particular person are gathered to create a dataset and store the images in XML file. We have used 1000 samples for each person's id using 1000 samples gives more accuracy about the person's image.

Training Datasets: The generated dataset of the authorized persons is stored in YML file. The Local Binary Pattern Histogram (LBPH) technique is used for training purpose of the images.

The LBPH is used to label the pixels of the images.

The LBPH package provides the following metrics to compare the histograms:

Chi-Square: This equation is used to describe the expression of the person. In our project, it is used to judge the person of the particular person whose database is saved in the XML File.

$$D = \sum_{i=1}^{n} \left(\frac{h_i st_1 i - h_i st^2 i}{h_i st^1 i} \right)^2 \tag{1}$$

D = chi square obtained
$\sum$ = the sum of
hist1 = observed score
hist2 = expected score.

Euclidean Distance: This equation is used to measure the distance between two straight lines. It is used to measure the Dimension of the picture that have stored in dataset.

$$D = \sqrt{\sum_{i=1}^{n} (hist1i - hist2i)^2} \tag{2}$$

Where:
D = chi square obtained
$\sum$ = the sum of
(hist1, hist2) are two vectors.

Normalized Euclidean Distance: The Euclidean distance between points hist1 and hist2 is the length of the line segment connecting them (hist1, hist2). The position of a point in a Euclidean *n*-space is a Euclidean vector. This formula scaled the length of the image and make a square box around the picture.

$$D = \sqrt{\sum_{i=1}^{n} \left(\frac{hist1i - hist2i}{n} \right)^2} \tag{3}$$

Absolute Value: When the picture is captured through camera it is then trained a number of positive and negative images through the Haar Cascade Classifier. It is used to convert the gray scale images into the colored images.

$$D = \sum_{i=1}^{n} |hist1i - hist2i| \tag{4}$$

3.3 Recognition of Face Through Stored Database

If the particular person's database is created before. Then the recognizer predicts the person's face and it also shows the confidence about the images in terms of percentage.

In our system, the accuracy s about 85–90% of images. If an unknown person comes in front of the camera then it will predict as unknown person.

3.4 IoT Platform

For IoT, we have used Ubidots platform [17]. To make our homes more secure and smart, we have used IoT. When an unauthorized person tried to enter into the home. The picture of unauthorized person will be sent to the owner via email. If owner is far away from his house, he can control and monitor his home's door via internet. If the owner wants to give permission to unauthorized person to enter into the home. He can simply give access and door will be opened.

4 Results and Discussion

The real-time testing of the proposed system is performed using a prototype hardware which consists of webcam for acquisition of an image, servo motor for door locking/unlocking, raspberry-pi 3B+ microcontroller board for controlling functionality. It is a Linux based operating system. We can also use windows and other operating systems but Linux is open source and easily available. The step-wise visual illustration of the proposed method is shown in Fig. 3. The raspberry-pi microcontroller board is shown in Fig. 4. The IoT involvement is for remote monitoring and controlling the premises access.

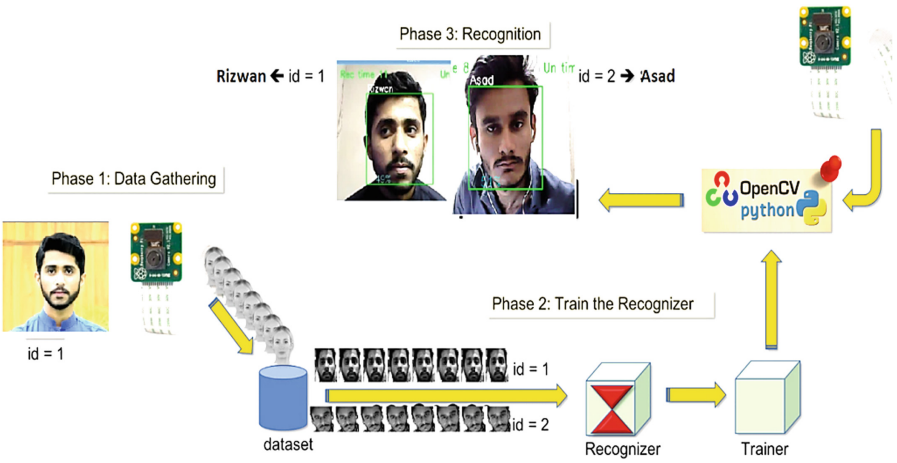

Fig. 3. Steps of proposed face detection and recognition

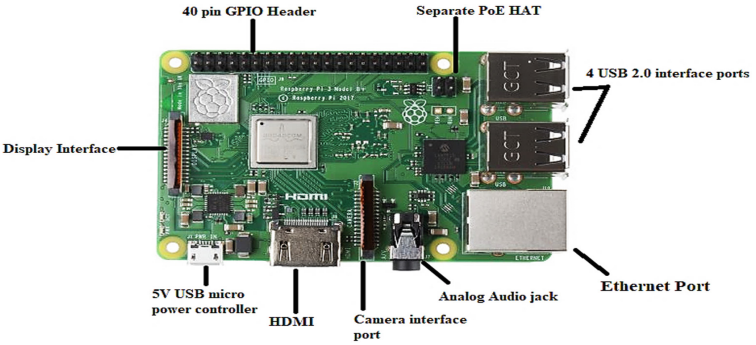

Fig. 4. Raspberry pi

Figure 5, shows the detection of face when a person comes in the front of camera. Figure 6, shows the dataset created. Figure 7, shows the detection and identification of a person through the proposed system. Figure 8, shows the denied access of the unregistered/unauthorized person. Figure 9, shows the image notification via email, in the case of illegal access. Figures 10, 11 and 12, shows the IoT platform used in this project to control and monitoring of home. Figure 13 shows that the owner will receive the SMS also in his mobile phone. User can open and close the door through the internet or via its mobile application remotely.

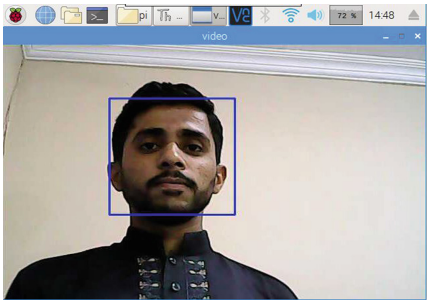

Fig. 5. Face detection

Fig. 6. Facial datasets

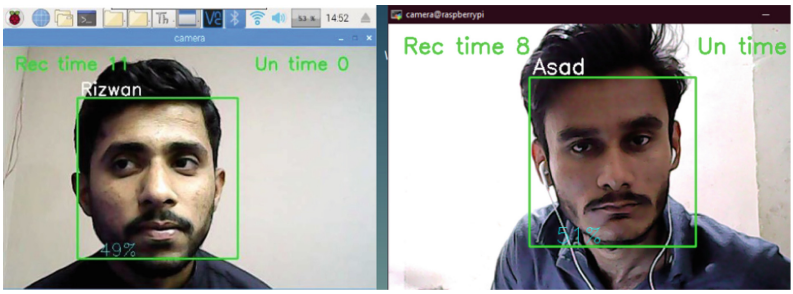

Fig. 7. Face recognition

Fig. 8. Unknown person

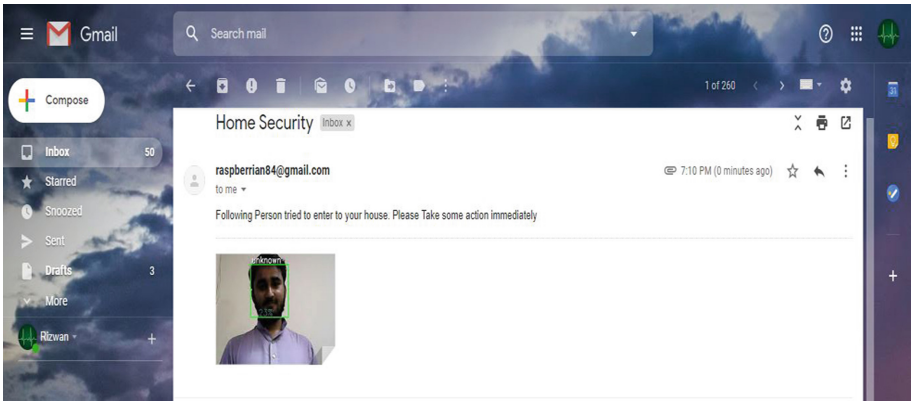

Fig. 9. Email notification received

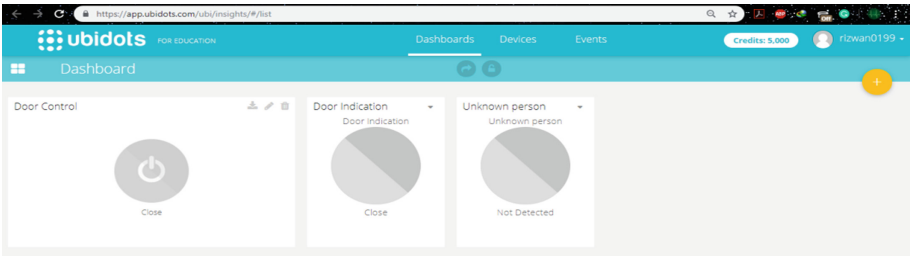

Fig. 10. IOT platform

Fig. 11. Door opened using mobile app

Fig. 12. Door closed via mobile app

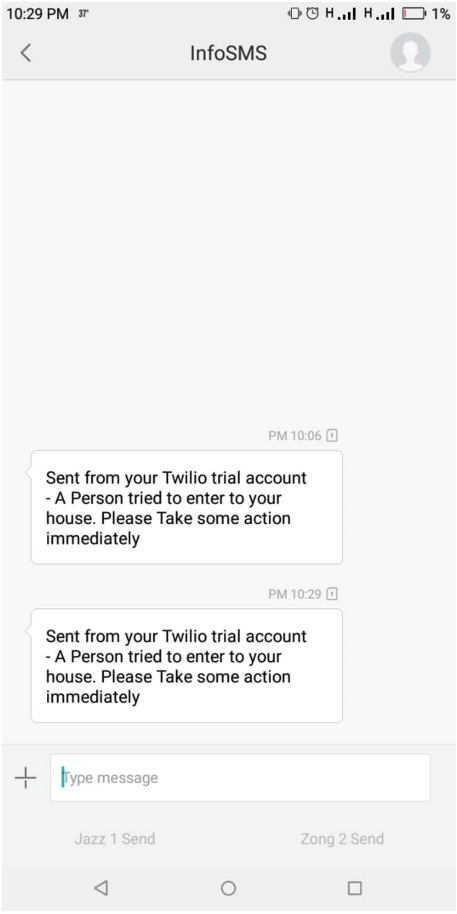

Fig. 13. SMS notification to user

5 Conclusion and Future Work

The proposed automated security scheme is low-cost and low power. The utilization of IoT in the proposed system makes it efficient and enabled for real-time applications. The accuracy is about 95% in our proposed system. System is based on WAN that the owner can monitor and control his house by sitting from far away his house. The utilizing of IoT in this system, provides remotely control and monitoring. The arrangement can be altered easily without interrupting the supplementary elements in the scheme. This system can be used in both online and offline modes.

In future, the IoT based security system can be deployed in the banking system, retailers, private companies and in debit cards in order to avoid frauds. Further, this system can be integrated and synchronized with the local police station's database, for detection and monitoring of the peoples having a criminal record.

References

1. United Nations Office on Drugs and Crime (2017). https://dataunodc.un.org/crime/
2. Patel, K.K., Patel, S.M.: Internet of Things-IOT: definition, characteristics, architecture, enabling technologies, application & future challenges. Int. J. Eng. Sci. Comput. **6**(5), 1–2 (2016)
3. Chin, H.: Face recognition based automated student attendance system. Diss. UTAR (2018)
4. Senthilkumar, G., Gopalakrishnan, K., Kumar, V.S.: Embedded image capturing system using raspberry pi system. Int. J. Emerg. Trends Technol. Comput. Sci. **3**(2), 213–215 (2014)
5. Sowmiya, U., Mansoor, J.S.: Raspberry pi based home door security through 3G dongle. Int. J. Eng. Res. Gener. Sci. **3**, 138–144 (2015)
6. Karri, V., Lim, J.D.: Method and device to communicate via SMS after a security intrusion. In: 1st International Conference on Sensing Technology, vol. 1, pp. 664–668 (2005)
7. Bangali, J., Shaligram, A.: Design and implementation of security systems for smart home based on GSM technology. Int. J. Smart Home **7**(6), 201–208 (2013)
8. Wati, D.A., Abadianto, D.: Design of face detection and recognition system for smart home security application. In: 2017 2nd International conferences on Information Technology, Information Systems and Electrical Engineering (ICITISEE), pp. 342–347. IEEE (2017)
9. Dalal, N., Triggs, B.: Histograms of oriented gradients for human detection. In: International Conference on Computer Vision & Pattern Recognition (CVPR 2005), pp. 886–893. IEEE Computer Society (2005)
10. Kodali, R.K., Jain, V., Bose, S., Boppana, L.: IoT based smart security and home automation system. In: 2016 International Conference on Computing, Communication and Automation (ICCCA), pp. 1286–1289. IEEE (2016)
11. Ramanan, D., Zhu, X.: Face detection, pose estimation, and landmark localization in the wild. In: Proceedings of the 2012 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 2879–2886 (2012)
12. Moghaddam, B., Pentland, A.P.: Face recognition using view-based and modular eigenspaces. In: Automatic Systems for the Identification and Inspection of Humans, vol. 2277, pp. 12–22 (1994)
13. Kartik, J.S., Kumar, K.R., Srimadhavan, V.S.: Security system with face recognition, SMS alert and embedded network video monitoring terminal. Int. J. Secur. Priv. Trust Manag. (IJSPTM) **2**, 15–17 (2013)
14. Lwin, H.H., Khaing, A.S., Tun, H.M.: Automatic door access system using face recognition. Int. J. Sci. Technol. Res. **4**(6), 210–221 (2016)
15. WILL BERGER (2018). http://www.willberger.org/cascade-haar-explained/
16. Open Source Computer Vision. https://docs.opencv.org/3.2.0/d7/d8b/tutorial_py_face_detection.html
17. Ubidots (2019). http://www.ubidots.com/education/