Engineering and Technology Journal e-ISSN: 2456-3358
Volume 08 Issue 02 February-2023, Page No.-1981-1985
DOI: 10.47191/etj/v8i2.03, I.F. – 7.136

Face Recognition System for Automatic Door Access Control

Oghogho Ikponmwosa[1], Otuagoma S.[2], Ufuoma Jeffrey Okieke[3], Ebimene E. E.[4], Dania B. P.[5], Azubogu D. I.[6], Anamonye U.G.[7], Oyubu A. O.[8], Okpare A.O.[9], Eyenubo O.J.[10], Efenedo G. I.[11], Okpeki K. U[12]
[1,2,3,4,5,6,7,8,9,10,11,12]Electrical/Electronic Engineering Department, Delta State University, Oleh Campus, Abraka, State, Delta State. Nigeria.

ABSTRACT: A face recognition system for automatic door access control has been developed in this work with a view to providing a relatively more robust and foolproof access control which can provide better security and reduce human errors inherent in other conventional methods.
The system was designed with machine learning and artificial intelligence to capture faces, train faces with machine mode, and run trained faces to grant access to the user. The system uses the RaspberryPi module, camera module, servo motor and the GSM module which were all incorporated into the fabricated building to make up the prototype developed to provide access control by means of facial biometrics. In order to grant access to registered users, various photos of the users were taken in different positions and expressions with proper illumination. The user's face is been captured by the camera module and saved in the database with the help of Raspberry Pi Module. Good lighting condition and other favorable conditions helps the camera module to recognize faces and sends signal to the Raspberry Pi which processes these images and opens the door with the help of the servo motor.
The developed prototype was used to train fifty (50) users. It granted access to all fifty (50) users when there was proper illumination and pose but five (5) and nine (9) users respectively were denied access due to challenges of poor illumination and pose variation.

1.0 INTRODUCTION

Top priority is being given to issues of security today in around the world (Manjunatha and Nagaraja 2017). Security risks is on the increase as the due to the ever increasing need to do things smartly. The need therefore arises to make issues of privacy and security a more general concern during the design phase to limit moderate risks (Bashir et al. 2021). Monitoring access into a building is a vital issue as it helps to keep lives and properties safe robbery of theft. Traditional building access security systems are expensive and can easily be broken hence there is need for more advanced security systems which provide more enhanced features.
Nowadays, manual or traditional methods of doing things are evolving to smart access control. Therefore, there is the need to change our traditional methods of accessing buildings to modernized methods of smart access. Security will be enhanced and existing draw backs of unauthorized access will be limited. In access control, three main features are necessary: identification, authentication, and authorization. Traditional access methods use keys, passwords, pattern drawings, cards, or identification (ID) (Bashir et al. 2021). Advances in science and technology and the consequent emergence of fields such as machine learning and artificial intelligence have led to the development of even more robust access control measures which use face recognition.
Face recognition systems have three major phases namely: detection of the face, extraction of the feature and identification of the face (classification).
Lwin et al. (2015), noted that face recognition systems have evolved to be one of the high end access control measures and offers a contactless means of verifying and identifying a user so as to allow or deny access. Nag et al. (2018), noted that human faces have distinctive facial characteristics and a face recognition system essentially compares a captured face with a face stored in the database to identify the person. Face recognition systems according to Nag et al. (2018), is one of the fastest growing fields and the need for face recognition system arises from increased commercial interest in areas such as bioscience, surveillance, human computer interaction, criminal investigation , law enforcement and access control.
Face recognition based systems have some challenges associated with their operations which include: i. Pose variation (as the people are not always directly in front of the camera) ii. Occlusion (as some parts of the face cannot be found) iii. Expression (humans have different facial expressions like happiness, unhappiness, anger, horror, surprise etc.) iv. Aging (facial changes occur as we get older) v. Transformations (Same face is presented to the system at various scales by varying the focal distance between the camera and the face. Also the orientation of the

head may vary due to rotations and translations) and vi. Illumination (face images are taken under different illumination conditions). Advances in information technology over the years have led to the development of specialized hardware and software to facilitate face recognition despite these challenges.

Nag et al. (2018), stated that glasses and beards, capture angle and a myriad of other complexities make effective detection and identification of face relatively more difficult, hence computer vision application such as OpenCV is a common leverage to develop functional face recognition and identification systems.

Although face recognition systems generally require high end hardware and computer, the development of relative powerful processors and internet of things (IoT) modules such as the Raspberry pi has afforded researchers, hobbyist and industry experts to develop face recognition based access control system at a much cheaper cost.

Face recognition access control system is becoming increasing popular in residential homes and commercial facilities due to its robust and relatively secure nature. This study developed a face recognition system which will capture the face of a user and perform facial detection and recognition, send a short message text to a designated phone number on the status of the person trying to gain access and either grant access or deny access to the user based on the status of the user stored in the database.

2.0 REVIEW OF PAST WORK

Several work exists which provide some form of enhanced security access to buildings. Different ways of sensing such as heat, motion and light sensors fingerprint and face recognition systems, etc. are being used to provide enhanced security to building.

Vaidya et al. (2017), developed a smart home automation system with unique door monitoring system features for old people using python, Open computer vision (Open CV), android and Raspberry pi. The researchers noted that leveraging on the processing power of the raspberry pi module, a cost effective face recognition based automation system was developed to control target electrical appliances.

Challa et al. (2017), worked on an intelligent door access control and home security system using face recognition. The developed system essentially consist of a raspberry pi module, universal serial bus (USB) camera, passive infrared (PIR) motion sensor, buzzer, an electromagnetic door lock and a few other electronic components. The system was programmed to capture the face of a visitor at designated location, send it via email, extract and scan the captured image to identify the user before either opening the door via the electromagnetic switch or sounding a buzzer to alert the operator on the presence of an unauthorized person.

Wen et al. (2022), developed a face recognition and access control system with the Esp32 development. The system was designed to use an ESP-EYE to collect and store images, and then sends them to the computer through the data bus. By comparing the collected and stored image information, the control of peripheral circuit can be realized. The experimental results show that the design cost of the system is low, the operation is convenient, the safety is strong, and has a strong practicability.

Namrata et al. (2018), developed an ESP32 CAM Face Detection Door Lock system. The developed system essentially has features for enrolling the face of users after which the face can be scanned via an integrated camera to detect and give authorisation to user by either opening or closing a door via a solenoid lock. Jogdand and Karanjkar (2015), implemented an automated door access control system with face design and recognition using the principal component analysis (PCA). The system was built by a combination of the Pic16f887 microcontroller module interfaced with MATLAB suite via an RS232 connection.

3.0 MATERIALS AND METHODS

The developed face recognition access control system (which provides access control by means of facial biometrics) included a prototype house with a door controlled by a servo motor, a suitable camera, power unit, and the entire system was built on the Raspberry Pi 4 single board computer. The system also has an integrated GSM module to enable remote override of the door control by the admin. The software required for developing this system are: Python-vscode (python-Visual studio code), Open CV library, Putty and VNC server.

The python-vscode is an integrated development environment (IDE) that was used to write, edit, run and the codes that were used to carry out the task of capturing, training and recognition of users.

The Open CV library is an open source computer vision and machine learning software library which was used for image processing and video processing. This software was used to build a set of codes to carry out the process of capturing, training and processing of images. The Putty is software that is a free implementation of SSH (secure shell) for PCs running Microsoft windows and it also includes a terminal emulator. It acts as an interface between two PCs (personal computer) which are the RaspberryPi and the network servers. The VNC (virtual network computing) server is a type of remote software that makes it possible to control another computer over a network. It was used simultaneously with the PuTTY to control the output and input data in the RaspberryPi.

The operation logic of the face recognition access control system is shown in Figure 1. The system is used to train and enrol faces in the dataset. When there is need for authorization, the system detects a new face and compares this face with enrolled faces in the dataset. If the face detected matches any of the enrolled faces, access is granted

as the door automatically unlocks. On the other hand, if the face is not recognised, access is denied as the door remains locked and an sms is sent through the GSM module to the designated phone number thereby registering the threat of illegal access. The onboard computer (raspberryPi Module) receives the signal from the camera module which is been displayed on the screen. If the detected image matches any of the enrolled images, a signal is sent to the door motor drivers (servo motor) to open the door and close after five (5) seconds. The system captures the face of the target user and train machine learning face recognition model based on the captured dataset.

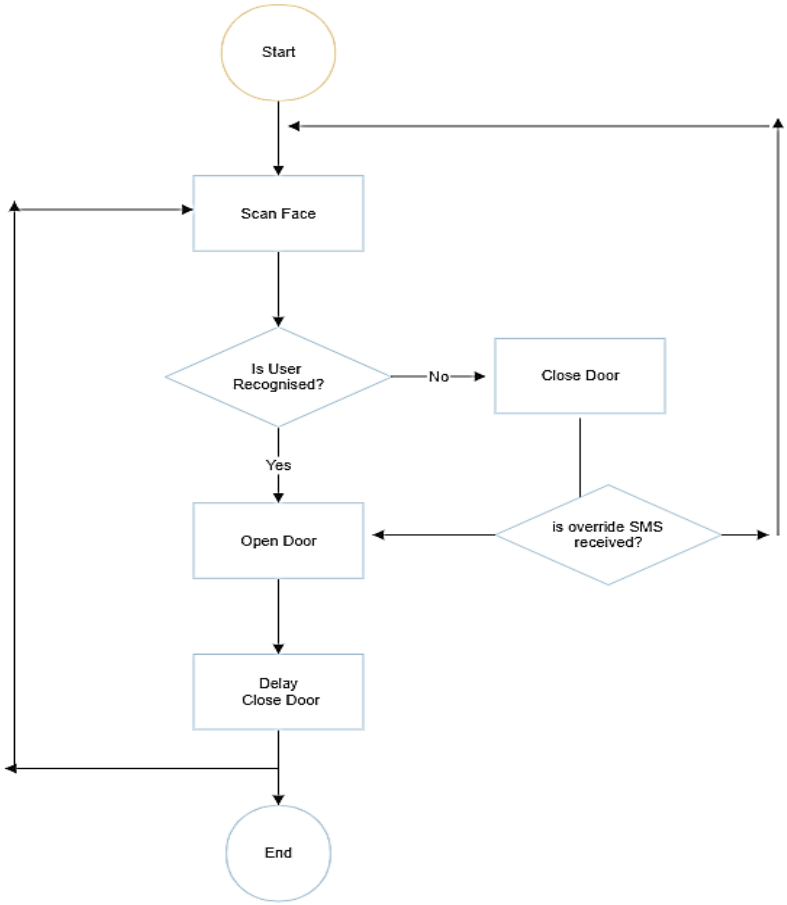

Figure 1. Operation logic of the face recognition access control system

4.1 Tests, Results and Discussion

To test the ability of the developed prototype to capture new users, the capturing script was launched and a new user's facial profile was captured by creating a folder for the new user and starting the script. A minimum of 10 images were captured for each user to form part of the training set. The training data serves as the data against which the Haar Cascade model learns the facial profile of each registered user and provides the background to differentiate registered users from unknown persons trying to access the door. With each user registered and captured, the system training script was for the OpenCV machine learning algorithm to train on the created dataset. Figure 2 shows the training script for the face recognition model. Figure 3 shows the face capture processing by the system. To test the face recognition capability of the developed system, the face recognition and the preregistered users were asked to scan their faces before the camera

The result of the face recognition testing is shown in Table 1. To test the face recognition door access control, a pre-registered user was asked to try and access the system by placing the face in front of the camera and the system's response was observed. This was repeated for fifty (50) different users and the results documented in Table 1. To ascertain the system's accuracy in denying unknown users, fifty unregistered persons were asked to stand before the door camera and the system's response was observed and documented as shown in Table 1.

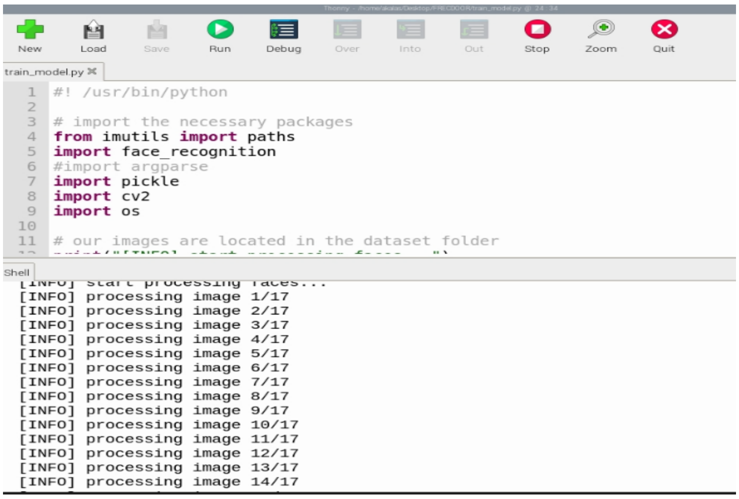

Figure 2. Training script for the face recognition system

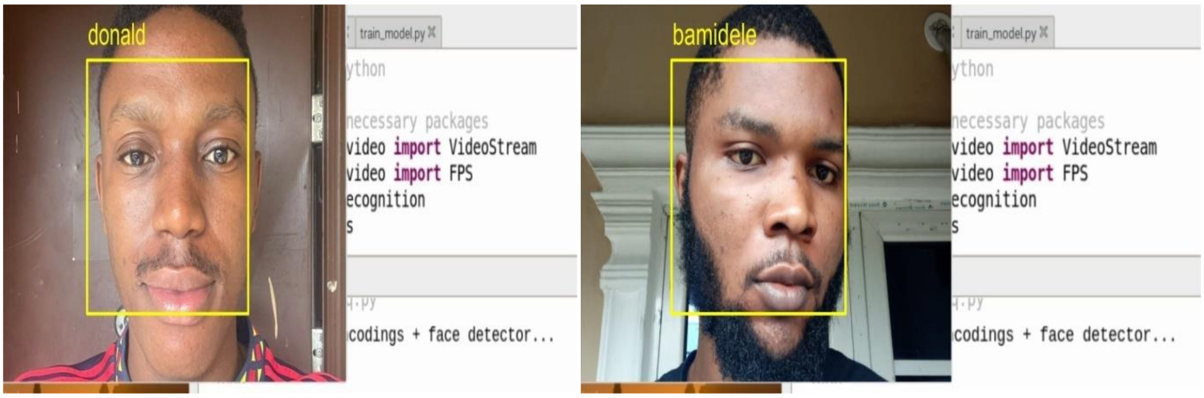

Figure: Face capture processing by the system

Table 1. Test Results

Parameter	Total Number of Registered Users	True Positives (TP)	False Positives (FP)	Total Number of Unregistered Users	True Negatives (TN)	False Negatives (FN)	System Accuracy (%)
Good Lighting Condition	50	50	0	50	50	0	100
Poor Lighting Condition	50	45	5	50	48	2	93
Expression	50	41	9	50	45	5	86
Pose Variation	50	41	9	50	48	2	89

The registered users were duly recognised by the prototype, although some instances of failing to identify a registered user (False Positives) were observed. An average response time of 3 seconds was observed for facial identification. The door remained closed for unauthorised users except for the occurrence of false Negatives.

Given system's accuracy was calculated from equation 1.

$$\text{System Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \quad \ldots 1$$

The efficiency of the system is reduced by poor lighting condition, pose variation and varying facial expression. The pre-programmed admins override SMS feature of the system

was also duly tested and found to be effective in providing access to the user regardless of identification status which is a feature that could be used during emergencies and system failure to allow for an admin override.

5.0 CONCLUSION AND RECOMMENDATION

Face-recognition based door access control systems are robust systems that leverage advancements in computer vision to identify crucial human biometrics and facilitate access control in target buildings or facilities. The developed prototype is built on the raspberry pi single board computer and uses the OpenCV computer vision library to facilitate user access control. The prototype also include an SMS based admin override feature to allow for the admin to override access restrictions in times of emergency or system failure.

The performance of the developed prototype was evaluated and the system was found to be relatively efficient in capturing user facial profile and providing face recognition capabilities for the servo motor based door access control.

The system can be expanded to included a robust interfaces for streaming live camera feed to dedicated admin cloud storage as well as sending email snapshot of unknown users who tried to access the system.

REFERENCES

1. Bashir, A. et al. (2021). Automated door with face recognition: using artificial neural network approach. *IOP Conference Series: Materials Science and Engineering*, 1052(1), p.012060.
2. Challa, K., Boddupally, K. and Lakha, M. (2017). An Intelligent Automate Door Access Control and Home Security System Based on Face Recognition. , pp.437–442. [online]. Available from: www.ijsetr.com.
3. Jogdand, S. and Karanjkar, M. (2015). Implementation Of Automated Door Accessing System With Face Design and Recognition. *International Journal of Science and Research (IJSR)*, 4(10), pp.2157–2158.
   Journal, I. IRJET- IOT BASED DOOR ACCESS CONTROL USING FACE RECOGNITION.
4. Lwin, H.H., Khaing, A.S. and Tun, H.M. (2015). Automatic Door Access System Using Face Recognition. *International Journal of Scientific & Technology Research*, 4(6), pp.294–299.
5. Manjunatha, R. and Nagaraja, R. (2017). Home Security System and Door Access Control Based on Face Recognition. *International Research Journal of Engineering and Technology(IRJET)*, 4(3), pp.437–442. [online]. Available from: https://irjet.net/archives/V4/i3/IRJET-V4I385.pdf.
6. Nag, A., Nikhilendra, J.N. and Kalmath, M. (2018). IOT Based Door Access Control Using Face Recognition. *2018 3rd International Conference for Convergence in Technology, I2CT 2018*, pp.1–3.
7. Namrata, S. et al. (2018). ESP32 CAM Face Detection Door Lock System. , pp.1392–1394.
8. S, D.J. and R. (2017). No Title. In *Int. Conf. on Cloud Computing, Data Sci. & Eng.-Confluence*. pp. 237–242.
9. Sandar, S. and Aung, S.O.N. (2019). Development of a Secured Door Lock System Based on Face Recognition using Raspberry Pi and GSM Module Related papers Face recognit ion based door unlocking syst em using Raspberry Pi Ijariit Journal Face Recognit ion Using OpenCv Based On IoT for Smart Do. [online]. Available from: http://creativecommons.org/licenses/by/4.0.
10. Vaidya, B. et al. (2017). Smart home automation with a unique door monitoring system for old age people using Python, OpenCV, Android and Raspberry pi. *Proceedings of the 2017 International Conference on Intelligent Computing and Control Systems, ICICCS 2017*, 2018-Janua, pp.82–86.
11. Wen, J. et al. (2022). Face recognition system design based on ESP32. In *2022 International Seminar on Computer Science and Engineering Technology (SCSET)*. pp. 114–116. [online]. Available from: http://doi.ieeecomputersociety.org/10.1109/SCSET55041.2022.00034.

CONFLICT OF INTEREST.

We have no conflict of interest to declare