FACE RECOGNITION FOR ENSURING SECURITY IN UNIVERSITY CAMPUS

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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NOVEMBER 2018

APPROVAL

This Project titled **"Face recognition for ensuring security in university campus"**, submitted by Pranta Kumer Bhuiyan, ID No: 151-15-5413, Parves Ahmed Moon, ID No: 151-15-5405, Md. Ali Akbar, D No: 151-15-5460 and Md. Shaheed Uddin Emon, ID No: 151-15-4759 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 25-Nov-2018.

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Nusrat Jahan, Lecturer, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ACKNOWLEDGMENT

First we express our heartiest thanks and gratefulness to almighty God for His divine blessing makes us possible to complete the final year project/internship successfully.

We really grateful and wish our profound our indebtedness to **Nusrat Jahan**, **Lecturer**, Department of CSE Daffodil International University, Dhaka. Deep Knowledge & keen interest of our supervisor in the field of "*Machine learning*" to carry out this project. Her endless patience, scholarly guidance, continual encouragement, constant and energetic supervision, constructive criticism, valuable advice, reading many inferior draft and correcting them at all stage have made it possible to complete this project.

We would like to express our heartiest gratitude to the Almighty Allah and Head**,** Department of CSE, for his kind help to finish our project and also to other faculty member and the staff of CSE department of Daffodil International University.

We would like to thank our entire course mate in Daffodil International University, who took part in this discuss while completing the course work.

Finally, we must acknowledge with due respect the constant support and patients of our parents.

ABSTRACT

Face recognition is one of the most popular topics in research at present. It makes a new way in the biometrics field. It is possible for a machine to know individuals, known and unknown for this purpose called face recognition. So it introduces a lot of field to work that makes human life more secure, comfortable. We use a surveillance camera to ensure security purpose. But it takes too much time to identify that what we are looking for. Sometimes it was not accurate and sometimes it is impossible to find out about what we looking for. So, here face recognition can make an extra layer in this security purpose. It is widely acknowledged that face recognition has played an important role in the surveillance system. It starts a new era in security system perspective and ahead one step more in term of digitalization our country. Face recognition, the technique to determine the individuals using facial images, not only a favored topic for research but also has plentiful application in the area of biometrics, access control, information security, law enforcement, smart card, surveillance system etc. Bounteous favorable outcome has seen on special dataset through different model along with machine learning approaches. In the paper, our aim was to apply Histogram of Oriented Gradient (HOG) on our dataset for live streaming on surveillance system applicable for security purposes to detect known and unknown face in real-time data, and for this purpose, we found 86.96% accuracy rate.

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CHAPTER 1

Introduction

1.1 Introduction

Human has an extraordinary power to identify a person in a different expression, condition, in light variation. Now an artificial system is developed which will work like human known as Face Recognition and still now many works are processing in this field for finding better performance. Face recognition system mainly work for identifying faces by matching it with facial datasets. In live streaming, video surveillance system captures all the individuals in range. When there occurs something unexpected then check the video streaming data. Using face recognition we can find the individuals as his information is caught by machine. It is possible to stop and catch the intruders in the restricted area. It must need to perform accurately, in light variation and speed of identification must need to keep in mind. Face recognition system can be used mainly in two ways:

- Determine one and his details using his images from a large dataset of facial images. Here one's information is stored in a database with his images. One can find out him and his information by searching him with his images.
- Real-time identification. While one passes through a surveillance system coverage area his basic information like the name will show in the security monitor. This is varying in different condition.

Facial recognition is a category of biometric software that maps an individual's facial features mathematically and stores the data as a face print. The software uses deep learning algorithms to compare a live capture or digital image to the stored face print in order to verify an individual's identity. Face recognition is mainly satisfied by learning the machine that learns by images. Machine learning is a form of artificial intelligence that allows computer systems to learn from examples, data, and experience. Through enabling computers to perform specific tasks intelligently, machine learning systems can carry out complex processes by learning from data, rather than following pre-programmed rules.

1.2 Motivation

Bangladesh is moving towards the digital world by implementing new and new technologies every year. But there is not a very much use of facial recognition in any sector of our country. Facial recognition can be used to create smart cards, implement a biometric monitoring system to identify criminals using traffic camera, securing parameters from intruders by alarming authorities, facial verification for accessing secure area or documents and much more. There are great possibilities that can be achieved with facial recognition which is yet to be seen in Bangladesh. Upon successful implementation of this technology, we can hope to build a smart city where the government can assure more protection to the citizens and daily life becomes easier with different applications of Facial Recognition.

1.3 Rationale of Study

Face recognition has become a topic of interest in research since 1961. But in last two to three decades here looks a huge momentum in this field. Principal Component Analysis (PCA) was applied by Alex Pentland and Mathew Turk in 1991 to face classification [1]. A paradigm alteration has done by introducing Histogram of Oriented Gradient (HOG) by Navneet Dalal and B. Triggs [2]. For person detection, HOG gives a very good result as its dense overlapping grid. The advantage of HOG is fine orientation binning, fine-scale gradient, relatively coarse spatial binning, well local contrast normalization which is important for good performance. Freeman and Roth used orientation histogram for hand gesture recognition [3]. In the era of Neural Network more specifically by applying Deep Neural Network (DNN) and Convolutional Neural Network (CNN), this field finds a tremendous swiftness and sequel. SHU Chang, and et al. used Histogram of Oriented Gradient achieving almost the same recognition rate with much lower computational time whereas this feature shows that single angle representation performs much better than double angle representation, applied this model on FRGC and CAS-PEAL databases [4]. However still now many models are being introduced that’s are applied in the different dataset and sometimes it is applied in some built-in dataset for verifying their model and accuracy.

1.4 Research Question

We already noticed that bounteous work has done and introduced different model on facial recognition. Among them, some model gives an extraordinary performance. However, in machine learning to train a model it will need a huge dataset for achieving better performance. On the other hand models like CNN which it needs high-level Hardware requirements. Again most of the work was done on a special dataset. Now the hypothesis is how the model HOG perform in our own dataset for security purpose in a university campus. It should be kept in mind that here we work with a small dataset in sample basis.

1.5 Expected Outcome

As we work for security purposes in university campus with a sample and our own dataset for test basis our aim is to detecting and recognizing known and unknown and also looking for a better accuracy rate.

1.6 Report Layout

The purpose of this project report is to provide a detailed description along with charts, graphs. The format of this report is simple. Boldface is used on a general topic or specific points of interest. The remainder of the document will be written using the standard font, Times New Roman with font 12. The remainder of this report as follows. Chapter 2 describes the background belonging literature work, the scope of the problem, summary, and challenges we face. Chapter 3 represents the whole methodology like dataset creation, model training and classification, and implementation requirements. Chapter 4 discusses the result and at last Chapter 4 finalized the report with a conclusion and future work.

CHAPTER 2

Background

2.1 Introduction

A facial recognition system is a technology capable of identifying or verifying a person from a digital image or a video frame from a video source. There are multiple methods in which facial recognition systems work, but in general, they work by comparing selected facial features from given image with faces within a database. It is also described as a Biometric Artificial Intelligence-based application that can uniquely identify a person by analyzing patterns based on the person's facial textures and shape. The human face plays an important role in our social interaction, conveying people's identity. Using the human face as a key to security, biometric face recognition technology has received significant attention in the past several years due to its potential for a wide variety of applications in both law enforcement and non-law enforcement. But the path to reach this stage is not so easy and has a huge, resourceful and a strong background since 1961. From then to till now many research works had introduced a lot method. Among them, different machine learning methods or model shows a huge success in his field and sometimes it reaches the accuracy rate near human accuracy. Machine Learning is the science (and art) of programming computers so they can learn from data. Machine learning is closely related to (and often overlaps with) computational statistics, which also focuses on prediction-making through the use of computers. It has strong ties to mathematical optimization which delivers methods, theory and application domains to the field. Machine learning is sometimes conflated with data mining, where the latter subfield focuses more on exploratory data analysis and is known as unsupervised learning. Machine learning can also be unsupervised and be used to learn and establish baseline behavioral profiles for various entities and then used to find meaningful anomalies. Here we mainly use the Histogram of Oriented (HOG) for this project. The processes are discussed in the later sections.

2.2 Related Work

In recent years many models have introduced for face recognition and image-based work. Among them, they show a huge success in this field. For this paperwork, we took knowledge of the following paper works.

Taha J. Alhindi et al. [5] conducted a recent study which compares Local Binary Pattern (LBP), HOG and deep features from VGG 19, a pre-trained deep network for feature extraction and Support Vector Machine (SVM), Decision Tree and Artificial Neural Network for the classification of histopathology image dataset, KIMIA Path960. The classification accuracy obtained in the study with LBP and SVM is 90.52%. Hilton Bristow and Simon Lucey compared that the classifier which preserves local quadratic pixel interaction perfectly distinguishes between natural and noise than pixel based classifier [6]. In this study, a marvelous performance has seen with HOG and SVM having accuracy 99.3% applied in the Cohn Kanade + expression recognition dataset. Kanade presents Automatic feature extraction using the ratio of distances gained accuracy rate 45%-75% with a dataset of 20 people [7]. A set of the geometrical feature was computed by Brunelli, Roberto and T. Poggio like mouth position, chin length, nose width and length [8]. They had the accuracy rate of 90% on a dataset of 47 people. Wiskkot and et al. compared 300 faces against 300 different faces of the same people taken from the Face Recognition Technology (FERET) dataset not only for face recognition but also for identifying gender. They record a recognition rate of 97.3% [9]. For matching two images of the same person in the unconstrained environment, (Convolutional neural network) Covnet-Restricted Boltzmann Machine has shown 97.08% accuracy [10]. A mixture distance technique achieved the recognition rate of 95% using a query dataset of 95 images (each image has 30 extracted feature) introduced by Cox et al. [11]. Handcrafted features such as Local Binary Pattern (LBP) has received a respectable performance in Face Recognition in a constrained environment [12]. But the performance is deteriorated when the images are taken in an unconstrained environment. Harihara Santosh Dadi and et al. introduce an improved facial recognition rate using HOG feature and SVM classifier having an improvement of 8.75% face recognition rate. They applied the formula on color FERET, Yale Database, Yale faces Database ‘B', BioID, Georgia Tech, FEI, leveled faces in the wild and get 68.5, 98.2, 88.6, 75.67, 81.25, 80.13, 64.6 percent accuracy respectively [13].

2.3 Research Summary

In this proposed paper, our goal was to experiment on our own created dataset using OpenCV, Dlib, Face Recognition library and HOG classifier for feature extraction and classification in real time data for recognizing intruders for increasing the security into the university campus.

2.4 Scope of the Problem

This system can play a vital rule in the different field especially in security issues. Besides this, it can be implemented in the classroom for taking attendance. For time maintaining in institutions that have a huge staff, can use the system by data analyzing from attendance data. A lot more problem we can solve by this system. However, if the system is applied practically once, many fields can fix up related with this and can contribute to many fields in our country.

2.5 Challenges

At first, the facial images for the dataset need to have good quality such as the need to take images avoiding noise as much as possible. Because if the images have too much noise, the model will not train as expected level, so the result will be hampered. Again for the test video, the video quality also needs to be good and fresh as much as possible. Now the most important thing is come out, the hardware abridgment. For face recognition using machine learning a better configuration for better performance is must. For example, it needs more than 45 minutes just to feed the images to the network to train. On the other hand for CNN, GPU is must required. So, by solving the problem it is possible to get more efficient performance.

CHAPTER 3

Research Methodology

3.1 Introduction

A facial recognition system is a computer application capable of identifying or verifying a person from a digital image or a video frame from a video source. One of the ways to do this is by comparing selected facial features from the image and a face database. The proposed system is supposed for real-time to live streaming surveillance system to recognize the individuals and also detect known and unknown for informing the doer of the team related with security purposes which will differ from the conventional system. The different implementation methods regarding our system are described in details in below sections. Different technologies are being used to make the system widely available through cross-platforms and to provide the best performance within limited resources. These help to build system rapidly and help to maintain the consistency that helps developers to meet their deadlines. Among the technology used to build the system, some of them are explained in the next sections.

3.2 Research Subject and Instrumentation

A. Python

We are using Python for building our system. Python is an open source programming language. Python is easy-to-read and powerful. Its high-level built in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development. For its beauty, simplicity, power, and availability of powerful modules and packages for modern technology like Data Analysis, Artificial Intelligence, IoT and many more, we are building our system on Python.

B. Dlib

Dlib is a library which is a C++ toolkit containing machine learning algorithm and tools for creating complex software to solve the real world problem. A wide range of domains including

the embedded system, robotics, mobile phone and large high-performance computing environments it is used. It is used to construct our face embeddings used for the actual recognition process. To train a network from scratch, huge data will be needed but it is easier to use a pre-trained network and then use it to construct 128-d embeddings for each faces in the dataset. Here the network quantifies faces constructing 128-d embedding for each.

C. Face Recognition

Face recognition is a library which wraps around dlibs facial recognition functionality. Dlib has given the facility to use a variety of machine learning algorithm but in face recognition library in dlib allow two model for facial recognition that's are Convolutional Neural Network (CNN) and Histogram of Oriented Gradient (HOG).

D. OpenCV

OpenCV known as Open Source Computer Vision is a leading open source library for computer vision, image processing, and video processing. It also supports machine learning which enables this tool to be used for object detection from videos or images. It can also input/output videos in real time. OpenCV provides different machine learning algorithms for face recognition from images. For the wide range of utilities, we are using OpenCV interface for Python to process face identification in real time.

E. Face Detection

For detecting faces in images, HOG is used here. The images are break into small squares of 16x16 pixels each. In each square, count up how many gradients point in each major direction. Then replacing that square in the image with the arrow directions that were the strongest. To measure the gradient point or magnitude and direction at first the images are filtered using sobel operator.

-1	-2	-1
0	0	0
-1	-2	-1

(a)

-1	0	-1
-2	0	-2
-1	0	-1

(b)

Figure 3.2.1: (a) sobel operator for calculating gradients and directions in y-axis, (b) sobel operator for calculating gradients and directions in x-axis

$$g = \sqrt{g_x^2 + g_y^2}$$
$$\theta = \arctan \frac{g_y}{g_x}$$

The values g_x and g_y is being calculated from the filter value of the pixels of the images. According to the direction the position of the faces detected.

F. Posing and Projecting Faces:

Faces turned from different directions look totally different to a computer. For this, warp each picture so that the eyes and lips are always in the sample place in the image. Face landmark algorithm is used for this. [14]

$$S^{(t+1)} = S^{(t)} + r_t (I, S^{(t)})$$

To begin we introduce some notation. Let $x_i \in R^2$ be the x, y-coordinates of the i^{th} facial landmark in an image I. Then the vector $S = (x^T_1, x^T_2, \ldots. x^T_p) T \in R^{2p}$ denotes the coordinates of all the p facial landmarks in I. Frequently, vector S is refer to as the shape. We use $S^{(t)}$ to denote current estimate of S. Each regressor, $r_t (\cdot, \cdot)$, in the cascade predicts an update vector from the image and $S^{(t)}$ that is added to the current shape estimate $S^{(t)}$ to improve the estimate. [14]

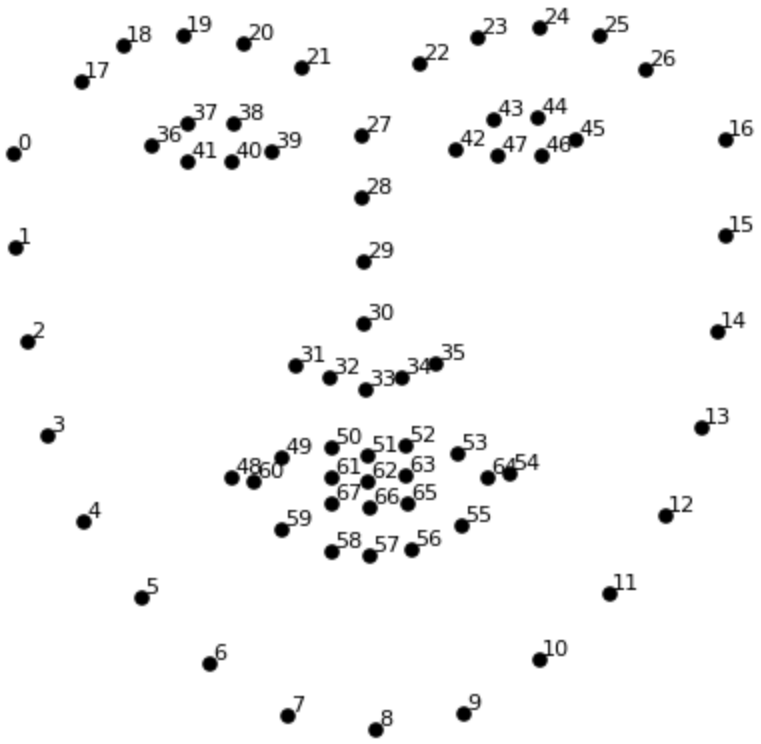


Figure 3.2.2: The 68 landmarks we will locate on every face. This image was created by Brandon Amos of CMU who works on OpenFace.

The basic idea is we will come up with 68 specific points (called *landmarks*) that exist on every face—the top of the chin, the outside edge of each eye, the inner edge of each eyebrow, etc.

G. Encoding Faces:

To encode the faces, it is extracted in a few basic measurements. Then measuring the unknown faces the same way and find the known face with the closest measurements. These measurements are called embeddings. To measure the embedding need to train a network and the network is trained by triplet loss. According to [15] The Triplet Loss minimizes the distance between an anchor and a positive, both of which have the same identity, and maximizes the distance between the anchor and a negative of a different identity. It embeds an image x into a d-dimensional Euclidean space. Here we want to ensure that an image x^a_i (anchor) of a specific person is closer to all other images x^p_i (positive) of the same person than it is to any image x^n_i (negative) of any other person.

$$\|x_i^a - x_i^p\|_2^2 + \alpha < \|x_i^a - x_i^n\|_2^2.$$

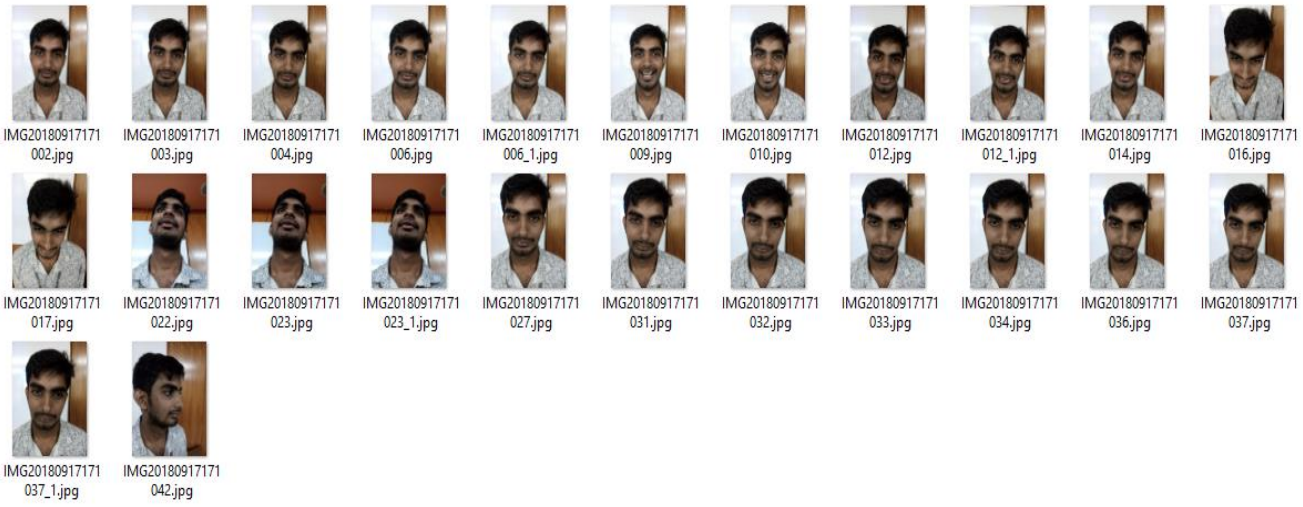
where α is a margin that is enforced between positive and negative pairs.

H. Find Individuals ID from Encodings:

Now all it needs to find the known and unknown comparing faces from dataset. Basic classification algorithm can be used here for classification. Training a classifier that can take in the measurements from a new test image and tells which known person is the closest match. The result of the classifier is the ID of the individuals. Here HOG classifier is used for classification.

3.3 Data Collection Procedure

Here are the main purpose and most important part of the proposed study or system. The system is mainly proposed for the security purpose so for recognition and for training the network, the dataset is a must. In this dataset images of 22 subjects are taken in total. Among them, 14 images are for train and 8 for the test. For each person or subjects, 20 images are taken. So the total number of images is 440. For each person or subjects, the images are taken in four modes (Figure 3.3.1) happy, sad, normal mode and side view (left, right, top, bottom). For making the dataset we focused on images and background to keep clean as much as possible, as well as proper light condition, must be kept in mind.



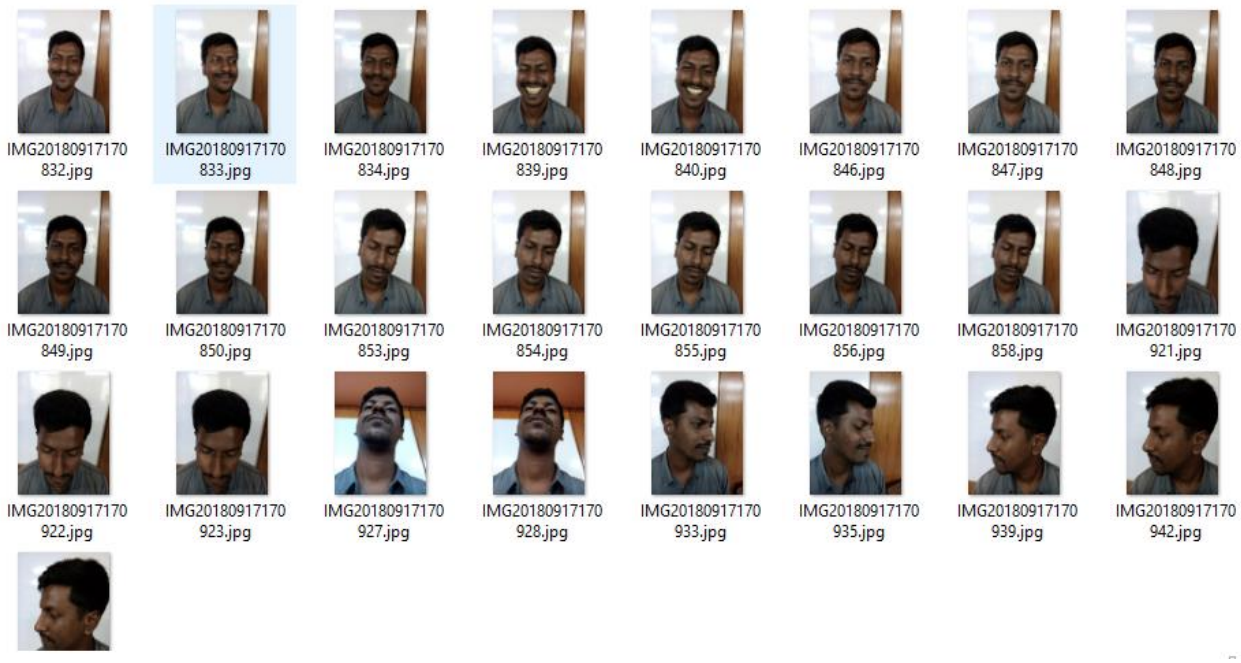


Figure 3.3.1: Dataset images from different individuals in different views and angle

In the time of data collection the ID of each student was taken with images for identifying individuals.

TABLE I: DATA COLLECTED FROM INDIVIDUALS

SL. No	Data	Description	Usability
01.	Id	Individuals Id	Identity
02.	Image	Individuals Image	Recognize

Here, Id of the individual is taken for identification which is corresponding with their images. If the face, shown in the surveillance system, matches with dataset then the system informs the id otherwise the system will recognize him as an unknown face.

For achieving a better and more accurate outcome as well as to train the model or network, a well-formed dataset is needed. So, here we used our own dataset to see not only the accuracy rate but also applied it in real life for security purposes in the university campus.

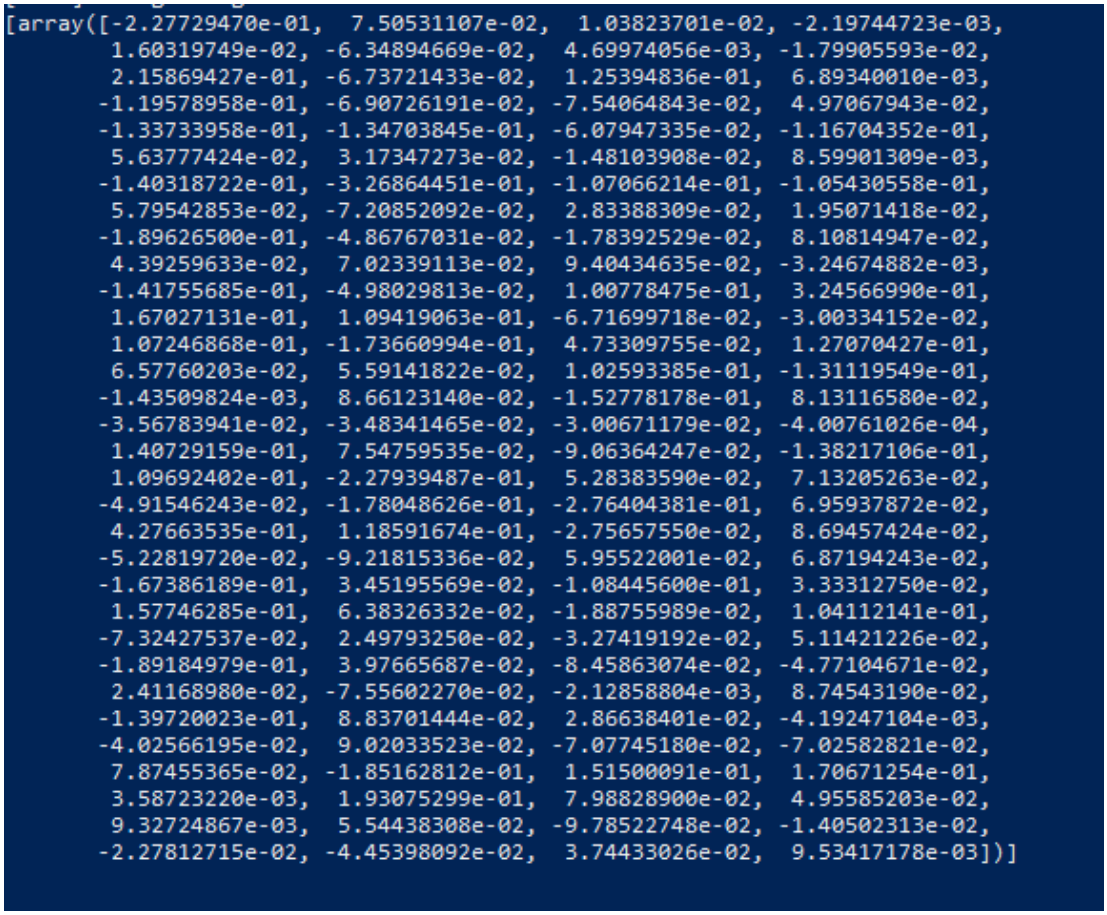
Source of data: The source of images for the dataset and also the credit goes to Daffodil International University (Batch: 40th, Section: D).

3.4 Statistical Analysis

We have already mentioned earlier in Technology part that we used the dlib library which is a toolkit containing machine learning algorithm for implementing our system. For dlib facial recognition, the output feature vector is 128-d means a list of 128 real-valued numbers that is used to quantify the face. So, at first, images need to be processed for dlib compatible.

For processing the images at first OpenCV is used here to convert the images from BGR to RGB. Now, we need to quantify the faces of our dataset in 128-d embeddings. In dlib, a network has already been trained to create 128-d embeddings on a dataset of ~3 million images. So, we just feed the images of our dataset to the network to construct 128-d embeddings to quantify the face. Figure 3.4.1 presents 128 embeddings values for an image.

(a)



(b)

Figure 3.4.1: 128-d embeddings value present in (b) for image (a).

After that, we get the facial feature or location from input images then its need to encoded faces. In the encoding process, two arrays are used, named Known Encodings and Known Names. In Known Encodings face locations according to id and in Known Names, Id is being stored. Then pickle package is used for serializing the encoded data. For classification, votes are used. Comparing face locations between test and train dataset matching points are known as the vote. The system will identify using the maximum number of votes matched with that embeddings. For better performance, the tolerance must be kept below 0.6.

In this part, we will discuss how the system will work. Basically, it will work like another machine learning process. But we utilized it as our requirements.

The following figure 3.4.2 describes basic part of system procedures. In this system when an individual entry in the main entrance then through surveillance system take the images of the individual and then the images are comparing with the dataset by which it is trained. If the images match with his/her images then the id of the individuals otherwise recognize him/her as an unknown.

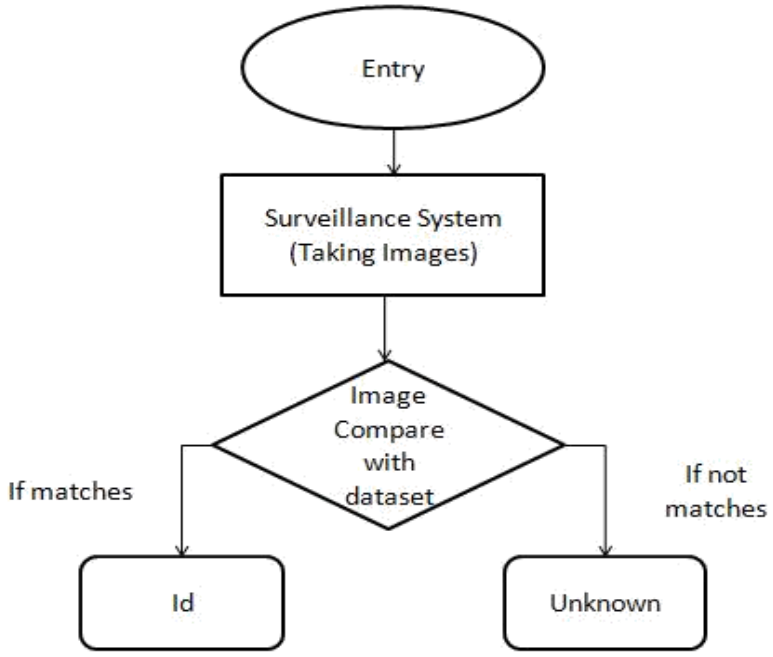


Figure 3.4.2: Comparing images of individuals with the dataset, and system give the expected outcome.

Here the feature extraction and classification as well as the total system procedure shown in figure 3.4.3 After collecting the data they will feed to the network, it will convert it in 128-d embedding using Dlib library for processing. That will train the model. Now we collect images from live streaming as test data and compare them with classified faces using our model. At last, it gives the result based on votes.

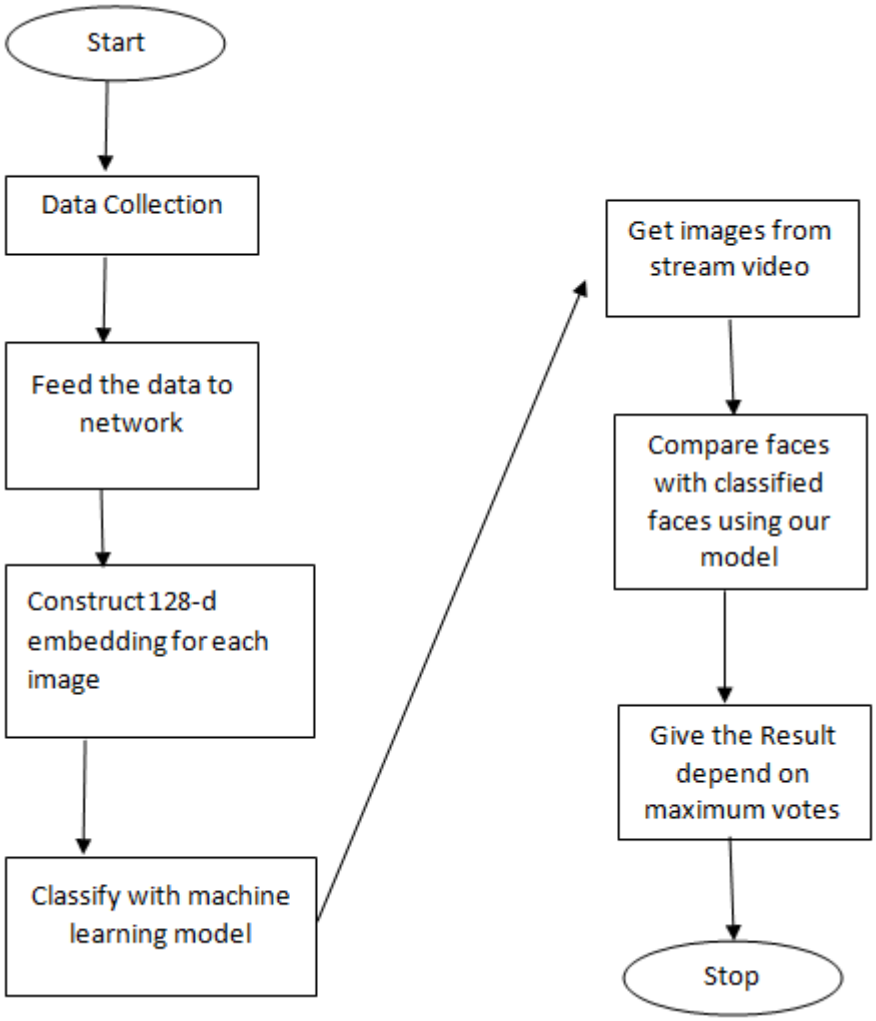


Figure 3.4.3: Feature extraction and classification process.

3.5 Implementation Requirements

- Hardware
  - Graphics card 2GB
  - Ram 4GB and hardware requirements that usually we have. But for better performance need higher requirements than this. For implementing CNN, GPU is must.

- Software:
  - Operating System: Windows 10, Linux, Ubuntu.
  - Development platform: OpenCV, Dlib, Face recognition library

CHAPTER 4

Experimental Results and Discussion

4.1 Introduction

The Confusion matrix is used to measure the performance. The Confusion matrix is a matrix that is used to justify the classification model whatever it is true or false. Here in this study true is considering as known and false as unknown. The Total number of subjects to measure the performance is 23. Among them, 9 are known and 14 are unknown. The proposed system can perfectly recognize 20 people but for another 3 it shows a little confusing result.

4.2 Experimental Result

TABLE II: CONFUSION MATRIX FOR MEASURING PERFORMANCE

	Prediction Unknown	**Prediction Known**
Actual Unknown	12	2
Actual Known	1	8

Now the equation for accuracy is:

$$\text{Accuracy} = (TP + TN) / \text{Total number of subjects}$$

Here, TP formed for True Positive which means the face is actually known and the model prediction is also known. On the other hand, TN considers as True Negative which means that the face is actually unknown and the model also predicts the face as unknown. So, the accuracy rate of our model is $(12 + 8) / 23 = 0.8696 \times 100 = 86.96\%$.

From here the error rate can also be calculated. The Equation for error rate is:

$$\text{Error rate} = 100 - \text{Accuracy}$$

The error rate is 13.04%. The accuracy rate will increase more if can remove our constraint to implement the model. In the next part, we will discuss it.

4.3 Descriptive Analysis

Figure 4.3.1 shows the actual outcome of the system. Two faces in left shows with Id and in middle one recognized as unknown so we can say the system work perfectly. But for the person who is staying at right does not show the id because he is partially engaged with the frame.

Figure 4.3.1: Determine known and unknown from real-time data.

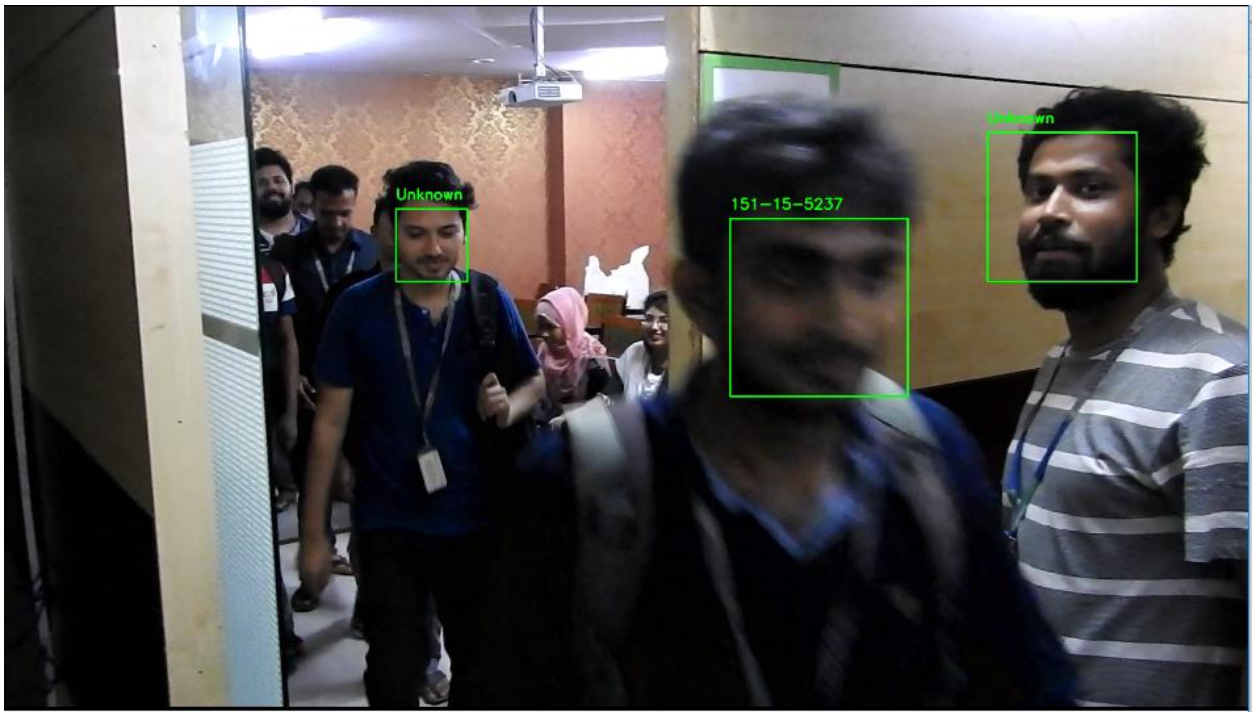


Figure 4.3.2: Determine known and unknown from real-time data.

In figure 4.3.2 here the right one shows unknown middle one recognized with Id. But we would also see some faces in screen but they do not shows either Id or detected as unknown because are out of range.

4.4 Summary

Here we can see the system work perfectly and gives a better accuracy rate. But still, now it has some constraint. As we can see a face that was partially detected that was not perfectly recognized. Again faces that are not in range limit also cannot be recognized. So, need to work with this area to fix up those issues. But it can surely be said that the system has done better with our own dataset.

CHAPTER 5

Summary, Conclusion, Recommendation, and Implication for Future Research

5.1 Summary of the Study

In this study, our approach was to apply the system to our own dataset and experiment the possibility to apply it in university campus to detect known and unknown in real time live streaming of surveillance system. For maintaining and saving the time and reducing the difficulties to implement the network we use the Dlib library which provides us the facility to use several model or network that has created a network. So, we just need to feed our images data in the network. That makes our work quite easier but we face difficulties in hardware constraint otherwise we can use the CNN model for our system which can give us a more accurate outcome or accuracy rate. So, it is for farther steps to implement CNN which will the more powerful.

5.2 Conclusion

In this paper, we implemented a basic real-time face recognition system. This system can be further improvised to create more complex and advanced system for reaching any particular goal. There are many areas of improvements for this project. We are using Haar cascade classifier for face detection that can be replaced with other object detection algorithm to achieve more accuracy. Moreover, there are now advance libraries more Machine Learning and Artificial Intelligence available. With APIs like Tensorflow, there are more powerful algorithms that use Deep Neural Networks for processing data, providing more accuracy over the given data. By improving these areas, we can build our system to be more powerful and ready to be used in any existing system.

5.3 Recommendation

This document is intended to read by the Software Engineers, Operation Engineers, System Engineers or any Manager level employees who are interested in face recognition as well as machine learning. This is a technical document and the basic technical terms should be understood by the readers. The rest of this report contains the logical and physical architecture of face recognition and the system.

5.4 Implication for Further study

In this paper, we implemented a basic real-time face recognition system. This system can be further improvised to create more complex and advanced system for reaching any particular goal. In the future, we just need to focus on the challenges. In the proposed system, HOG is used but using CNN more perfect result will be found. This system can play a vital rule in security purposes everywhere in our country. In traffic control, this can also give a great support. In the classroom, it can be used to take attendance.

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Appendix A: Research reflection

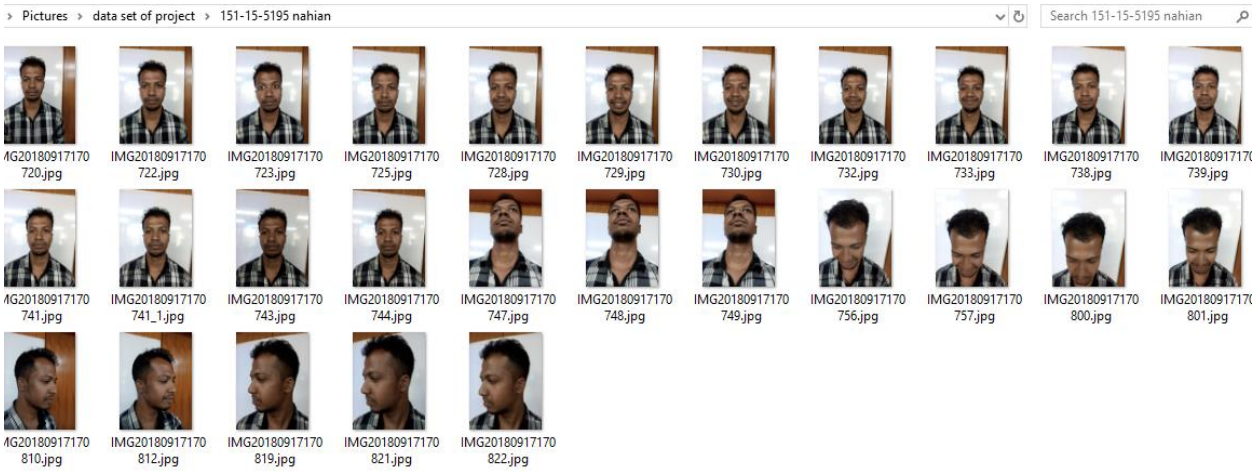

Figure A1: Image in dataset (clear background)

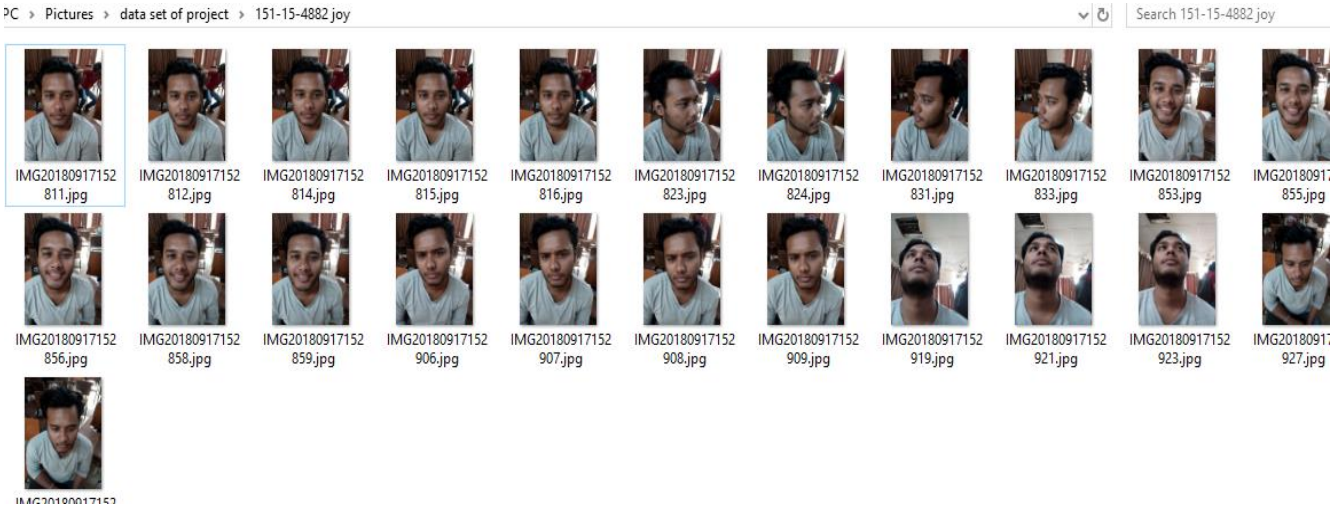

Figure A2: Image in dataset (noise in background)

Appendix B: Related Issues

HOG:	Histogram of Oriented Gradients
CNN:	Convolutional Neural Network
OpenCV:	Open source Computer Vision Library
SVM:	Support Vector Machine
GPU:	Graphical Processing Unit