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A smart login system using face detection and recognition by ORB algorithm

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ABSTRACT

We can identify human faces using a web Camera which is known as Face Detection. This is a very effective technique in computer technology. There are used different types of attendance systems such as log in with the password, punch card, fingerprint, etc. In this research, we have introduced a facial recognition type of biometric system that can identify a specific face by analyzing and comparing patterns of a digital image. This system is the latest login system based on face detection. Primarily, the device captures the face images and stores the captured images into the specific path of the computer relating the information into a database. When any body tries to enter into any room or premises through this login system, the system captures the image of that particular person and matches the image with the stored image. If this image matches with the stored image then the system allows the person to enter the room or premises, otherwise the system denies entry. This face recognition login system is very effective, reliable and secured. This research has used the Viola and Jones algorithm for face detection and ORB for image matching in face recognition and Java, MySql, OpenCV, and iReport are used for implementation.

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1. INTRODUCTION

In our daily lives, we often remember and recognize people by looking at their faces. This is a part of the body that is highly visible and is important for interaction. We store information of a face and later use that information for recognition and matching purposes. This mechanism can be used by machines to recognize and authenticate a human being with the increasing importance of technology in business and human lives where security has become a critical concern for modern applications. Users' authentication is the most important part of securing an application from unauthorized access. For this, knowledge-based, token-based and biometric based systems can be used. Traditional knowledge-based and token-based systems are losing appeal due to the issues associated with their usage. This situation has increased the importance of biometric (what we are) characteristics rather than knowledge (what we know) and token (what we have) approaches [1]. In our country there many types of login systems are used such as login by punch card, user id or password. But in these systems, there is possibility of misusing the systems through mutual understanding. The developed smart system can overcome the previously developed systems' limitations. The system checks individual user's face with existing stored faces, that's why there is no chance of misuse.

Objective

a) To help organizations to make their login systems more secured and smart.
b) To detect individuals by using the face detection system.

c) To reduce the use of punch cards or any common login systems.
d) To generate Automatic login report.
e) To monitor easily.

2. LITERATURE REVIEW

Here, we have illustrated some related works which have been conducted by the researches previously. We have studied the research works and tried to find out the limitations of the researches. Such as Yogesh Maniktala et al. proposed a Robust Technique of Face Recognition [2]. In this research, they have described the face detection process and recognition systems using pixels and analyzing the images. Smriti Tikoo et al. developed a Face detection System using Viola Jones and Recognition system using Back Propagation Neural Network [3]. In this paper, the facial detection has been carried out using the Viola-Jones algorithm and recognition of face has been done using Back Propagation Neural Network (BPNN). Dr. Nita Thakare et al. have carried research on "Face Detection and Recognition for Automatic Attendance System" [4]. In this research, they have described their experience in developing face detection and recognition system for attendance software. Gunjan Mehta et al. was introduced a Face Recognition System using PCA, FLDA and Artificial Neural Networks [5]. The paper presented a technique to implement a system that aims to describe four different methodologies for Face Recognition. There is another paper where neural a network is also used for detecting a face. This paper proposed a face localization technique and developed a new feature extraction algorithm for human face recognition. There is another paper where the neural network is also used for detecting a face. This paper proposed a face localization technique and developed a feature extraction algorithm, Neural Network (NN) using Back Propagation Networks (BPN) and Radial Basis Function (RBF) networks for human face recognition. The neural network model is used for recognizing the frontal or nearly frontal faces and the results are tabulated [6]. Mamata et al. developed a real-time face detection and tracking using OpenCV [7]. In this paper, they represented a methodology for face detection in a real-time environment and was used Harr like classifier and AdaBoost algorithm for tracking faces on the OpenCV platform which is an open source and developed by Intel. D. A. R. Wati et al. also used Face detection and recognition systems for smart home security applications [8]. To implement this system, they used MyRIO 1900 and LabVIEW for programming. For performance evaluation, they have considered several variables like a change of distance, light intensity, light position angles, person's fixtures, and shirt color. To increase the system security they added the password field. Aanjana Devi. S et al. were proposed a confidential e-voting system using face detection and recognition. Eigenface algorithm and viola jones were used for implementation which provides high security, and reliability [9]. Haar-Like feature and Eigenfaces also applied as an algorithm for detecting the face of a visually impaired person. In this paper, researchers developed a smart cane for recognition of face by using Haar-like features and Eigenfaces [10]. There is another paper, Facial Action Coding System (FACS), applied for detecting facial expression. They worked with six basic emotions of happiness, sadness, shock, fear, anger, and disgust [11]. Reivind P. Persada et al. proposed a security system on Smart Parking based on face recognition and VLP's (Vehicle License Plates) identification. In this paper, the Structural Similarity (SSIM) method applied for reliable and simple computation for the face detection and recognition process [12]. Ghazal et al. research on Fast Discrete Curvelet Transform (FDCvT) and Invariant Moments with Support vector machine (SVM), these two algorithms are used for face recognition [13]. J. Vinoj et al. research to provide a security system in the smart city through the vehicle login system, the researcher developed a sensor chip-based model [14]. Kumar et al. the researchers proposed a review paper based on face detection techniques [15]. There are many researchers used face recognition and detection system in various purposes; even they developed a security system for face recognition [16-21]. From the above-mentioned research works, we have had some idea relevant to the system and conducted this research to overcome the previous limitations and to introduce the new idea.

3. THE METHOD OF SYSTEM DESIGN

Image processing is a smart and modern technology. We have studied various methods of image processing. In this section, we described the algorithm of face detection and recognition. We have used the Viola and Jones algorithm for face detection and ORB (Oriented FAST and Rotated BRIEF) for image matching in face recognition. The BRIEF algorithm works as descriptor and FAST works as a detector and ORB works as both descriptor and detector for image matching. The overview of all algorithms is briefly described below:

3.1. Viola and Jones algorithm for face detection

The Viola and Jones algorithm is a good detection algorithm because of its robustness. A vital contribution of the method is the use of the integral image representation together with Haar-like features,

shown in Figure 1. There are four types of features, the output at a specific coordinate position is a scalar value calculated from the difference between grey and white areas of the feature. The values of the gray and white areas are determined by the sums of pixels values within. The calculation of all features at a certain position is thus a succession of double sums (in x and y direction) and subtractions.

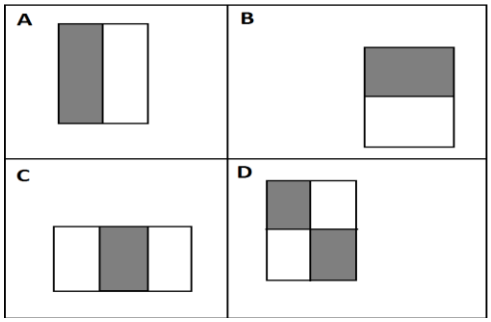

Figure 1. The four types of Haar-like features used in the Viola-Jones method

The integral image, also known as a summed-area table, is a technique that enables fast and simple computations of sums over rectangular areas in an image. Each pixel (x, y) in the integral image is equal to the sum of pixels above and to the left of (x;y) in the original image, as shown in (1).

$$I\,I\,(x, y) = \sum_{x' \le x,\ y' \le y} I\,(x', y') \quad (1)$$

Any rectangular sum can then be calculated using very few operations. In practical terms, an integral image is the double cumulative sum of an image, along the row dimension and the column dimension. Each point in the integral image corresponds to the sum of the original image up to that point, as Figure 2.

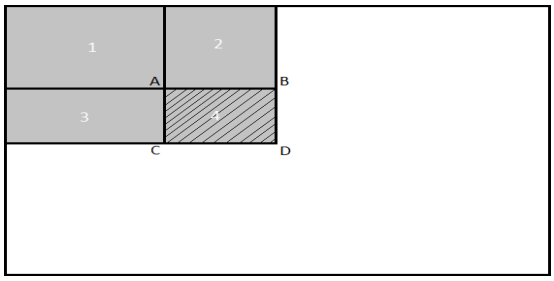

Figure 2. The sum of the gray area in the image corresponds to point D in the integral image

Any arbitrary rectangle can be defined in the image as four points, and these points are the four corners of the rectangle, A, B, C and D as shown in Figure 2. There are also four areas numbered in the Figure, and we can now define the value each of these four corners as a sum of these areas. Point A in the integral image corresponds to area 1, B is the union of 1 and 2, C is the union of 1 and 3 and D is the union of all gray areas. This gives us

Area 4 = II(D) + II(A) - II(C) - II (B)

The algorithm has four stages:

a) Haar Feature Selection
b) Creating an Integral Image
c) Adaboost Training
d) Cascading Classifiers [10].

3.2. Binary robust independent elementary features (BRIEF)

BRIEF is a feature descriptor. It provides a shortcut to find the binary strings directly without finding descriptors. It takes a smoothened image patch and selects a set of (x,y) location pairs uniquely. Then some pixel intensity comparisons are done on these location pairs. For example, let the first location pairs$I(p) < I(q)$, then its result is 1, else it is 0. This is applied for all the n_d location pairs to get a n_d -dimensional bi string. This n_d can be 128, 256 or 512. OpenCV supports all of these, but by default, it would be 256 (OpenCV represents it in bytes. So the values will be 16, 32 and 64). So, once you get this, you can use Hamming Distance to match these descriptors [22].

3.3. FAST algorithm for corner detection

A FAST algorithm is used for image matching. This algorithm works with three steps namely-
Feature Detection using FAST **ii)** Machine Learning a corner detector and **iii)** Non-maximal suppression.

a) Choose a pixel p in the image as an interest point or not. The intensity of a pixel is denoted by I_p .
b) Choose a threshold value t.
c) Select a circle of n pixels around the pixel under test.
d) The pixel $P$is a corner if the circle consists of a set of n contiguous pixels which are all brighter than $I_p + t$, or all darker than $I_p - t$. In below Figure 3, there are 16 pixelsshown as white dash lines and for n=12.

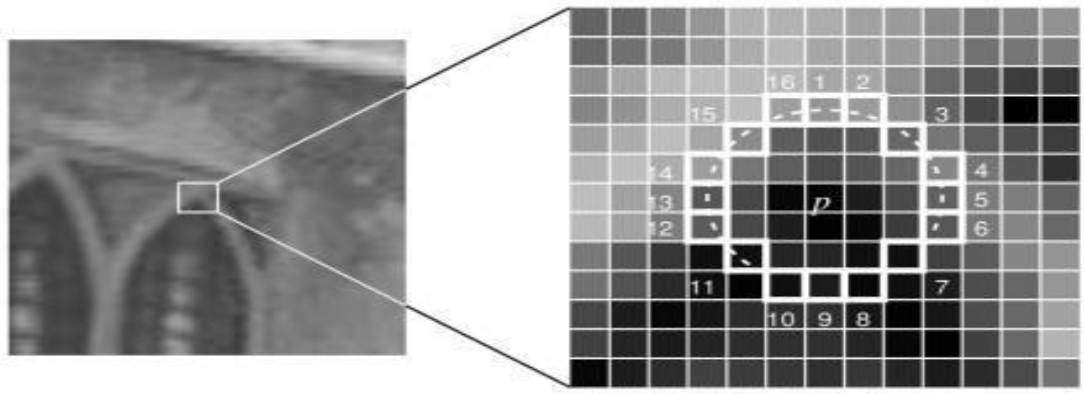

Figure 3. Contiguous pixel

e) A high-speed test was proposed to eliminate a large number of non-corners. If p is a corner, then the pixels must all be brighter than $I_p + t$ or darker than $I_p - t$. If not, then p cannot be a corner. In the test, the four pixels at 1, 9, 5, and 13 are examined. Here, First 1 and 9 are tested if they are too brighter or darker. If so, then checks 5 and 13 which shown in the above Figure 3. This detector provides high performance, but there is some lacking which are:
   a) It does not eliminate many candidates.
   b) The choice of pixels is not optimal.
   c) Results of high-speed tests are thrown away.
   d) Multiple features are detected adjacent to one another.

The first 3 points are addressed with a machine learning approach. The Last one is addressed using non-maximal suppression [23, 24].

3.4. Oriented FAST and rotated BRIEF (ORB)

ORB is a modified version of the FAST detector and BRIEF descriptor which increases the performance. It calculates the intensity weighted centroid of the patch with the located corner at the center. The performance of the BRIEF is poor.Instead of ORB use BRIEF descriptors. ORB is to "steer" BRIEF according to the orientation of key points. For any feature, we consider a set of n binary tests at the location(x_i, y_i), define a$2 \times n$ matrix, and S is the coordinates of these pixels. By applying the orientation of patch,θ, its rotation matrix is found and rotates the S to get steered(rotated) version S_θ. OR Bincrements the angle of $2\pi/30$ (12 degrees), and build a lookup table of recomputed BRIEF patterns. If the key point orientation θ is consistent across assessments, the correct set of points S_θ will be used to

compute its descriptor. BRIEF provides high variance and a means near 0.5. When it works with key point direction, it loses high variance and means which make it distributive. A feature becomes more discriminative because of high variance. To overcome these problems, ORB uses a greedy search among all possible binary tests to achieve high variance and means close to 0.5, as well as being uncorrelated which is known as BRIEF [22]. Using the below Figure 4, we have calculated the orientation of the patch; rotate it to a canonical rotation, we can compute the descriptor, consequently obtaining some rotation invariance.

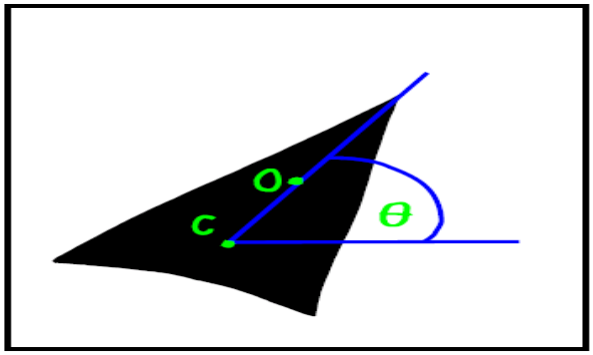

Figure 4. Rotation in a BRIEF algorithm

3.5. Reasons to choose ORB algorithm

Here are the status of Different Detector and descriptor:
SIFT:slow, good quality, not free,
SURF:fast + good quality, not free,
BRISK:fast + good quality, free
FREAK ≈ BRISK
ORB: faster + little bit less quality

We found different comparison:

Considering the above data as shown in Table 1, Table 2, and Table 3, we think ORB is the best algorithm to make faster and perfect Software for Face detection and Recognition [25-27]. So, we have chosen ORB as a detector and descriptor.

Table 1. Based on computation times for 1000 key points for diverse descriptors

Descriptor	Run time(ms)	Speed up()
SURF	117.1	3.83
SIFT	448.6	1.0
BRIEF	3.8	118.05
BRISK	10.6	42.32
ORB	4.2	106.80

Table 2. Diverse descriptors average computation time

Detector	Run time(ms)	Speed up()
SURF	176	1.9
FAST	2	169
BRISK	10	33.8
ORB	*7*	*48.3*

Table 3. Speed-up over the sequential matching

Descriptor	Size(bytes)	Run time(ms)	Speed up
SURF	64	390	859.4
SIFT	128	2095	160.1
BRIEF	32	370	905.9
BRISK	64	524	640.1
ORB	32	370	905.9

4. IMPLEMENTATION OF SYSTEM DESIGN

4.1. Flow chart

In this process, the system detects face from a web camera and check with stored images, if the pattern matched then users allow login the system otherwise reject. This process is shown below like Figure 5:

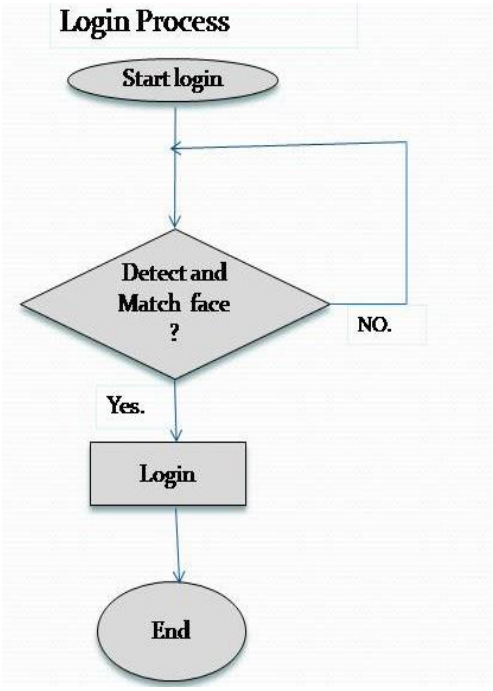

Figure 5. Flowchart of login system using face detection techniques

4.2. Interface design

If the system detects any face in front of the camera, it marks with a square and shows a captured face on the right side screen to save for further process as like as Figure 6 and Figure 7.

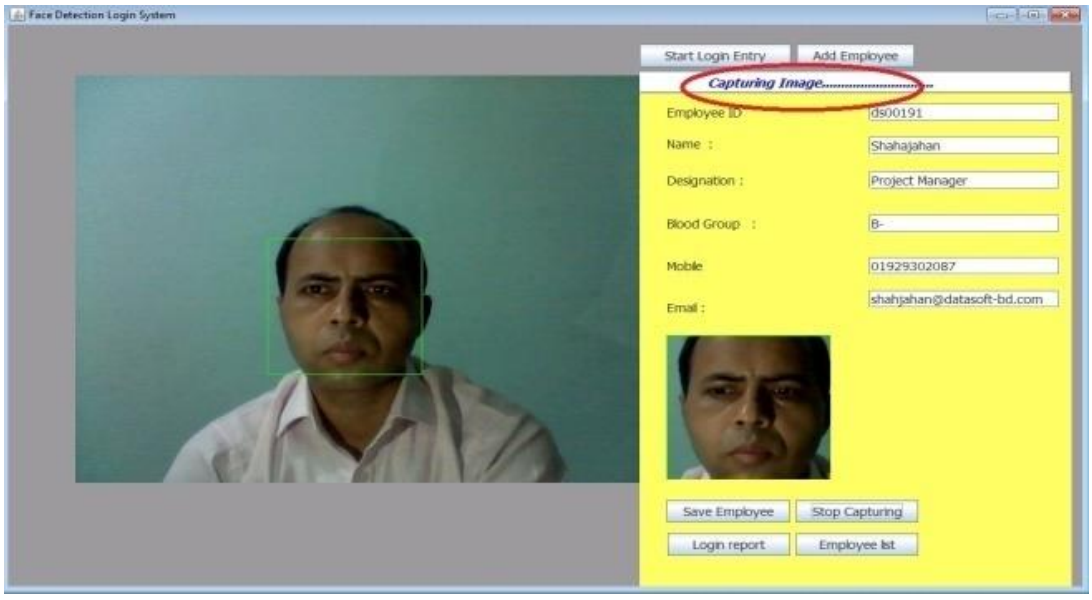

Figure 6. The interface of the system

Figure 7. Sample of stored face images

Here, the user can add user details information with the image of the face. After saving user details information into the system, any user can log in from the next time. In this case, the user has to show his/her face in front of the camera, then the camera captures his/her image of the face and matches this image with the database images. If the image gets matched then it will show confirmation of login; otherwise the system will reject him/her and suggest trying again.

5. RESULTS AND DISCUSSION

To match the face with database, users' need to press the "Start Login Entry" button and put an Employee ID forwhich login he/she wants to do. Then keep the face of the employee in front of the camera. The system takes the image of the face through the camera and these images will then get matched with the database stored face images. If any image gets matched with any stored images then it collects all others stored images from the database and displays those on respective text fields and shows message login entry that has been done in the Figure 8.

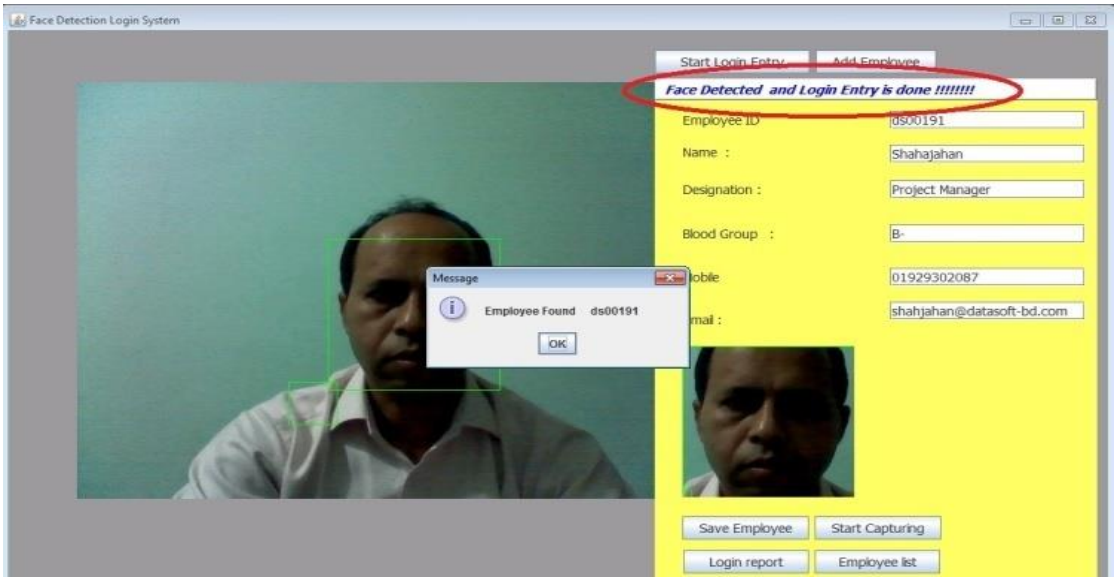

Figure 8. Valid Login entry

5.1. Performance analysis

The performance of the system depends on the capacity of the server, camera and working environment. It takes 6-10 seconds on face recognition and 10-15 seconds for face matching or login on a Normal computer while it works with high performance on a high configured server such as HP 9 G server, here it takes 2-3 seconds on face detection and 4-5 seconds on the login system by matching the face with existing images.

5.2. False rejection

Sometimes when people try to login with a sweated face or bearded face, the system cannot recognize, in that case, it returns false rejection. Besides this, if people face change for various reasons such as *sickness, hungriest,* in that case, it does false rejection.

5.3. False acceptance and matching thresh hold

We have used ORB Algorithm for image matching with threshing hold for minimum feature matching. System checks features of face images, when the minimum matching distance becomes more than thresh hold 10 (>10), it rejects and less than or equal to (<=10), then it accepts as shown in Figure 9. From the system, a user can find the Login report and List of Employees as like as below Figure 10 and Figure 11.

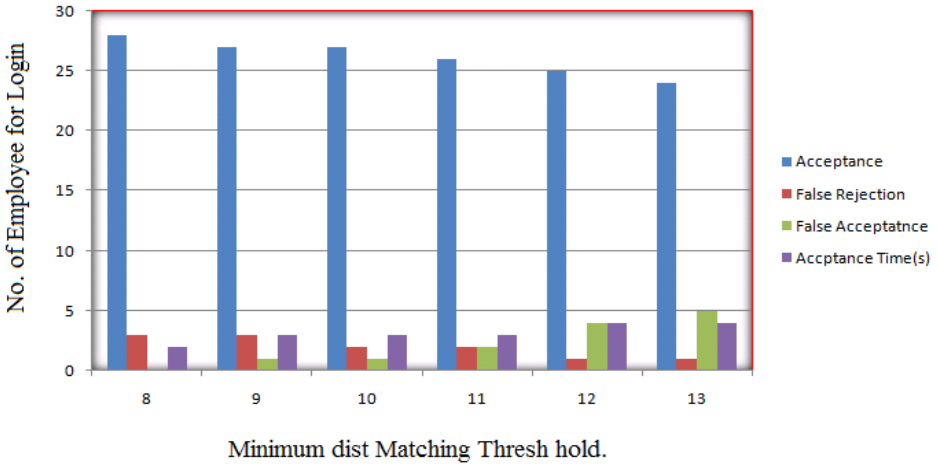

Figure 9. The graph of acceptance, false rejection, false acceptance, and performance based on minimum dist. matching thresh hold

Employee List

Print date: 07-Feb-2019 3:11 PM

Employee Id	Name	Designation	Blood Group	Mobile No	E-mail id
ds0010	Mr. Alam	GM	B+	01819225544	malam@gmail.com
ds00125	Ms. Chy	DGM	A-	01713548257	chy212@yahoo.com
ds00191	Mr. Shahjahan	Project Manager	B-	01929302087	shahjahan@datasoft-bd.com
ds00428	Mr.Md Hanif Bhuyan	Asst DBA	B+	01911434117	hanif.bhuy@datasoft-bd.com
ds00353	Mr.Shafiqul Haider	Sr. Admin	O+	01711702079	faisal@gmail.com
ds00396	Mr.Shadat	Software Developer	O-	01916688503	shadat@yahoo.com
ds00544	Mr.Anamul Hoque	Manager Operations	AB+	01819538742	moin@ datasoft-bd.com
ds00382	Mr.Abdul Awal	Software Engineer	O+	09238234	abdul.awal@datasoft-bd.com
ds00291	Ms.Khalan Nandi	Software Engineer	B+	01819525759	khl.nan@gmail.com
ds00271	Ms.Farjan Boby	Software Developer	B-	01717225588	farjan.boby@gmail.com
ds00127	Ms.Dalia Fouzi	Web developer	O-	01611336879	dfozi@datasoft-bd.com

Figure 10. List of employees

Login Report

Print date: 10-Feb-2019 5:25 PM

Date: 09-02-2019

Emp Id	Name	Designation	Login Time	Logout Time
ds00191	Mr. Shahjahan	Project Manager	8:50 am	5:15 pm
ds00428	Mr.Md Hanif Bhuyan	Asst DBA	8:51 am	5:15 pm
ds00125	Ms. Chy	DGM	8:52 am	5:06 pm
ds00353	Mr.Shafiqul Haider	Sr. Admin	8:53 am	5:19 pm
ds00010	Mr. Alam	GM	8:55 am	5:17 pm
ds00396	Mr.Shadat	Software Developer	8:55 am	5:10 pm
ds00291	Ms.Khalan Nandi	Software Engineer	8:56 am	5:16 pm
ds00271	Ms.Farjan Boby	Software Developer	8:57 am	5:15 pm
ds00544	Mr.Anamul Hoque	Manager Operations	8:57 am	5:18 pm
Ds00127	Ms.Dalia Fouzi	Web developer	8:58 am	5:21 pm
ds00382	Mr.Abdul Awal	Software Engineer	8:59 am	5:20 pm
			Total 11	

Date: 10-02-2019

Emp Id	Name	Designation	Login Time	Logout Time
ds00191	Mr. Shahjahan	Project Manager	8:46 am	5:20 pm
ds00428	Mr.Md Hanif Bhuyan	Asst DBA	8:50 am	5:05 pm
ds00353	Mr.Shafiqul Haider	Sr. Admin	8:50 am	5:06 pm
ds00125	Ms. Chy	DGM	8:52 am	5:06 pm
ds00271	Ms.Farjan Boby	Software Developer	8:54 am	5:13 pm
ds00544	Mr.Anamul Hoque	Manager Operations	8:54 am	5:14 pm
ds00396	Mr.Shadat	Software Developer	8:55 am	5:21 pm
ds00291	Ms.Khalan Nandi	Software Engineer	8:56 am	5:07 pm
ds00382	Mr.Abdul Awal	Software Engineer	9:00 am	5:21 pm
Ds00127	Ms.Dalia Fouzi	Web developer	9:00 am	5:07 pm
			Total 10	

Figure 11. Login report

6. CONCLUSION

In this research, we have developed a Smart Login Systems using Face Detection which is very efficient for any organization. We believe that organizations will be benefited by using this application because of easy access to this application. We have completed the research using different types of algorithms mostly the ORB algorithm to make it secure, faster and efficient. We have tested different users to make it more effective and error-free.

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