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Attendance Management System Using Hybrid Face Recognition Techniques

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***Abstract*— Attendance recording of a student in an academic organization plays a vital role in judging students performance. As manual labor involved in this process is time consuming, an automated Attendance Management System (AMS) based on face detection and face recognition techniques is proposed in this paper. The system employs modified Viola-Jones algorithm for face detection, and alignment- free partial face recognition algorithm for face recognition. After successful recognition of a student, the system automatically updates the attendance in the excel sheet. The proposed system improves the performance of existing attendance management systems by eliminating manual calling, marking and entry of attendance in institutional websites.**

***Keywords*— FaceDetection; Face Recognition; Viola-Jones algorithm;Alignment - free Partial face recognition algorithm; Attendance Management Systems**

I. INTRODUCTION

Every organization has adopted its own method for AMS. Some continue with the traditional method for taking attendance manually while some have adopted the biometric techniques. The traditional method makes it difficult to verify students one-by-one in a large classroom environment. Moreover, the manual labor involved in computing the attendance percentage becomes a major task. The Radio Frequency Identification (RFID) helps to identify a large number of crowds using radio waves [1]. It has high efficiency and hands-free access control. But it is observed that it can be misused. An automatic biometric system would indeed provide the solution. They include fingerprints, eye retina, voice, etc. However, each biometric method has its own advantages and disadvantages.

Rashid et al. [2] proposed biometric voice recognition technology using voiceprints of an individual to authenticate. This system is useful for people having difficulty in using hands and other biometric traits. However, this system is sensitive to background noise. Also, the voice of the person tends to change with age. The voice recognition system may not accurately identify the person when he/she is suffering from throat infection or flu. Thus, this system is not reliable.

Retina scanning uses the unique blood vessel pattern of the human eye for verification. This pattern remains the same and is not affected by aging as well [3]. However, this device can be used by only one person at a time. It proves to be time-consuming for a large crowd. This equipment also requires the person to be in close contact with it for authenticating. Since it is open for public, it is susceptible to be vandalized. Alternately, optical sensors are used for scanning the fingerprints of an individual [4]. This system is most commonly used in every organization because of its high reliability. However, the optical sensor can be used only one at a time which tends to waste a considerable amount of time for large crowds. The optical sensor comes in direct contact with the student. It is exposed to high risk of getting dirty or damaged.

The biometric system is efficient, reliable and provides a high level of security when compared to the traditional authentication methods. However, these systems offer some disadvantages as well. Most of the devices are unable to enroll some small percentage of users, and the performance of the system can deteriorate over time. To overcome these disadvantages face recognition based authentication techniques are developed. Face recognition technology involves scanning the distinctive features of the human face to authorize the student.

Section II presents literature survey on face recognition based Attendance Management Systems (AMS). Section III describes the proposed Attendance Management System (AMS). Section IV presents the implementation results and Section V concludes the paper.

II. LITERATURE SURVEY

A lot of time can be saved by the lecturers with automated Attendance Management System (AMS), where the attendance can be updated by capturing the images of the students by a high definition camera without the human intervention.

Visar Shehu and Agni Dika et al. [5], have used real-time face detection algorithm which has been integrated on Learning Management System (LMS). This system automatically detects and registers the students attending the lecture. The approach uses a non-intrusive digital camera installed in the classroom, which scans the room every 5 minutes to capture the images of the students. HAAR classifier is used for face detection. For face recognition, Eigen face methodology is implemented. However, a drastic change in the student's appearance causes false recognition of

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the student. The students are required to pay attention to the camera while capturing images.

Naveed Khan et al. [6] proposed a method that uses Viola-Jones algorithm for face detection and Eigen face methodology for face recognition. However, cropping of images is required after the face detection process in order to recognize the faces of the students. Yunxiang Mao et al. [7] performed the multi-object tracking to associate detected faces into face tracklets. Jonathan Chin et al. [8] performed experiments by placing webcam on the laptop to continuously capture the video of the students. At regular time intervals, frames of the video are captured, and used for further processing. Viola-Jones algorithm is used for face detection due to high efficiency. Eigen face methodology is used for face recognition. However, the students are required to remain alert as the Eigen face methodology is not capable of recognizing the titled faces captured in the frames. Also, a small classroom has been used due to the limited field of view of the webcam used on the laptop.

Another AMS proposed by Muhammad Fuzil et al. [9] uses HAAR classifier for face detection and Eigen Face methodology for face recognition. This system is intended only for frontal images. Moreover, the faces which are not detected by the HAAR classifier are required to be manually cropped, which results in reduced overall efficiency of the system. Rekha A.L. et al. [10] proposed a method that uses Viola-Jones algorithm and correlation method for face detection and face recognition respectively. However, in the images where multiple people are captured in the same or different sequence, the face recognition efficiency is very low.

All the existing automated attendance systems are proved effective only for frontal images. This paper presents an AMS that can improve the performance of the existing automated systems, as it is efficient in detecting the partial faces. It employs modified Viola-Jones algorithm for face detection, and alignment- free partial face recognition algorithm for face recognition.

Section 3 describes the proposed Attendance Management System (AMS). Section 4 presents the implementation results and Section 5 gives conclusion.

III. PROPOSED METHODOLOGY

In the proposed method, a high resolution camera is placed on the top of the blackboard as shown in Fig. 1. The collected images are transmitted to the server where they are stored and real time processed as shown in Fig 2.

The face detection method proposed by Viola-Jones et al. [11] is used due to its high accuracy and low false detection. The image of the students captured from camera located at the top centre of the blackboard at fixed intervals, is first pre-processed. It is converted to gray scale before performing the face detection. The Viola-Jones method uses integral images to compute the features which classifies the images and uses Adaboost learning algorithm to select important features from the potential features computed. Efficient classifiers are formed and then combined to form a cascade to eliminate background regions of the image, so that computational time is spent on face regions.

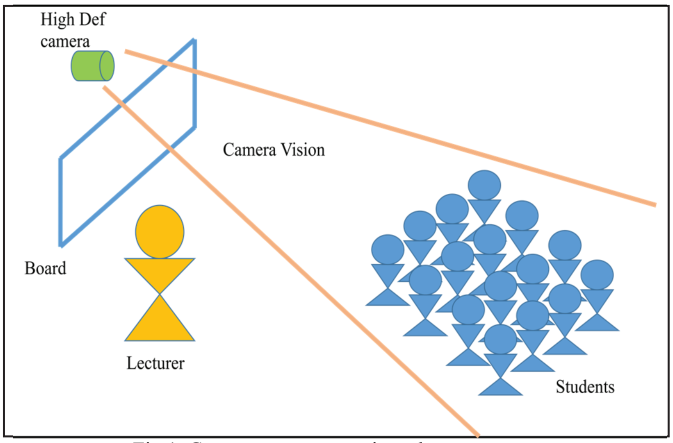


Fig 1. Camera arrangement in a classroom

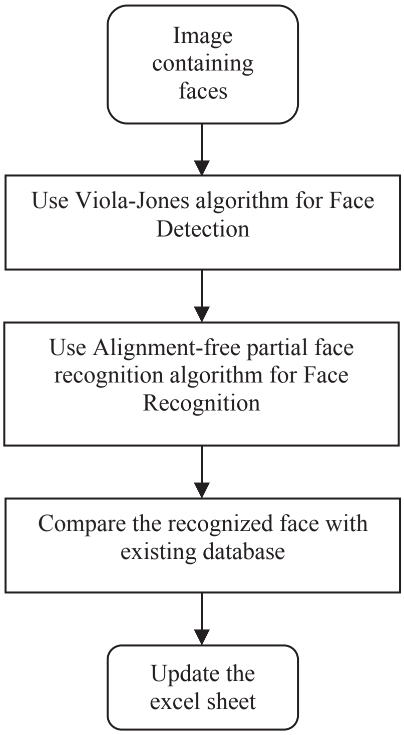


Fig 2. Flowchart of the proposed AMS

The advantages of using Viola-Jones algorithm [11] are:

i) Extremely fast feature computation

ii) Efficient feature selection

iii) Instead of scaling the image, it provides the scaling of the features

After performing the face detection, boundary boxes are inserted at the detected faces. The detected faces are then passed through a filter to determine their size. If the detected faces are found to be in between *30x30* to *200x200*, the detected faces are cropped and stored for face recognition. These steps are repeated until the lecture has ended.

The faces once detected are sent to the Alignment-free partial face recognition algorithm for recognition [12]. The advantages of the Alignment-free partial face recognition algorithm are:

i) No pre-alignment of the face required

ii) Images can be captured without the need of student's attention

iii) The algorithm can work under occlusion, pose variation and extreme illumination.

The categorization of the partial faces in the proposed method includes:

i) External occlusion: This includes the blocking of a face by other faces or objects in the image.

ii) Self-occlusion: This includes the blocking of a face due to non-frontal pose.

iii) Facial accessories: This includes the blocking of a face due to the use of facial accessories like sunglasses, hat, scarf, and mask.

iv) Limited Field of View (FOV): This includes the faces which are partially out of camera's FOV.

v) Extreme illumination: This includes the images in which the facial area is gloomy or highlighted.

vi) Sensor Saturation: This includes the underexposure or overexposure of the facial area in the images.

This algorithm employs Multi-Key point Descriptor (MKD), where the faces are represented by sparse representation and by a large dictionary of gallery descriptors. Further, the method uses Gabor Ternary Pattern (GTP) for robust and discriminative face recognition. In the MKD approach, salient feature points and the descriptors for each feature points are extracted without pre-alignment. An advantage of MKD is its robustness. Due to the robustness of MKD, the descriptors of partial faces and the holistic faces does not change.

Multi-Keypoint Descriptor (MKD) is used for the dictionary as well as the probe image. A probe image is an omnidirectional, high dynamic image that records the incident illumination at a particular point in space. Multi-task sparse representation is done on probe images. Then, Sparse Representation Classification (SRC) approach [12] is used for face recognition

This method includes Gabor Ternary Pattern (GTP). Each column of the dictionary is related to the one corresponding gallery image. This method uses a descriptor of variable size to represent each face. A large number of descriptors are used to compose the dictionary of the images. This makes it possible to sparsely represent probe image. Furthermore, this algorithm requires a single training sample to cover all possible variations in illumination for each image. This process is performed irrespective of whether the face is holistic or partial.

Multi-Keypoint Descriptor satisfies the following principles:

i) Alignment free representation

ii) Variable length descriptors

In the MKD approach, salient feature points and the descriptors for each feature points are extracted without pre-alignment. An advantage of MKD is its robustness. Due to the robustness of MKD, the descriptors of partial faces and the holistic faces does not change.

III.1. CanAff detector

This is an edge based detector that finds more detectors for face images. The affine invariant shape adaptation method has the advantage of making the images more robust to pose variations.

The CanAff detector works in the following manner:

i) Extraction of edges with a Canny edge detector.

ii) This is followed by a scale invariant neighbourhood for each edge point.

iii) The detected local region is adapted to be affine-invariant shape.

iv) Each detected affine invariant region is enclosed with an ellipse $x^TMx=1$, where M is defined as

$M=[a\ \ b,\ \ b\ \ c]$, are estimated from the affine-invariant neighbourhood.

v) All the detected ellipses are normalized by the affine transformation $x'=M^{1/2}x$.

vi) The output regions are cropped to 40x40 pixels

vii) To combat for illumination variations, normalization of pixels is carried out within the range [0,1] by clipped Z-score normalization. This is done by linearly stretching the pixel values into [0,1] by mapping between $(\mu-3\sigma)$ to 0, and $(\mu+3\sigma)$ to 1.

III.2. Gabor Ternary Pattern Descriptor

A Gabor filter is then applied to each patch of the image after the normalization of the detected regions to a fixed size. The Gabor Filters are robust enough to overcome the illumination variations. The Gabor kernel is defined as,

$$\Psi_{\mu,y}(x,y) = [(\|k_{\mu,v}\|^2) \div \sigma^2]\ \exp[-(\|k_{\mu,v}\|^2 \|z\|^2) \div 2\sigma^2] \times \{[\exp(ik^T_{\mu,v})] - [\exp(-\sigma^2 \div 2)]\} \ldots\ldots\ldots\ldots (1)$$

where, μ = orientation of the Gabor kernel

v= scale of the Gabor kernel

$z=(x,y)^T$

The wave vector is given by,

$$k_{\mu,v} = (k_v \cos\varnothing_\mu\ ,\ k_v \sin\varnothing_\mu)^T \ldots\ldots\ldots (2)$$

Due to the relative small size of the image, Gabor kernel is processed at $v=0$ i.e. single scale and four orientations ($\mu\in\{0,2,4,6\}$), for the angles 0^o, 45^o, 90^o and 135^o with $\sigma=1$. Only odd Gabor kernels are used as they are sensitive to edges. For each pixel (x,y) in the normalized region, there are four Gabor filter responses

$$F_i(x,y) = G_i(x,y) * I(x,y)\ ,\ i = 0,1,2,3 \ldots\ldots\ldots\ldots \ (3)$$

where, $G_i = \text{imag}(\Psi 2i,0)$ is the ith order Gabor kernel,

$*$ = convolution operator

The combined output of the four filters is given as,

$$GTP_t(x,y) = \sum_{i=0}^{3} 3^i\ [(f_i(x,y) < -t) + 2(f_i(x,y) > t)] \ldots\ldots (4)$$

t is a positive threshold. GTP encodes local structures from the responses of odd Gabor Filters in four different orientations [13]. There are a total of 34= 81 different GTP patterns. Figure 3 gives the block diagram of the GTP descriptor.

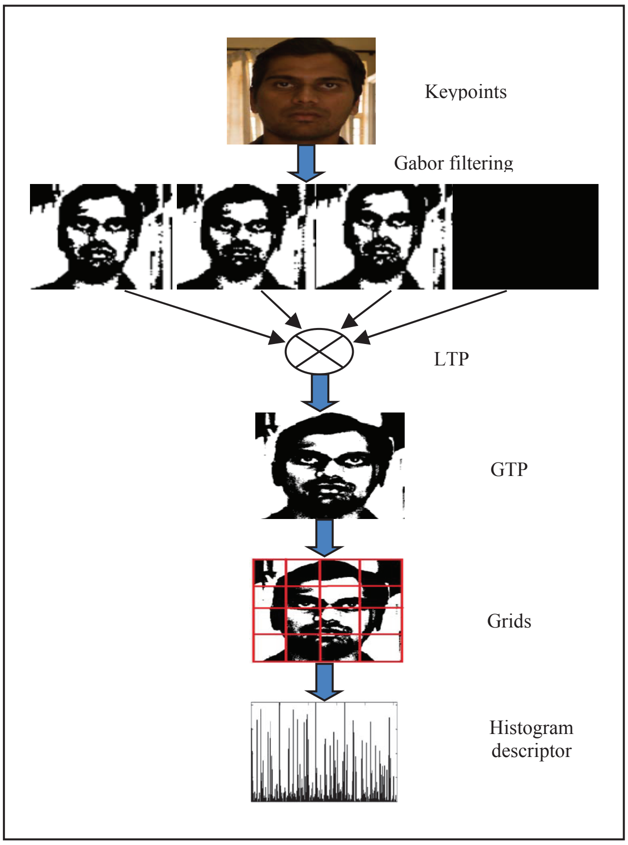


Fig 3. Block diagram of GTP descriptor

The four corresponding pixels in the four Gabor response images form a GTP pattern. The 40x40 region is further divided into 4x4=16 sub grid cells, each of size 10x10 pixels. A histogram is calculated for each grid cell. Thus, GTP performs better in uncontrolled scenarios.

III.3. Dictionary construction

For each image an MKD representation is been used. Suppose kc keypoints are detected for a particular image c. The corresponding kc GTP descriptors is an M-directional vector.

$$D_c = (d_{c1}, d_{c2}, \ldots\ldots, d_{ckc}) \ldots\ldots\ldots\ldots (5)$$

Thus for each image c, a sub-dictionary of size Mxkc is created. For all the images, the dictionary is constructed as,

$$D = (D1, D2, \ldots\ldots, Dc) \ldots\ldots\ldots\ldots (6)$$

Any descriptors haven been derived from the probe image can be expressed by the sparse linear combination of the dictionary D.

III.4. Sparse representation

Consider a probe image with n descriptors,

$$Y = (y1, y2, \ldots\ldots, yn) \ldots\ldots\ldots\ldots (7)$$

The sparse representation of the above equation can be formulated as,

$$x = \arg\min_x \sum_{i=1}^{n} \|xi\|_o \text{ s.t } Y=DX \ldots\ldots\ldots\ldots (8)$$

where, $X = (x1, x2, \ldots\ldots, xn)$

$\|\ .\ \|_o$ represents the l0 norm of the vector. However, this results in an NP-hard solution. The sparse signals can be recovered using the l1 minimization. The l1 minimization problem can be defined as,

$$X = \arg\min_x \Sigma n\ i=1\ \|xi\|_1 \text{ s.t } y_i=Dx_i \ldots\ldots\ldots\ldots (9)$$

Considering the equation 9 for solving each probe descriptor yi ,

$$\chi i = \arg\min_{xi} \|xi\|_1, \text{ s.t. } yi = Dxi\ ,\ i=1,2,\ldots,n \ldots\ldots\ldots\ldots (10)$$

The sparse equation used to recognize the probe image can be defined as,

$$\text{Min}_{rc}(Y) = (1/n) \sum_{i=1}^{n} \| yi - D_c\delta_c(\chi i) \|_2^2 \ldots\ldots\ldots\ \ (11)$$

where, δc selects the coefficients corresponding to c. The unknown probe image can be recognized using equation 10 and 11.

III.5. Filtering

At this stage, both the face detection and face recognition algorithms are combined. Each time a student is recognized, the system will award a point to the corresponding student. This will continue till the lecture has endedOnce the face is recognized, it is compared with the existing database which is a collection of different views including front view, side view and down view of each student.

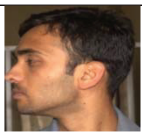
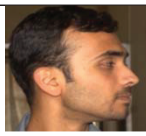
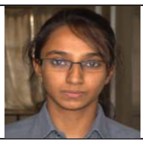
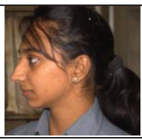
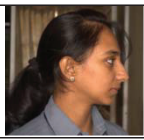
IV. RESULTS

The results section includes the following:
i) Enrolment of student's faces for database creation
ii) Face detection
iii) Face recognition
iv) Updating of excel sheet

i) Enrolment of student's faces for database creation

Initially, a database for 20 students is been created. This helps to match the recognized faces from the existing photographs stored as database. The database consists of a range of different poses of students at different angles. The college at the time of admission takes pictures from every student, which later is stored in the database. The database is then trained to identify the students eve if there are gradual changes in the appearance in a student. The name of the student along with the University Seat Number is also recorded.

Table 1: Database creation of students with different poses

Front view	Left view	Right view
		
		

ii) Face detection:

The camera used here is iBall CHD20.0 webcam which has a resolution of 20 Mega pixels. For every 20 minutes a frame of the classroom is captured. So in an hour, 3 frames are captured. The results for face detection after the application of Viola-Jones algorithm is shown below:

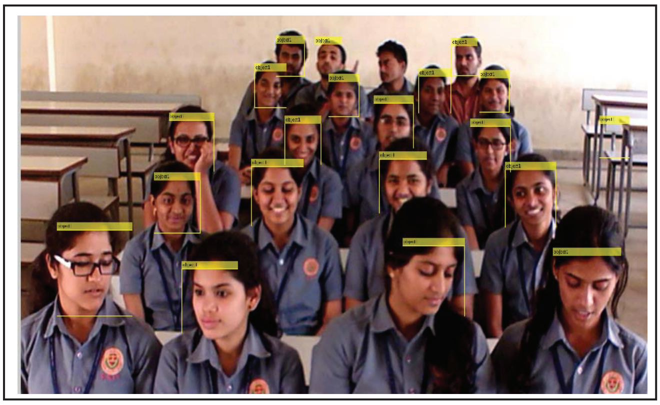


Fig. 4 Face detection results for frame 1

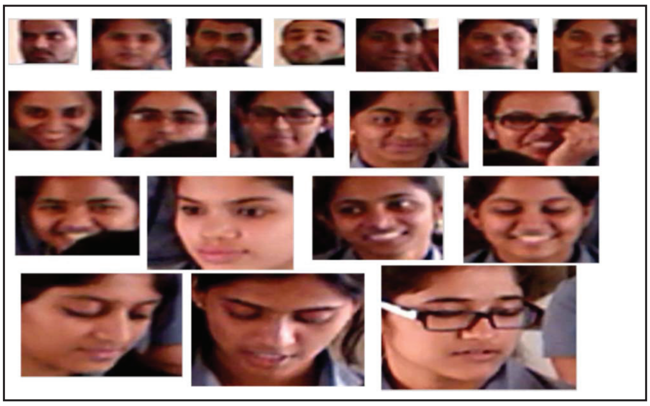


Fig. 5 Cropped faces for frame 1

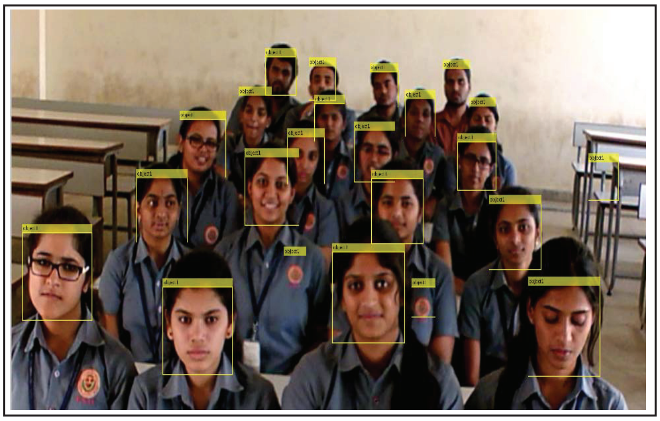


Fig. 6 Face detection results for frame 2

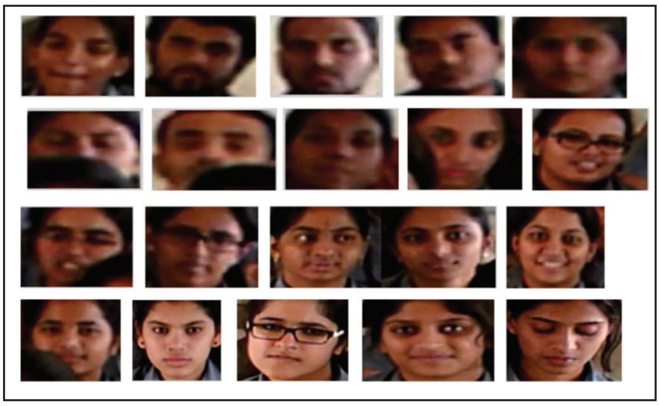


Fig. 7 Cropped faces for frame 2

Fig. 8 Face detection results for frame 3

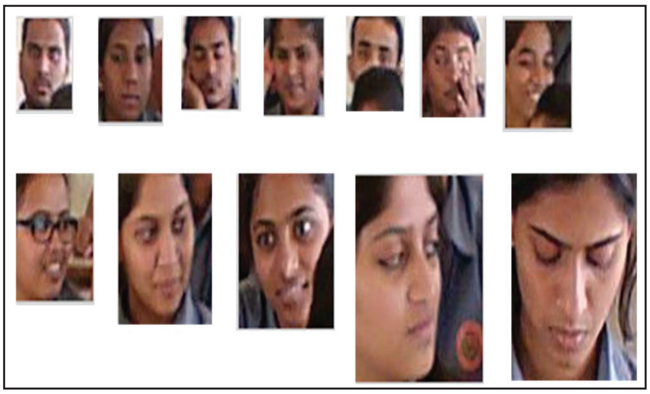


Fig.9 Cropped faces for frame 3

Table 2. The percentage of detected faces in each frame

Frame number	Number of students detected	Percentage
1	19/20	95%
2	20/20	100%
3	12/20	60%

The number of students detected depends upon their pose variation. Frame 2 gives the highest percentage of students detected while frame 3 gives the lowest percentage. It also depends upon the attentiveness of the students during class hours. Once a student's face is detected, the faces are stored as the training set for the database of that particular student. This is necessary as the student may have different appearance each day. The algorithm could also detect partial faces of the students.

iii) Face recognition:

The cropped faces are then given as an input to the face recognition algorithm. The efficiencies obtained for the above frames are listed below:

Table 3. The percentage of recognized faces in each frame

Frame number	Number of students recognized	Percentage
1	9/19	47.36%
2	14/20	70%
3	5/12	41.67%

Again, frame 2 has the highest efficiency of 70% while frame 3 has the lowest efficiency of 41.67%. Thus, we can say that the efficiency of face recognition depends upon the number of faces detected. The higher the detected faces the higher the face recognition rate.

iv) Updating of excel sheet:

The correctly recognized students are marked against their name in the excel sheet.

V. Conclusions

To eliminate the manual labor involved in recording attendance, an automated Attendance Management System (AMS) based on hybrid face detection and face recognition techniques is proposed. The popular Viola-Jones algorithm and alignment- free partial face recognition algorithm together are used for face detection and recognition. The proposed system improves the performance of existing attendance management systems in the following ways:

i) Automatic tracking of the records of the students
ii) Minimizing the manual labor and pressure on the lecturers for accurate marking of the attendance
iii) Minimizing the time required for marking attendance and maximizing the time required for actual teaching process
iv) Increase the efficiency of the overall system
v) Improving the security [14]

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