Relative Evaluation of Face Recognition based Identification and Indexing System

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ABSTRACT

In our paper we present a strong alternative to existing attendance and identification systems and inspect the efficiency & reliability of facial recognition & detection in the field of real-time attendance systems. Facial detection & recognition system (specifically) is one of the widely used Biometric authentication systems out there in the industry and can also be deployed for mass indexing documentation for schools, colleges, offices & other public places. Our System uses Haar Cascade classifier implemented using python and OpenCV in real time to index faces and gives an accuracy of 85-90% with minimal hardware dependency.Such system can not only control proxies but can also act as an better alternative to control Covid Virus spread as compared to other biometric systems requiring physical contact.

Keywords: Comparative Evaluation • Face Recognition • OpenCV • Human Face Indexing • Haar-Cascade Classifier • K-Nearest Neighbours • Linear Binary Pattern • Contactless Identification .

1) INTRODUCTION

Conventional indexing is an extra encumber to faculties & regulatory bodies in schools, colleges & sometimes, offices. Ethical Discrepancies, like proxies, are also prevalent in them. Consequently, many institutions have started using other smart alternatives for recording & managing attendance. Some of the smart systems are RFID (Radio Frequency Identification), fingerprint identification, iris scanning & so on. Nevertheless, these systems are queue-based, consume more time and are obstructive in nature. Facial recognition-based systems are relatively heedless to various facial expressions & faces are a very specific biometric feature. This system is built on two main properties, Face Detection and Face Identification. The latter is a 1:1 matching problem, it differentiates the face image with the image that is already stored in the database, whereas the former is a 1:N matching problem that compares a query face. The ultimate motive of this model is to build a transparent, hassle-free & flawless indexing system.

As one of the most successful applications of image analysis and understanding, face recognition has recently received significant attention, especially during the past several years. Face recognition has the benefit of being a passive, unintrusive system to verify personal identity in a “natural” and friendly way. At least two reasons account for this trend: The wide range of commercial and law enforcement applications, and the availability of feasible

technologies after 30 years of research. Nowadays, real-time systems and specifically, facial recognition systems are gaining huge popularity & are being used extensively. In this paper, we brought forward a system which detects the faces of attendees in real time & marks their attendance only if the detected face matches with the face data stored within the database.

2) RELATED WORKS

In June 2021, Mr. P. Anvesh implemented a “Face Recognition Door Lock System using Raspberry Pi "[1]. Although it uses a micro-controller like raspberry pi, the face detection technique used is Haar Cascade classifier technique to detect face features. For pre-processing and features extraction, the LBPH(Local Binary Pattern Histogram) algorithm is utilized. With the microcontroller the rest of the door locking system is carried out.

Published in April of 2019 by Senthamizh Selvi.R [2] is “Face Recognition Using Haar - Cascade Classifier for Criminal Identification”. Raspberry pi is mainly for criminal identification purposes,but the accuracy rate achieved in this is 85-95%. The Haar Cascade classifier to classify human faces and LBP are the two main components implemented. The haar classification feature takes in 200 features out of 6000 features which yields the mentioned recognition rate.

Sarika Raga implemented the “Real Time Face Recognition of Human Faces by using LBPH and Viola Jones Algorithm” [3] in 2018. This method uses com fusion and recognition techniques and is done using Viola Jones algorithm. Algorithm is applied for Face detection, feature extraction which is done by a LBPH technique and Euclidean Distance Classifier.It ultimately helps in face recognition. Their work has a recognition accuracy rate of about “85%-95%”. The Algorithm they derived can be further modified and rescripted to favour in all conditions such as brightness, in case of twins, big beards, wearing goggles, in low light conditions for night time.

In 2017, Li Cuimei,Qi Zhiliang [4] applied a human face detection algorithm by combining three weak classifiers. Along with a Haar cascade classifier for basic human face detection, the algorithm also combines three weak classifiers to remove some false positive cases. Skin hue histogram, eye detection and mouth operation classifiers are the three weak ones which helps in rectifying the false positive cases. This in combination yields a sufficiently high detection rate. This method generates a position prediction value (PPV) to about 78.18% - 98.01%. Their algorithm can be reworked to recognize human faces of multiple races and different lighting conditions. It reduces the delay in detection and recognizing various faces among different images of people.

3) STUDY ON RELATED ISSUES WITH THE EXISTING SYSTEMS

In this 21st Century conventional Identification system holds many limitations and appears to be a time-consuming and hassling task. On a smaller level for institutes, it is an extra burden for faculties to manually call out names of students, thus wasting precious time of the class through a system which is also prone to proxies. These systems are not also suitable in the Current Ongoing Coronavirus pandemic scenario as physical contact or close proximity to scanners may act as a site to spread the virus.
Though many related work and development have been made in the field of facial recognition, a robust model which could replace other existing systems could not be brought forward due to mainly lack of ease of use ,cost inefficiency of these systems,and accuracy challenges.Our Study of the Indexing and Attendance System Market revealed some flaws, users of conventional identification system face that if solved by a model of facial biometric indexing system could change the dynamics of its market share.Below are some parameters of Evaluation and solution:

- **Seamless Experience:** Users revealed conventional systems wait time creates hindrance in user's experience and utilization of time and said that they would prefer a Seamless walk-in identification where a person can just pass through the camera vision area to get themselves registered or identified.

- **Proxy Control:** In a conventional attendance system like manual or RFID a person can easily give proxy for others which in turn is a challenge for system administrator but this problem can be solved in facial identification system as it can be integrated with IR sensors and camera recording/playback options so that no proxies can be given for a particular employee or a student .This in turn increases the motivation in students to maintain a good attendance record and in turn studies say that this leads to better grades as mentioned in study by Durden, Garey.[5]

- **Contactless alternative in Covid Scenario:** In any systems where physical contact is required like fingerprint attendance systems or other touch id systems there is a huge chance of it acting as an infection spreader because a huge number of people have to touch the scanner for fingerprint recognition. Thus these types of systems are not Hygienic and are unsuitable to be used in pandemic times as explained by Okereafor K, Ekong I in their paper .[6]

- **RFID Systems Hazard:** In systems like RFID(Radio Frequency Identification) the problems of giving proxy still remain but also pose the hazard of interference with other electromagnetic devices.These systems can also be swapped,cloned or disabled which makes them vulnerable and leads to many security issues with them as pointed out by Neumann, Peter & Weinstein, Lauren. in Risks of RFID.[7]

- **Cost Efficiency and Minimal Hardware requirement:** In earlier systems, dedicated hardware requirement and equipment cost was a huge concern but Facial Recognition identification can overcome this through integrating it by using organizations already present CCTV cameras installed for security. Thus there would be a huge cost cut in this proposed system installation and usage.

Other Surveys and Statistics like by the Centre of Data Innovation in 2018 show 54% of Americans support Facial Recognition and want it for safety screening and public safety[8]. In a survey at the University of Tal 84% students said they were facing problems in the current attendance system and would like to switch to a biometric alternative that is also friendly for students with disabilities.

With a forecast of Facial Recognition Market becoming worth $7.0 billion by 2024 with an annual growth rate of 16.6% done by Issue Wire there is much need of face recognition models of all levels to fill in the demand[9].Our system with an accuracy of 85-90%, not only provides accuracy but also is proxy-free and cost-efficient at the same time and can fully meet the requirements. The facial biometric identification system has set an important benchmark in biometric identification, which can be easily acquirable and is non-intrusive.

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4) PROPOSED SOLUTION AFTER MARKET ANALYSIS

When thinking about face recognition and identification, most people immediately associate it with the security industry. Facial recognition systems are worked upon everyday and solutions to exact identification of faces are being studied and updated extensively. These studies have resulted in work upon face detection methods and the segmentation of certain areas of the face is verified with the help of the system.

Our goal was to design a face recognition system which finds faces in the image frames and extracts those faces. Then, the extracted faces should be correctly identified by the system so that any type of mismatch in attendance could be avoided. Also, implementing face recognition in the time of the pandemic, decreases the rate of human interaction from scanners and attendance sheets. The mechanism of face recognition also tends to remove the idea of standing in a queue and raising hands to manually give attendance. The person can just walk right past the door and the camera will identify the person’s face and automatically send a present output for the person. Also, fingerprint

systems and attendance taken by an individual are also not cost-efficient and take a lot of time and effort. So, a facial recognition system might just be the right solution for not only attendance but also for security purposes in private and government offices and such.

By taking a look at one of the applications of facial recognition system (student attendance in school), initially we need to verify if all the students of the class are registered as a member of the student group by capturing their images and entering certain required details which will be stored in the dataset for later identification. When the time of recognizing the person comes, certain areas of the face will be detected with the help of live streaming from a camera. The captured image frames and the face features detected will be compared with the previously stored images in the dataset. If a facial match is discovered, the respective individual will be noted present for the session.

For accurate identification of faces, multiple images of an individual should be obtained from different angles. These image frames undergo detection and it is carried out using the implementation of Haar-Cascade Classifier along with OpenCV. Initially, the algorithm needs to be trained to identify faces of humans before applying it in facial recognition. This technique is known as feature extraction. The training data obtained needs to be prepared, then the trained face recognizer should be implemented to correctly predict an individual's face. The training data will take in image frames that will be stored in the dataset. These stored frames are then used for face recognition.

Detection and identification techniques can be influenced by differences in lighting, pose and facial emotions or expression. It is not possible to handle all effects of every method in just one same algorithm. When the recognition process comes to an end, the faces that are correctly recognized by the system will be noted as in attendance and the information of the person being present will be added in the database and the rest unrecognized individuals will be marked as absent. Finally, the absentees will be mailed to the respective faculties regarding their absence. The primary work flow or the architectural representation of the system is shown in the image Fig.1 below.

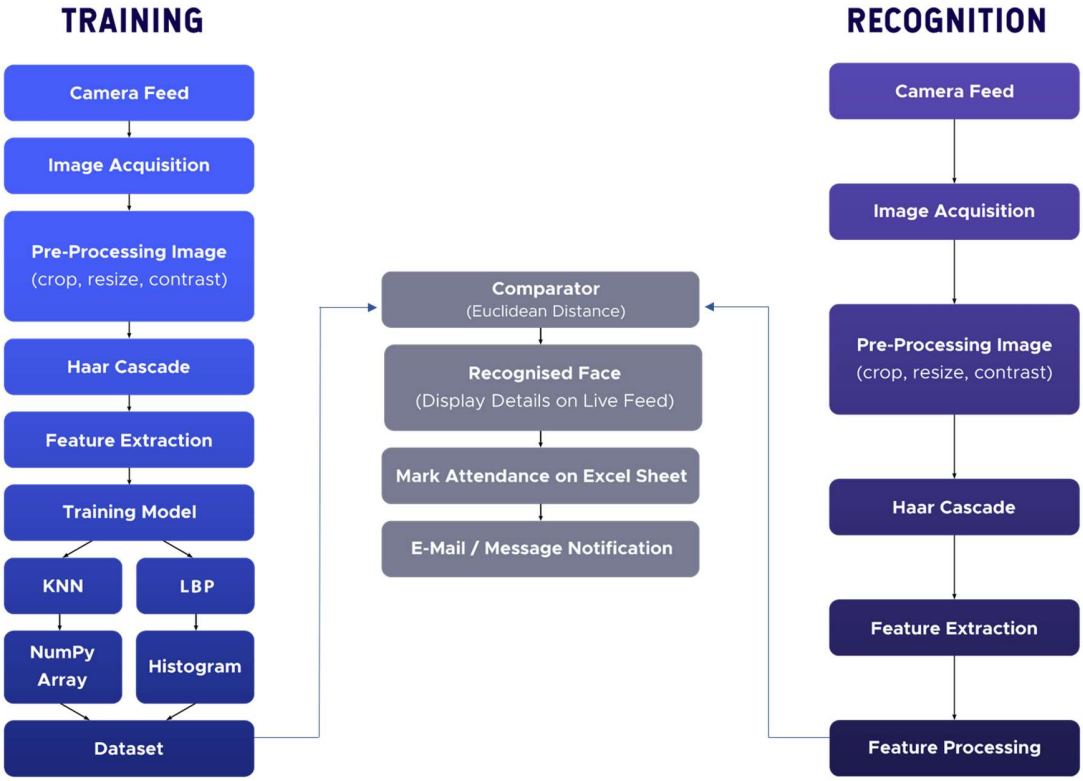

Fig.1 System Architecture

5) METHODOLOGY

There are many steps involved in implementation of such a system ranging from Capturing, raw camera feed, detecting faces, creating dataset, to giving final output insight on excel sheet which have been discussed in detail below.

a) Capturing the frame of the face:

The frontal face images are captured in the form of videos using a High definition (720p) camera or webcam at a specific distance of the user. The captured video needs to be converted into frames per second for easier detection and recognition of the users present in front of the camera and further preprocessed for optimal brightness, contrast and region of interest cropping.[10]

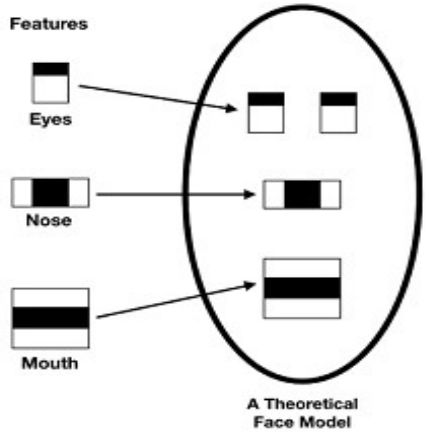

Fig.2 Haar-Cascade Classifier feature concept.

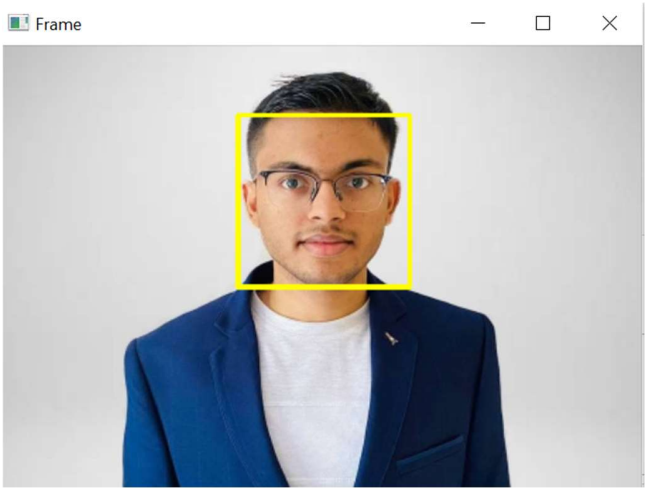

Fig.3 Face Detection for Training

b) Face Detection:

The first part of the workflow is to detect whether a face is present in the camera feed using Haar features, Adaboost ,and cascade classifier and draw a bounding box to show user successful face detection Fig.3 .The following section explains the working of the Haar Cascade Algorithm in a simple and lucid manner.

i) Haar Cascade face detection

Face detection is the process where the image, present as an image input is searched to find any face. Here the Haar-Cascade Classifier method by Viola Jones is used with OpenCV. The Haar-Cascade algorithm (visual representation is shown in the image Fig.2 needs to be trained to detect human faces before the face detection.We have used a Haar cascade model for frontal face to detect faces which can be combined with other haar cascade model to increase accuracy of classifier.The frontal face model contains Haar features trained to detect faces .The features are nothing but convolutional kernels.Each feature is a value obtained by subtracting pixels sum of black part from white .To make this feature calculation fast concept of integral image is used which brings the time complexity down for computing the features to O(1) from O(N^2).

ii) Adaboost

Out of the many pool of features to just select the relevant ones we use Adaboost (algorithm by which features with lowest error in classification of positive and negative of faces in images are given the most weightage)[11] .The paper by Viola Jones states that the with just 200 features one can get an accuracy of 95%.[12].Thus the final classifier which is a strong classifier is a weighted sum of weak classifier.This means individually the weak classifier are unable to classify images but together they can classify with high accuracy.

iii) Cascade of Classifier

This weak classifier further uses cascading to boost performance .Instead of checking all the features from adaboost it checks in stages where each stage acts as a filter. If a region window is rejected in the first stage it is discarded and the check moves on.Thus this helps to reject empty regions in image where face is not present without being computationally expensive.The window which passes all stages is considered as a face region.[13]

Trained Classifier used in our model:

```
haarcascade_frontalface_default

haarcascade_frontalface_alt
```

Functions Used

```
cv::CascadeClassifier::CascadeClassifier(const String & Name of Classifier)
```

DetectMultiScale(arguments)

```
detector.detectMultiScale(gray,scaleFactor,minNeighbors,minSize,
flags=cv2.CASCADE_SCALE_IMAGE)
```

iv) Feature Extraction and saving:

After using the cascade classifier the region of face is cropped and converted to gray scale.From here on our model offers both ways to proceed for face recognition either using LBP or KNN [14]or a pipeline of both so as to get maximum accuracy.At this stage 200 sample images taken realtime at different angles of face is trained in our model. To increase complexity of model number of training images and conditions like lighting,angle of face can be tweaked to get better results.[15]

Functions Used

```
cv::face::LBPHFaceRecognizer::create(radius,neighbors,grid_x,grid,threshold  )
```

v) Model Training And Saving

The detected face gray scale region is first divided into regions.Again each region is processed and compared with its neighbouring pixels.If the pixel is greater than the central pixel it is marked as 1 else 0.This algorithm implementation is shown in Fig.4 [16].Thus thereafter using these 8 binary numbers the histogram of each region is drawn.The final histogram is achieved by combining individual histograms. Finally based on the training images dataset an histogram model is saved for recognition step.

If a user chooses to implement KNN algorithm at the training stage instead of LBP a model is generated from the detected faces by storing the face data as a numpy array which will be compared later using KNN in the implementation stage.

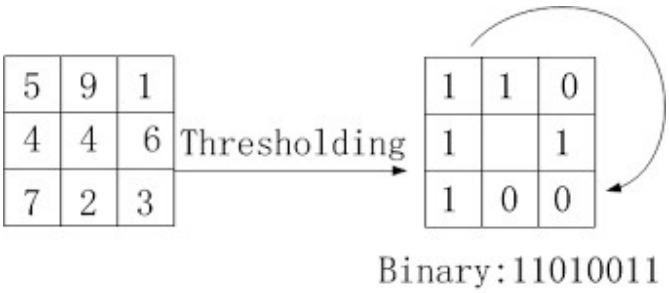

Fig.4 Implementation of Linear Binary Pattern

c) Facial Recognition:

This phase involved detecting the face and mapping them to their data based on similarity index.

i) Detect faces in frame

The same pipeline as explained in sections 5.2 are used in the face recognition phase also where first the whether a face is present in the input image is detected and if so is cropped to the region of interest.Next according to previous input by users at training stage further KNN or LPB model is invoked for facial recognition.The two models working are described below.

ii) Compare Saved model features using LBP or KNN

At this stage the LBP histogram for trained faces that are already present and the histograms of new detected faces are compared.The comparison can be done by many ways like Euclidean Distance ,Chi-Square,Absolute value.We have used Euclidean distance for comparison in our model because of its tested accuracy.This generates a confidence score(lower score is better) for each stored histogram and the one with lowest score is selected as an match.

Similarly K-nearest neighbours (KNN) algorithm which is a simple supervised machine learning algorithm that is used here for image classification. The KNN algorithm captures the idea of similarity based on distance, closeness with mathematics, i.e., distance between the points on a graph. In this algorithm also Euclidean distance has been used as the distance metric to perform the distance between two points on the graph.Thus in KNN the saved faces as numpy array values are compared to the new detected faces for matching.

Euclidean Distance Formula

$$d(x,y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$

Functions Used

```
knn(src)->label,confidence

cv.face_FaceRecognizer.predict(src) ->label, confidence

src:Sample image  label:detected face model number  confidence:distance from
closest predicted model
```

As our algorithm detects all the faces present in camera view and compares them individually it is fully capable of recognizing multiple faces on the go in real time for faster user experience as seen in Fig.5

iii) Thresholding for Unknown Faces

For the case when a face is detected which has not been earlier trained a threshold feature constraining the confidence and euclidean distance is used.The faces having confidence value lying outside this threshold value are considered as 'Unknown' and a visual feedback is shown on the bottom of the face on the screen Fig.6 . Thus this prevents mismatching or verification of untrained faces.

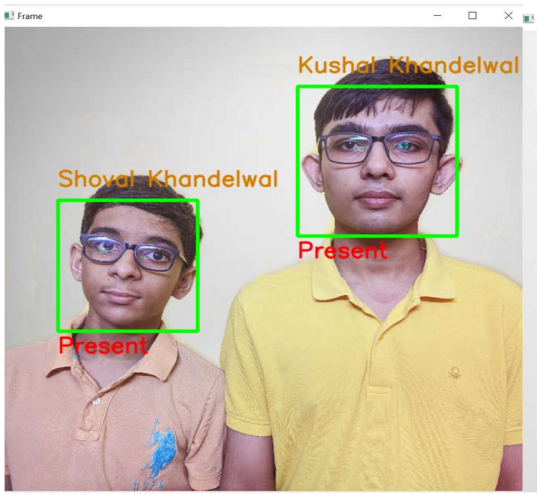

Fig.5 Facial recognition Multiple Face Case in Real Time.

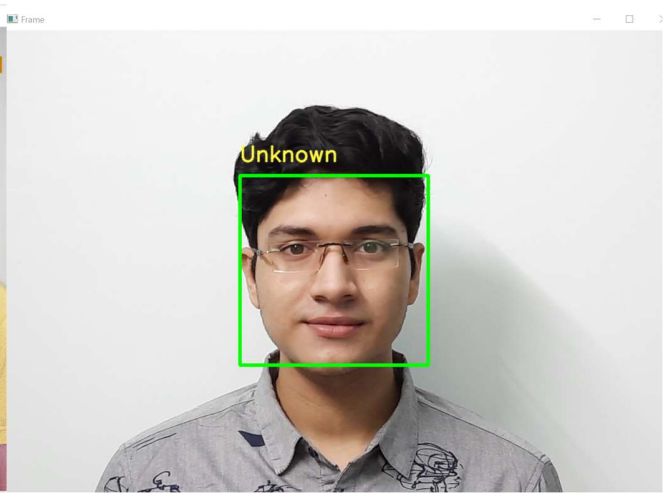

Fig.6 The 'Unknown' face Case.

iv) Attendance Record:

The idea behind using Excel sheet rather than a database model for recording attendance was done because of its ease of use and wide reach even for non technical users so as to make any manual changes seamless .This stage thus involves updating the names of the user into an excel sheet which is mentioned in the image in Fig.7. The registered user will be recognized on the screen, with their name mentioned above their face and 'Present' keyword at bottom for confirmation of the user. At backend the Excel sheet of current date and the cell alongside their name will turn to 'Present' for their attendance, which will be updated and saved simultaneously.But,as for a case if some unregistered user shows his/her face, they will be shown as 'Unknown' on their image as displayed in Fig.6.The excel sheet has also been custom made with relevant pie charts ,statistics and highlighted cells for a better visual understanding and data insight as in Fig.7.For user preferring DataBase model as an option out face indexing system can easily be modified to save the data in databases instead of excel sheets .

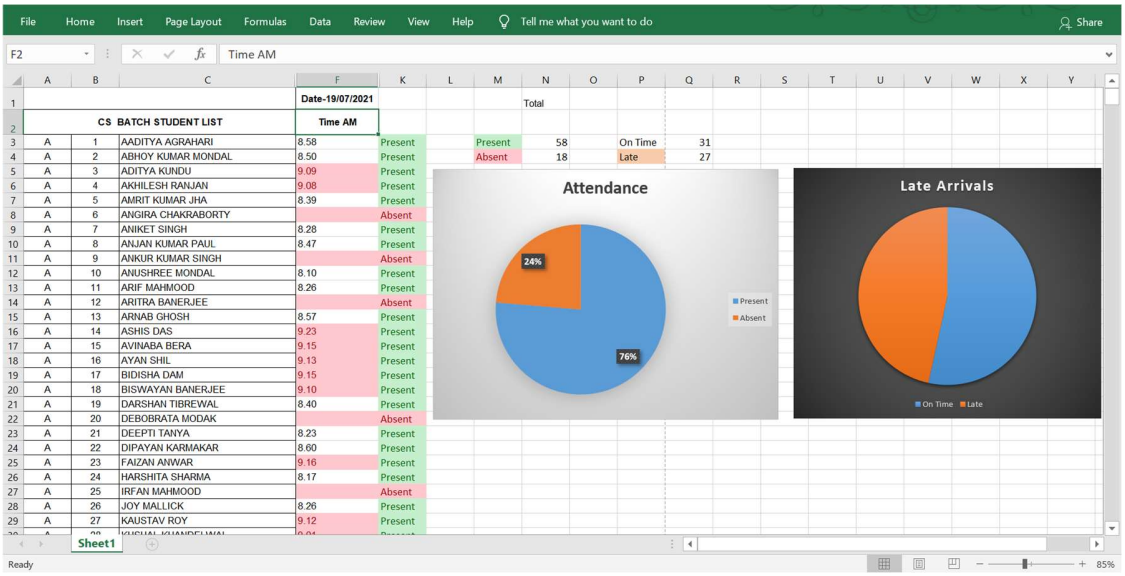

Fig.7 Attendance Excel Sheet Output of Face Identification model Real Time implementation on a class of 76 students.

6) MODEL EVALUATION

The Technical evaluation of our Facial Recognition indexing system parameters as compared to other popular systems being used for Identification.

Parameters	**Face Indexing**	**Fingerprint identification**	**RFID identification**	**Manual attendance**
Accuracy	87%-95%(IR)	98%	85%	70%
False report & Error	5-7%	1-2%	15%*	20-25%
Proxies	<2%**	<2%	10-15%	15-20%
Covid spread rate	Grade 1	Grade 3	Grade 2	Grade 2***
Social Acceptability	High	Medium	Medium	High
Indexing Range	<10 m	≤300 µm	<30 cm	<10 m
Relative Cost	$$	$$	$$$	$

Covid spread rate:

Grade1:Aerosol spread not in close proximity

Grade 2:Aerosol spread due to being in close proximity (less than 1.5 meters)

Grade 3:Spread due to Contaminated Surfaces.

*Based on data of forged RFID cards and wrong triggers.

**Based on data of Facial Detection Camera of 1080p camera integrated with ir sensor.

***Based on data of students in the classroom with normal social distance.

Implementation cost is determined on basis of various market analysis and papers like Performance analysis of biometric recognition modalities.[17]

7) FUTURE SCOPE

The proposed facial recognition system, if implemented properly on a large scale, can completely change how things are conventionally done in the fields it is applied in.

This system will be all the more relevant for times like these, when people are in the middle of an ongoing pandemic and unique ID Cards are required for travelling via bus or rail, especially in countries like India. Physical contact could be completely eradicated if a facial recognition system is used, eradicating the need of particular passes or cards, which would also save a few resources here and there, and most importantly, reduce the risk of infection. It will also help the government save some amount of money and let it invest in more important fields.

In the field of law and order it can work for criminal identification, it will not only help detect petty thefts, but it can also be programmed to detect jaywalkers and other violators. It can also be used in casinos to identify cheaters from and verify members included in exclusion lists.

As biometrics are constantly evolving & this technology has tremendous potential [18], this facial recognition system will overcome its shortcomings with time, as more advanced camera technologies will surely be found.

Proper implementations of this system will unlock endless possibilities, and help boost welfare and development to a great extent [19].

8) CONCLUSION

This system successfully eradicates the discrepancies in the conventional attendance and identification systems. It will help prevent the hassle teachers and office staff are put through every day, and provide them more time to help students understand what is more important, and office employees to work more efficiently and with more enthusiasm.In its implementation cost, it clearly stands out among all its competitor systems.It also proves to be a better alternative compared to other biometric systems requiring physical contact as mentioned by Okereafor, Kenneth & Ekong in Fingerprint Biometric System Hygiene and the Risk of COVID-19 Transmission [20]. We can thus conclude that in the near future the face recognition based indexing and attendance system would emerge as the leading model for identification and indexing among all others.

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