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Facial Recognition Technology in Academic Attendance: A Comparative Study For Real-Time Management

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A R T I C L E I N F O

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A B S T R A C T

In today's academic settings, managing daily tasks like attendance tracking has become increasingly burdensome. Traditional methods of manual attendance taking are inefficient and time-consuming, particularly with growing numbers of students and staff. To address this challenge, various approaches, including face identification systems, have been developed. This research introduces a smart face recognition (FR) system for managing attendance efficiently. The system employs multiple face recognition methodologies such as Local Binary Histogram, PCA/Eigen Face Recognizer, and Fisher Face Recognizer, enhancing system performance. These methods are combined using Ensemble Fusion to improve accuracy. Additionally, the system utilizes Multitask Cascaded Convolutional Network for face detection and attribute extraction. Extracted attributes are matched with stored facial templates to identify recognized faces and mark attendance. Integration with Cloud API facilitates record-keeping. The system also includes a feedback and notification system for process status indication. Results indicate that the proposed system achieves 82.1% accuracy in face recognition and requires minimal time (0.000081s) to predict and mark attendance.

1. INTRODUCTION

In recent years, technological advancements have revolutionized various aspects of academia, particularly in attendance management systems. One of the most promising innovations in this realm is the integration of smart face recognition technology. This technology offers a seamless and efficient solution for real-time attendance tracking, eliminating the need for manual processes and reducing administrative burdens on educational institutions. Traditionally, in MAS i.e. Manual Attendance System the Staff or various HR-Professionals may phase certain experience difficulty in both the approval and keeping up every student record in a classroom all the time. So, for the verification of each and every student or an employee record, every organization or an institute especially HR- Professionals, Administrators or each personal Staff Members must have an appropriate, efficient or a smart system that can consistently maintain the attendance record. An AI-based attendance system, the Elegant Attending Network, addresses the challenges of traditional methods by leveraging AI technology to enhance education quality. With AI's integration into daily life and various educational applications like personalized learning and task automation, universities seek technological solutions to improve education experiences. This system facilitates easier tracking of student and staff performance, handling large amounts of data efficiently (Andrejevic & Selwyn, 2020).

By the use of this AI Facial Acceptance Framework, for an idea behind the hallmark of an attendance is the fashionable approach of attendance

management system as it is more valid & quicker method which cut down the possibility of an intermediary attendance. It further provides apathetic identification of a person by just a random snapshot i.e. being captured from our webcam, and doesn't entail to grasp any exertion for its integrity. It call for two phases i.e. Detection and Identification. For the detection we have used Multitask Cascaded Convolutional Network to detect and locate faces within the image. Our system also uses three different FRModels i.e. based on an OpenCV. These three different approaches in CV are being used for the uprooting of massive pattern group of an attributes, model training & for classification. Later on these extracted features or patterns were then receive or compares with stored face templates or embedding's and determine the identity of the recognized face based on the model's predictions & will automatically update the records on a Google Sheets API. Furthermore, it has some Facial Database for Model Training and Classification.

The whole process consists of certain face recognition classifiers and Computer Vision (server side). The random click of an individual are being captured in terms of a snapshot i.e. feed from our webcam is then dispatch to a network for another inspection, the inserted snap are connected to all the three FR-Models from where these models will be trained and give their predictions. These models will later on also work as a classifier i.e. it compares among a group of instance of an images of every individual candidates & update their attendance. Furthermore; it also draws a boundary around each face it detects. In addition, the system will also exhibit or tag the signature of the detected person in the upper corner of the screen.

2. THEORETICAL FRAMEWORK

In framing the analysis of smart face recognition systems for academic attendance management, this study draws upon several theoretical perspectives and conceptual frameworks that are relevant to understanding the technology's implementation, impact, and implications within educational settings. After conducting content analysis, four descriptive attributes were identified:

- Technology Acceptance Model (TAM)
- Ethical Frameworks
- Surveillance Studies
- Human-Computer Interaction (HCI)

Integration of these four attributes encapsulates the essential information regarding each AI system's role in academic attendance management.

Technology Acceptance Model (TAM): It is widely used theoretical framework in understanding users' acceptance and adoption of new technologies. It posits that perceived usefulness and perceived ease of use are key determinants of users' attitudes towards technology adoption. In the context of smart face recognition systems for attendance management, TAM can help analyze factors influencing stakeholders' acceptance, such as teachers, students, and administrative staff.

Ethical Frameworks: Ethical frameworks, such as consequentialism, deontology, and virtue ethics, provide lenses through which to evaluate the ethical implications of deploying face recognition technology in academic settings. These frameworks can guide the analysis of ethical considerations surrounding privacy, consent, data security, and potential biases inherent in face recognition algorithms.

Surveillance Studies: Drawing from surveillance studies, particularly the concepts of sousveillance (inverse surveillance), panopticism, and the right to privacy, can illuminate the implications of implementing face recognition systems for attendance management. This framework can explore power dynamics, control mechanisms, and the implications of constant surveillance on individuals within educational institutions.

Human-Computer Interaction (HCI): It provides insights into the interaction between humans and technology. It can help analyze the user experience, interface design, and usability issues associated with smart face recognition systems for attendance management. This framework can inform recommendations for improving system usability and user acceptance.

Each selected theoretical framework offers unique insights into different dimensions of the adoption and implementation of Smart Face Recognition Systems for academic attendance management. By employing a multidisciplinary approach, the analysis can provide a comprehensive understanding of the technical, ethical, social, and organizational challenges and opportunities associated with this technology.

3. LITERATURE REVIEW

3.1. Analysis on Existing Methods

They're numerous methods or currently existing related to Smart Attendance System, a few of them are analyzed beneath, which further represent us valid evidence of how our system would be more systematic to utilize.

3.1.1. Digitalization of Primitive Path

Traditionally student attendance refers to checklist all the candidates that consume a large amount of time for both students and teachers to accompany departmental convention (Mann, M., & Smith, M. 2017). The very first online system designing for the reduction of a complete attendance verification was introduced by Mendonca et al. It suggest a better genuine & expeditious way to keep an eye on attendance. The advisor will no more depends upon handling a work manually to mark student attendance in their recommended system.

They can generate the history of attendance data by acquiring the obligatory data from the database, and so making the above policy digital (Kaur et al., 2020). Furthermore, there is also alternative Research i.e. based on a handheld computer in the attendance management system that were designed & insert into practice. These cellular-based attendance management program i.e. Android systems was designed using VB. NET and SQL Server. This research study basically permit for the preservice of student attendance, computing attendance grades, & generating a report. The combination of Five constituents comprises the system i.e.: admin, registration, student, SMS, and an Android Constituent. The Candidates can utilize the android section to transmit messages to the system enlighten lecturers of their absence (Smitha, P. S. H. 2020). Fig 1 shows the Architectural View of Old Approach.

Figure 1: Basic Architectural Designing of Digital Attendance Old Approach

3.1.2. Barcode / QR Code Based Attendance System

The correlation of a barcode is a pictorial strategy for the delineation of data with respect to the element can read. A faster retaliation code, also known as a QR code, is analogous to a barcode. Nevertheless, it contains information in two crosswise path due to its two-dimensionality. As a result, a QR code may store fewer times more data than a barcode, invented by (Sunaryono et al., 2021). Another alternative way or suggested method, which was built utilizing QR code automation & is based on research by (Sutar et al., 2022), is a smart attendance system that would rapid the attendance process by scanning QR codes. Moreover, to persuade student attendance, Sunaryono et al. suggest "an Android-based course attendance system using face recognition.". The information in this system conceal into a QR code & bestow from the front class. The candidate just need to avail their phone to take a snap of their face & exhibit a QR code. The image will eventually be broadcast to the server to supervise the attendance. The following **Fig 2** briefly explains the idea of Barcode System in Auto-Attendance.

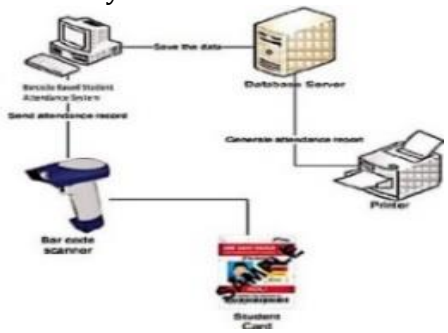


Figure 2: Barcode/QR-Code based Attendence System

3.1.3. Barcode / QR Code Based Attendance System

The idea behind locating human profile in an allusion or videos named as facial identity verification. It is a type of innovation that makes comparison between facial snaps from a video or photograph to a database of a specified & unspecified faces. It was invented by Smitha to design an assembled classroom attendance system utilizing (FR) approach (Zhu, C. 2019).

Through facial ID, the system can recount implication. Through a webcam, it locate profile & then identifies them. (D. Sunaryono et al., 2021).

Fig 3 illustrates the idea of Facial Recognition System in SAMS.

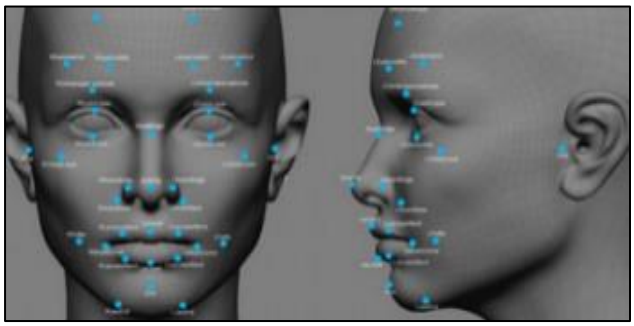


Figure 3: Facial Recognition Based System in Auto-Attendence

The following Table I represents the systematic review of the above Existing Data related to Auto-Attendance System along with their various Technical Methodologies and their Ratio.

Table I: Critical Review On Existing Methodology Along With Their Technologies

Existing Methodology	**Technologies Used**				
	Web-Based	***Facial Recognition***	***RFID Approach***	***Barcode/ QR-Code***	***Old Approach***
Barcode/QR Code Based	No	No	No	Yes	No
Digitalization of Old Approach	No	No	No	No	Yes
S.A.M.S by Jacksi & Ibrahim (2018)	Yes	No	No	No	No
Facial Recognition Approach	No	Yes	No	No	No
Auto Attendance System by Yuru at el (2013)	No	No	Yes	No	No

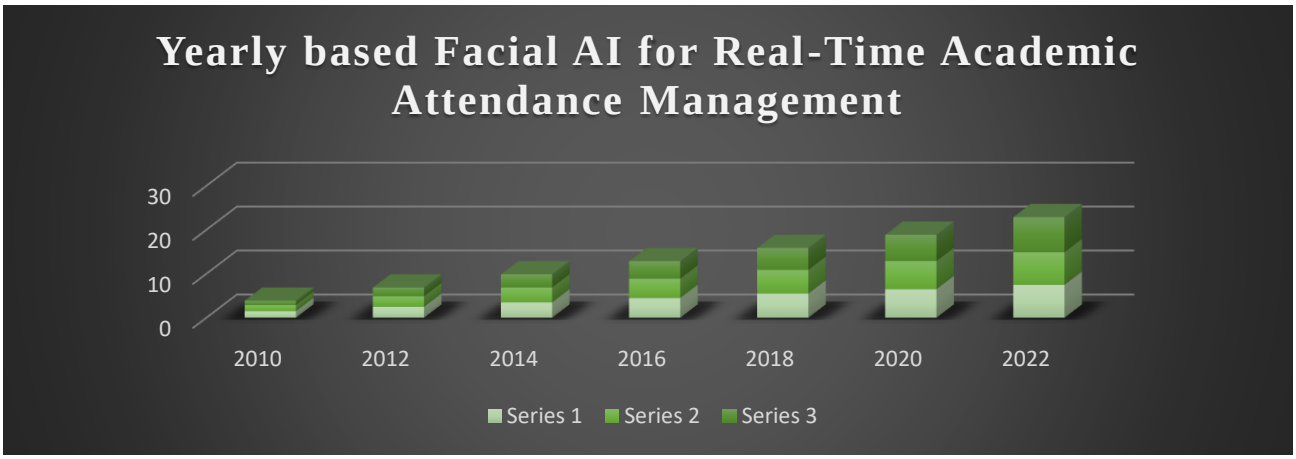
3.2 Comparative Analysis with Existing Method

This section undergoes to both the critical review on the Traditional System & our Proposed System. **Table II** indicates the comparative view of the above Smart Attendance System with the well-known previously existing methods as mentioned above. Whereas, **Fig 4** represents the yearly based Facial AI for Real-Time Academic Attendance Management.

Table II: Comparative Study

Parameter	**Method**	**Attributes**				
		Human Interference	***Face Analyzer***	***Real Time Tracking Through a Live Video/Images & Maintaining Record***	***User Friendly***	***Synopsis of AI System i.e. Facial Detection Technique through Open-CV & Google Sheet)***
Traditional System	Digitalization of Old Approach	Yes	No	No	No	No

Parameter	Method	Attributes				
		Human Interference	***Face Analyzer***	***Real Time Tracking Through a Live Video/Images & Maintaining Record***	***User Friendly***	***Synopsis of AI System i.e. Facial Detection Technique through Open-CV & Google Sheet)***
	Barcode/QR Code Based	Yes	No	No	No	No
	Facial Recognition Approach	No	Yes	Yes	Yes	No
	S.A.M.S by Mann & Smith (2017)	Yes	No	No	Yes	No
	Auto Attendance System by Navarrete et al., (2002)	No	No	No	Yes	No
Proposed System	FR Technique through Open-CV & Data Entry on Google Sheet	No	Yes	Yes	Yes	Yes



Yearly based Facial AI for Real-Time Academic Attendance Management

3.3 Research Gap/Problem Statement for real-time academic attendance management

In a comparative analysis of smart face recognition systems for real-time academic attendance management, several potential research gaps could be identified:

Performance Evaluation Discrepancies: Many studies might focus on comparing the performance metrics of different face recognition systems, such as accuracy, speed, and scalability. However, there could be a gap in the consistency and standardization of evaluation methodologies across studies. Addressing this gap could involve developing standardized protocols or benchmarks for performance evaluation to enable more reliable

comparisons between systems (Waelen, R. A. 2023).

Long-Term System Reliability: While short-term evaluations of face recognition systems may demonstrate promising results, there may be a gap in understanding the long-term reliability and robustness of these systems in real-world academic environments. Future research could focus on longitudinal studies to assess system performance over extended periods, considering factors such as changing environmental conditions, system degradation, and evolving user behavior.

User Acceptance and Experience: Comparative analyses often emphasize technical aspects of face recognition systems, but there may be a gap in understanding user perceptions, acceptance, and experiences with these systems. Future research could explore qualitative aspects, such as user satisfaction, usability, trust, and privacy concerns, to provide a more comprehensive understanding of the human factors influencing system adoption and effectiveness.

3.4. Integration Challenges and Implementation Strategies

While some studies may compare face recognition systems in isolation, there could be a gap in addressing the complexities of integrating these systems into existing academic infrastructure. Research could explore the practical challenges, integration requirements, and best practices for implementing face recognition systems within diverse educational settings, considering factors such as interoperability, resource constraints, and stakeholder engagement.

3.5. Ethical and Societal Implications

Comparative analyses often touch upon ethical considerations, but there may be a gap in thoroughly addressing the broader societal implications of deploying face recognition systems in academic environments. Future research could delve deeper into issues such as data privacy, consent, surveillance implications, and potential biases embedded in face recognition algorithms. Additionally, research could explore strategies for mitigating risks and promoting ethical use of these technologies in educational settings.

3.6. Case Studies and Real-World Implementations

Comparative analyses may lack sufficient real-world case studies and implementation examples across diverse academic contexts. Addressing this gap could involve conducting in-depth case studies or field trials in various educational institutions to explore the contextual factors influencing the adoption, implementation, and outcomes of face recognition systems for attendance management.

Thus, by addressing these research gaps, future studies can contribute to a more holistic understanding of the effectiveness, challenges, and implications of smart face recognition systems for real-time academic attendance management, ultimately informing evidence-based decision-making and policy development in educational settings.

3.7 Hypotheses and Research Model

H_{O1}: Smart face recognition system are more accurate and efficient for real-time Academic Attendance Management compared to Traditional Manual Methods.

H_{O2}: The effectiveness of smart face recognition systems varies based on factors such as accuracy, speed, scalability, user-friendliness, and cost-effectiveness, with certain systems demonstrating superior performance in specific contexts and environments.

The following **Fig 5** represents the Research Model of our Proposed Methodology. The detailed description of each block is as follows:

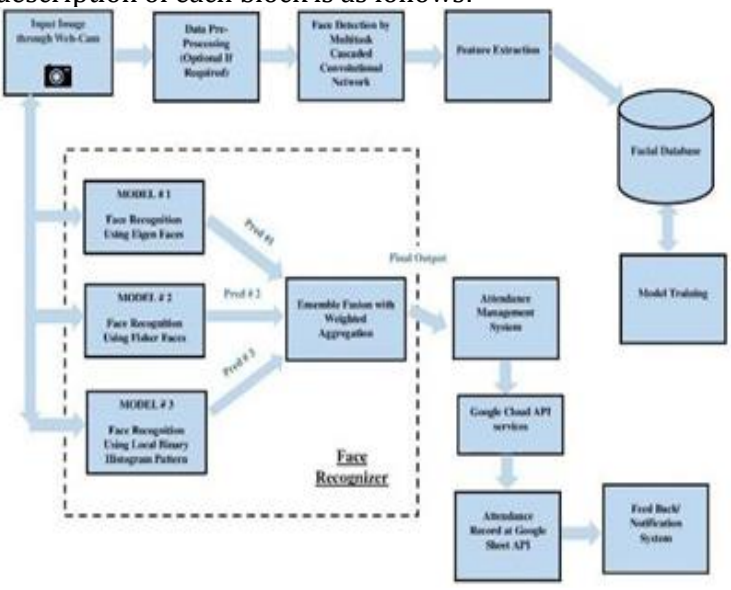


Figure 5: Research Model of our Proposed System

4. METHODOLOGY AND RESEARCH DESIGN

In this section we are designing an AI based application to manage the attendance record sequentially to confirm the status of each candidate or an employee by the technique of Informal face endorsement. So here we undergo to six steps to perform this whole System. These steps involve: Data selection which is based on a Facial Images, Image Processing which includes Data Pre-processing, Face Detection to detect and locate faces within the image, Feature Extraction to extract Face Patches from each individual faces, and Face Recognition for Model Training and Classification of an Images.

4.1. Data Selection

The random selection of a Facial Image datasets of Students, Teachers or an Employee is used as an Input captured by a webcam. Whereas, for the training of models we have selected some reference images of a specific celebrity from Kaggle. So, this reference dataset has four distinct classes i.e. Angelina Jolie, Tom Cruise, Will Smith & Johnny Deep. Each datasets holds 400 images from each class, as shown in **Fig 6**.

Each Facial Input Image Dataset of an individual hold the specific information about either the Staff or a Students that were newly registered at the time of Registration. All the image Dataset that are exploit in this exploration and have various Analytical and Absolute Data Attributes contingent on number of Students or Staff Registered at that particular organization, along with their Total Entries & No of Absent and Present. These captured snapshots or datasets are then further detected and undergoes to the classification system i.e. it makes comparison with those faces that are already stored in the database. On the basis of Identification, the Attendance will automatically be marked on a Google Sheet based on cloud API service.

Figure 6: Unprocessed Input Image

4.2. Image Processing

4.2.1. Data Pre-Processing

To construct the AI algorithm extra dynamic, preprocessing is crucial ahead using evidence for detection & pattern training (Mann & Smith, 2017) as shown in **Fig 7**. It is a typical AI system for the conversion of a crude data into applicable facts. These information pre-processing techniques are used to enhance facial features if it's necessary. It consists of rinsing, outlier verification, and identical, discard etc. (Varadharajan et al., 2016). Thus, every single datasets are pre-processed before employing data for prognosis.

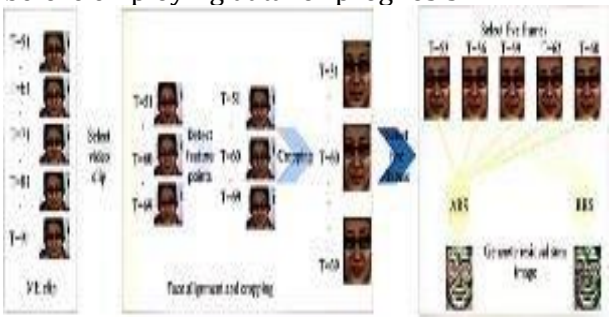


Figure 7: Data Pre-processing of Facial Images

4.2.2. Face Detection

Face Detection uses certain Data Pre-processing or Image Processing techniques to find larger images of a Human Faces and it further differentiate them with non-face objects i.e. body parts, buildings etc. (Mann & Smith, 2017). The prime function of this procedure is to detect and locate faces within the image by using certain Face detection Algorithms like Multitask Cascaded Convolutional Network i.e. it localizes and classifies faces in an image as shown in **fig 8**. The possible expected outcome or targeted image of this procedure occurs in terms of Patches, which holds each face in the Input Image.

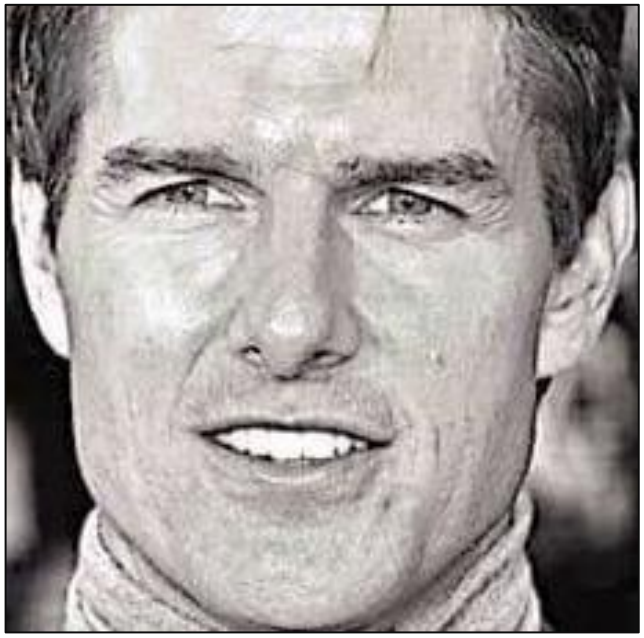


Figure 8: Face Detection of Input Image

4.2.3. Feature Extraction

After the detection of Human Faces, another key step involve in this system is Feature Extraction i.e. it extracts facial features or landmarks from the detected faces shown in **Fig 9**. It works as a Visual Image Analyzer to find the pattern of each individual Faces. Hence after traversing this step, we are able to determine the fixed co-ordinate points or a set of vectors by the conversion of a face patch.

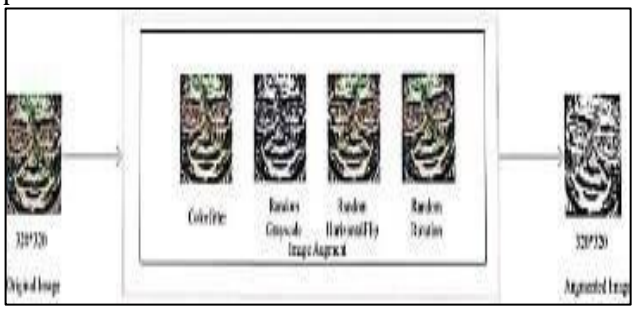


Figure 9: Face Extraction and Embeddment of an Images

4.2.4. Detail Overview of Proposed Research Model

A. Registration Process

The Registration Process of our System is basically based on the No of Employees or the Student or Staff Enrolled in that particular Organization I.e. College, Universities, and Enterprises etc. He/she will be registered along with their Facial Snapshots to keep their record in our data base. Database on Google Sheet has been outline at backend which contain the entire data of registration and Data entry i.e. Attendance Marking of both the Staff Members & students as well. After the completion of Registration process, the students or an employee may be able to login the site and can check his/her performance record easily.

B. System and Database Designing

The first stage, involves the creation of a Facial Database that will further be used during Model Training and Detection Process. The input images will be taken on a random basis through a camera or a webcam and then these input images will be used for the Detection of Faces i.e. the above proposed implemented system consist of using the Multitask Cascaded Convolutional Network for the detection of a Human Faces from a web-cam. The no. of cage to be drown for deliberation can be adapt for accuracy levels. These photos are then kept in the database accompanying the Registration ID. Furthermore, CV Library i.e. OpenCV is also a major side in this research study for Facial Detection System & Google Sheet for database scheming. We choose Python for chief prosecution of system & is implemented on Pycharm. Whereas, database is deliberate based on a Google Sheet that holds several tables for keeping data categorically.

C. Face Detection

The above proposed implemented system consist of using the Multitask Cascaded Convolutional Network for the detection of a Human Faces from a web-cam. These Algorithms detect and locate faces within the image.

D. Face Recognition

It is the final step of the above system and its purpose is to identify the faces after Facial Representation. Here we are utilizing a trained face recognition model to compare the extracted facial features with stored face templates or embeddings. Various Facial Images of each person are taken and their attributes are extorted & conserved in a database. Now through an incoming loaded facial image, which is glutted for facial verification & removal of attributes, these features through a certain CV approach are then further make a comparison which finally identifies those Facial Images that are Captured in terms of an images.

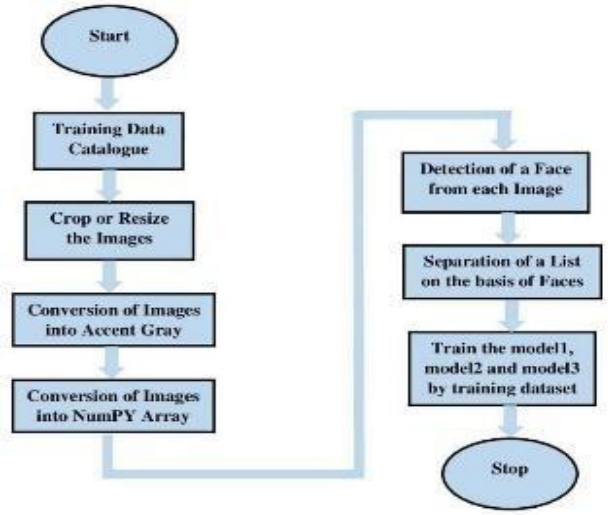


Figure 10: Work flow of the procedure used for Training Steps

The training activity initialize with spanning of the learning set catalogue shown in **Fig 10**. Every single snap during training data is reformed into gray scale. A scrap of the snap is drowned as kernel & threshold its neighbors against it. Thus, if the strength of the central portion is greater or equivalent than its neighbor then indicates it with 1 else 0 if not. These snaps are further transformed into a numpy array which is the key data structure of numpy library. Each of face in the snap is highlighted. Generation of discrete checklist of every single profile is drained & the faces are conjoining accompanying their respective IDs for training.

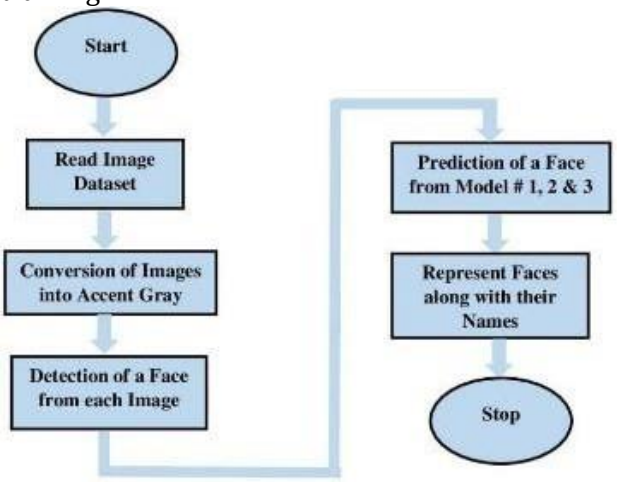


Figure 11: Flow Diagram of Strategies for Face Detection & Classification

The captured snap is perused by webcam or any smart devices. After the study of image, it's reshape into gray scale. These faces in snaps are disclosed using the Haar Cascade frontal face component. Thus, by applying the following three algorithms down below, the profile images are divine. After that these identified faces are display in a green box along with their names shown in **Fig 11.**

4.3. Algorithm

In this section we are focusing on the main Algorithms that are being used for both face recognition i.e. Model Training & Classification. These are:

- FR using Eigen Faces
- FR using Fisher Faces
- FR using Local Binary Histogram Patterns

A. FR using Eigen Faces

It is a collection of eigenvectors when apply in the CV issue of a person face recognition. This methodology is based on a statistical plan i.e. it takes all training faces of all people at once and looks at them as a whole and then it keeps the most important components & removes the rest. This way it not only draws out the necessary element from the training sets but also liberate memory by eliminating the un-necessary elements. It has been termed as principal component analysis (PCA). Furthermore, it keep documentation of each essential section per human & these algorithms also consider illumination as crucial element.

The entire methodology depends upon the training database that will be offered. Hence, when we provide a new Snap to the algorithm, the repetition of whole process will be started on that image. The following figures represents the Eigen Face Representation of our System. **Fig 12**, illustrates the left is average of all faces in our dataset, Whereas, **Fig13**, on the bottom below represent the most prominent deviations from the mean in our face dataset.

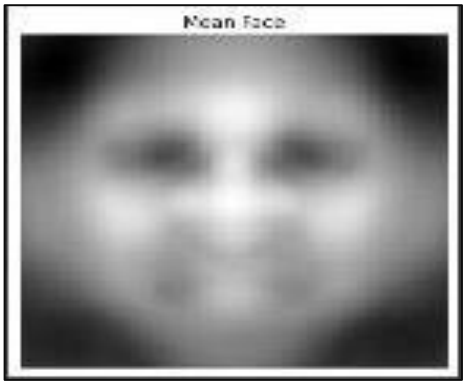


Figure 12: Mean Face Image of Eigen Process In Our System

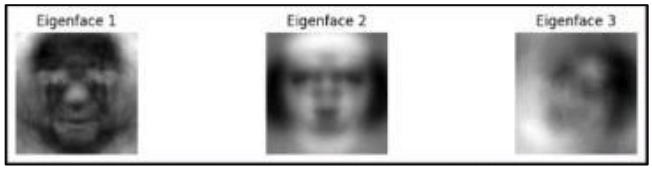


Figure 13: Representation of Eigen Faces From Our System

Figure 14: Training Images using Fisher Face Recognizer in our System

B. Accuracy

As we already know that Eigen Face works on PCA to extract features from the images of faces which will later on uses for the identification of individual faces. So, the Accuracy of Eigen Face Algorithm depends upon the several factors i.e. quality of training data, no. of Eigen faces used and the threshold values for classification. In short, the more we use high quality training data the more maximum accuracy will get. Hence, the Accuracy of our System after applying Eigen Faces, we get is 0.8017465872695378 i.e. 80.17% which would have considered as quite beneficial in our smart attendance system.

C. FR using Fisher Faces

Fisher Face is considered as one of the trendiest used Algorithm for Face Recognition. It is widely superior to other Algorithms such as Eigen Faces due to the maximization effort for the dissociation of groups in the Training Steps. It is also considered as an improved version of Eigen faces recognizer. This algorithm, network is awaiting to regulate whether the snapshot to be evaluated & is identified accurately or not. Instead of voiding important attributes that present all the faces of an individual, it brings out necessary features that differ one person from the others. Hence, by following this strategy features of a single person do not influence over the others & so we have the attribute that distinguish one person from the others.

This Algorithm is essentially helpful when facial images have large distinction in radiance & facial utterance. As it removes the first three principal components liable for the strength of light changes. It was conceived by the well-known statistician Sir R. A. Fisher, who profitably applied for allocating bloom in his 1936 paper "The use of multiple measurements in taxonomic problems"

The figures down below illustrate the resemblance of Fisher Face in our proposed system. **Fig 14** shows the Training Process of an image dataset, whereas **Fig 15** shows the prediction of a model i.e. testing data of the above datasets which are being used in our Smart Attendance System.

15: Testing Data using Fisher Face Recognizer of our System

D. Accuracy

Fisher Face uses Linear Methods to solve the problems of sensitivity to light conditions in FR-System. It is considered as one of the best FR-Methods that achieves 68% accuracy without threshold. Hence, the Accuracy of our System after applying Fisher Faces Recognizer we get is 0.8120509723770593i.e. 84.425% which would have considered as quite beneficial in our smart attendance system. The following **Fig 16** & **Fig 17** shows both the Graphical View of both the above Methodology i.e. Eigen Faces and Fisher Faces and Blueprint of F1 score of Fisher Faces in our Proposed System.

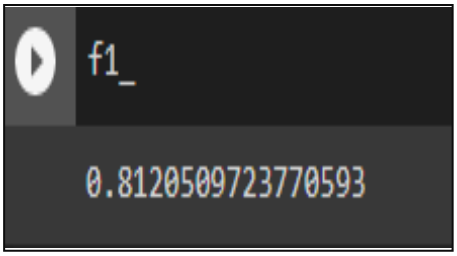


Figure 16: F1 Score of Fisher Face Recognizer in our System

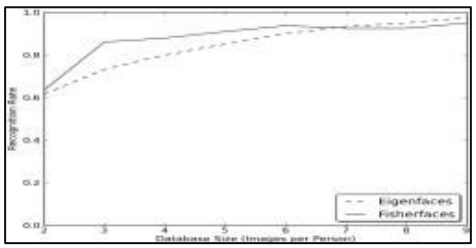


Figure 18: Graphical View of Accuracy in both the Eigen Faces and Fisher Face Recognizer

4.4. FR using Local Binary Histogram Patterns

It is basically a FR-Algorithm which is primarily based on a local binary operator. It is highly designed for the recognition of both the sides & frontal face of a mankind.

In general, this algorithm uses feature extraction methodology for CV & Image Processing Applications. It focuses on the Central Point surroundings & test whether these surrounding points are Greater or Lesser than the Central Point. This Algorithm has very efficient Texture Operator which are being used to label the pixels of a snap by thresholding the neighborhood of every pixel. It works by dividing the image into a smaller regions & computing a histogram of each LBP-Values across each region. These histograms are then concatenated into a single feature vector that can be further used for classification. This Algorithm further works on a Grey Scale Images to deal the Training Section.

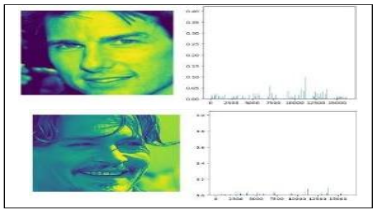


Figure 19: Trained Images by LBPH on our System

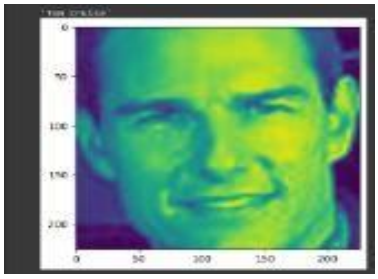


Figure 19: Tested Images by LBPH on our System

a) Parameter

This Algorithm consist of a certain Parameters i.e. Radius which holds the round district binary pattern and indicates the radius on each side of the mid pixel, Neighbors that contains illustrated bits nearby the kernel pixel & computationally it increases with the rise in number of sample points. And Grid (X, Y) that illustrates the direction of the number of cells across with the axis i.e. horizontal and vertical. Hence, with enlargement in no. of cells its grid will be admirable which upshot in enlargement of dimensional feature vector.

b) Image Data Training

For better performance and efficiency of our system, it will have to train first along with the several set of Input images that are provided by the Database. Hence it provides several sets of information from these images i.e. from providing capture images and giving the output.

These images are them further store in gray scale behind being captured by a webcam. Its recognizer is engaged to guide these faces for the trained sets; intention & thus, the identified face decision is entirely modified. Some portion of a snapshot is select as mid & its neighbors are threshold against it. If magnitude of the mid part is higher or equal than it neighbors, then it is displaying as 1 else 0 if not. And so will conclude in binary ornament normally considered as LBP codes. The **fig 18** down below represent some of the Images that are being tested on our system.

c) Image Data Testing

The **fig 19** down below represent some of the Images that are being tested on our system.

d) FR Model Prediction

The training of the algorithm is complete. Now for locating the snapshot which is exactly equivalent as the intake image, the two bar graph are in contrast with the corresponding closest histogram is returned. Distinguish techniques are utilizing for the computation of interspace lying the two bar-graphs. Here we apply Euclidean distance formula:

$$D = \sqrt{\sum_{i=1}^{n}(hist1_i - hist2_i)^2} \qquad (1)$$

Hence the consequence of the above methodology is the ID of an image that has the subsequent histogram. It must reciprocate the interval computed in the frame of 'confidence'. Hence, both of the threshold & 'confidence' could be utilized impulsively to estimate either the snapshot is flawlessly identified. If 'confidence' is lesser than

the stated threshold value, it implicit that the image has been skillfully identified by the algorithm. **Fig 20** shows the Labeled class and its calculated confidence value on our system.

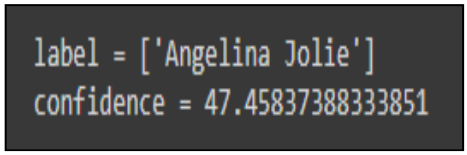


Figure 20: Labelled Class & their nearest Histogram Calculation Interms of 'Confidence'

e) Accuracy

The accuracy of LBPH depends upon various factors, such as size & shape of neighborhood, no and distribution of patterns and the choice of a classifier. It further has been proposed for the improvement of accuracy and applicability to different problems. LBPs can achieve higher accuracy & speed in FR tasks, especially while combining with other methodology such as (PCA, LDA or SVMs). Hence, the Accuracy of our System after applying LBPH Faces Recognizer we get is 0.8442530970836611 i.e. 84.425% which would have considered as quite beneficial in our smart attendance system. The following **Fig 21** shows Blueprint of F1 Score of LBPH in our Proposed Methodology.

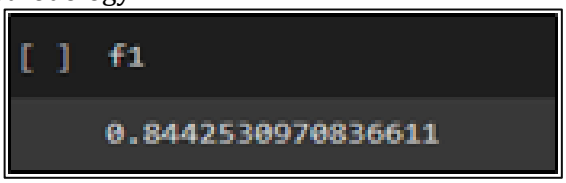


Figure 21: F1 Score of LBPH in our System

4.5. Comparative Analysis between LBPH with other two Algorithms

The following **Table III** illustrates certain comparison between all of the above three Algorithms that are being used in our Proposed Method.

Table III; Comparative ANALYSIS OF LBPH WITH OTHER ALGORITHMS

Eigen Face Algorithm	**Comparative Study**	
	Fisher-Face Algo	***LBPH Algorithm***
Confidence strand hinge on output is 2,000-3,000	It's 100-400	
The value of Threshold: 4000	Threshold worth: 400	Threshold worth: 7
Assumption of dataset production element form.	It's a constituent based.	It's a pixel formation.
Fundamental postulate: PCA.	Fundamental postulate: LDA	Pivotal principle: Bar-Graph
Backdrop noise is utmost.	Context noise is medium	Framework noise is slightest.
Capability is minimal	Higher than Eigen face.	Adaptability is maximum

4.6. Ensemble Fusion with Weighted Aggregation

It refers to the process of combining multiple models or predictions to obtain a consolidated result. This Algorithm or Methodology are most commonly used in Ensemble Learning, Information Fusions and combination of certain AI Algorithms etc. It is an association of weighted aggregation of support task by operating Gaussian Function to allocate weights hang on Classifier & Class Labeled. "Weighted Aggregation" indicates that you are assigning different weights to the outputs of the models based on their accuracy or other criteria, and aggregating them accordingly. In our Proposed System, this technique combines all the above three models along with their prediction to give its final possible output. The prediction of all three Model will be acts as weights where with the help of a Gaussian Function we will be finding its final

output.

4.7. Mathematical Calculation of a Weighted Aggregation Ensemble Model

As we are already familiar that in ensemble model we are calculating both the Model Averaging and Weighted Averaging Ensemble so this process we first perform Model Averaging and for this we are giving equal priority to each of three models and we are now just taking the prediction of each model and performs an average in order to get the final prediction.

After taking Model Averaging the next step we will perform would be Weighted Averaging Ensemble i.e. assigning weights to each model its depends on the performance of the models, which model is performing better so in that model we give high weights.

Finally, in the last step we will perform Bagging. The concept behind bagging is to associate an outcome of multiple models to acquire an infer upshot from a single model. It basically reduces variance of an estimate value by taking the mean values of multiple estimates. In general, we are performing this step we simply take the average of all the predictions to make a final overall prediction.

a) Method # 1: Model Averaging Ensemble

The following **Table IV** illustrates certain predicted values of all the above three Algorithms that are being used in our Proposed Method.

Table IV: MODEL AVERAGE OF PREDICTED VALUES

Models/ Classifiers	**Model Average**	
	Predicted Values (1,2,3)	***Average/Final Output***
Model:1 Local Binary Pattern Histogram (LBPH)	0.8442530970836611	0.8193502189
Model:2 Eigen Face Recognizer	0.8017465872695378	
Model:3 Fisher Face Recognizer	0.8120509723770593	

Hence the final output values we get by using Model Ensemble among all of three Models is 0.8193502189 i.e. 81.9%. So there is slight increase in accuracy or F1 score i.e. 0.7% in an ensemble model.

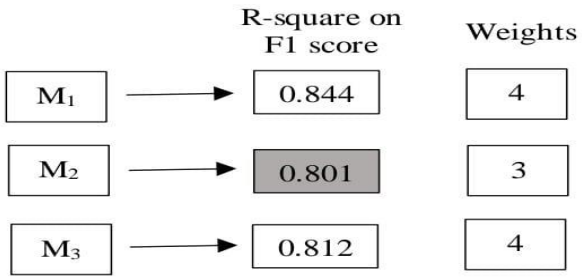
b) Method 2: Weighted Averaging Ensemble Model

Here we have three multiple models denoted by M1, M2 and M3, Along with their prediction values i.e. 0.844, 0.801 and 0.812 respectively. Now, we are assigning Weightage Values on the basis of predicted values. So for M1 with a Prediction Value 0.844 its weightage value would be 4, similarly, for M2 and M3, its weightage value would be assigned as 3 and 4.

Now we have to multiply the weightage value to the predicted value in order to get the Final Predicted Values, i.e. for M1 and M3 its predicted value will be multiplying by its weightage value i.e. 4 and for M2 its predicted value will be multiply by its weightage value i.e. 3. After then we have to calculate the Average Values or the Final Prediction of all the Final Predicted Values i.e. summing up all the values and divided by the Total of all the weights i.e.

$$Final\ Weights = \sum_{w=1}^{3} w1 + w2 + w3 \qquad (2)$$

$$Final\ Weights = 4 + 3 + 4 = 11$$



The following **Table V** illustrates certain predicted values and their final predicted values of all the above three Algorithms that are being used in our Proposed Method.

Table V: WEIGHTED AVERAGE ENSEMBLE MODEL

Models/ Classifiers	**Model Average**		
	Actual Predicted Values (1,2,3)	***Final Predicted Values (1,2,3)***	***Average/Final Prediction***
Model:1 Local Binary Pattern Histogram (LBPH)	0.84425309 70836611	3.37701 2388	0.8209505491
Model:2 Eigen Face Recognizer	0.80174658 72695378	2.40523 9762	
Model:3 Fisher Face Recognizer	0.81205097 23770593	3.24820 389	

Hence the final output values we get by using Weighted Average Ensemble among all of three Models is 0.8209505491 i.e. 82.1%. So there is slight increase in accuracy or F1 score i.e. 0.9% in an ensemble model.

c) Step# 3: Bagging

This is the last or concluding step of the above two Methods i.e. Model Averaging Ensemble, and Weighted Averaging Ensemble. Here we are combining or calculating the overall final predicted values of our above three multiple models by calculating its mean values i.e.

- **For Model Averaging Ensemble:**

$$f(x) = \frac{1}{M}\sum_{m=1}^{M} f_m(x) \qquad (3)$$

Or;

$$U = f(\, y(i), \omega(w,b)\,) \qquad (4)$$

So;

$$U = \frac{0.8193502189 \; + \; 47.45837388333851}{2}$$

U = 24.13886205 (Overall Predicted Value)

- **For Weighted Averaging Ensemble:**

Using the above **Eq 3 and 4** for finding the Weighted Average Ensemble

$$f(x) = \frac{1}{M}\sum_{m=1}^{M} f_m(x) \qquad (3)$$

Or;

$$U = f(\, y(i), \omega(w,b)\,) \qquad (4)$$

So;

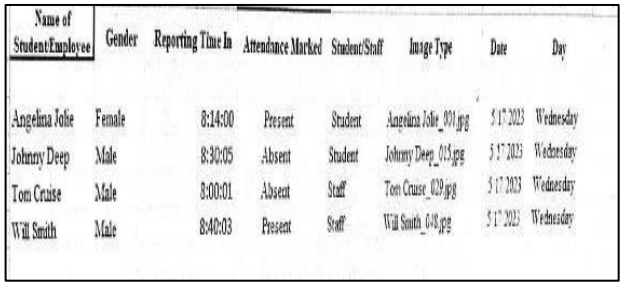
$$U = \frac{0.8209505491 \; + \; 47.45837388333851}{2}$$

U = 24.13966222 (Overall Predicted Value)

4.8. Marking Attendance Automatically

Later on we are further deploying these Trained AI models to a web-based Spreadsheet Application Program i.e. a Google Sheet, to mark as "present" automatically as explained in **Fig 22**. This will streamline both the attendance and tracking process and improve Accuracy. Furthermore, it has some Facial Database for facial identification and comparison of a people and a Recorded Database

that can keep their attendance renovate with complementary time & id.



Name of Student/Employee	Gender	Reporting Time In	Attendance Marked	Student/Staff	Image Type	Date	Day
Angelina Jolie	Female	8:14:00	Present	Student	Angelina Jolie_001.jpg	5/17/2023	Wednesday
Johnny Deep	Male	8:30:05	Absent	Student	Johnny Deep_015.jpg	5/17/2023	Wednesday
Tom Cruise	Male	8:00:01	Absent	Staff	Tom Cruise_029.jpg	5/17/2023	Wednesday
Will Smith	Male	8:40:03	Present	Staff	Will Smith_048.jpg	5/17/2023	Wednesday

Figure 22: Auto-Marking of Student/Employee on the basis of Facial Identification using a Google Sheet

The following **Table VI** represents the total Academic Attendance Record of Staff Members and Students.

Table V: DATASETS OF STAFF/STUDENTS AND THEIR ATTENDANCE RECORD

Name of Student/Employee	**Attendance Record**				
	Gender	***No. of Present***	***No. of Absent***	***Total % of Present***	***Student / Staff***
Angelina Jolie	Female	16	6	72%	Student
Johnny Deep	Male	13	9	59%	Student
Tom Cruise	Male	20	6	56.9%	Staff
Will Smith	Male	21	5	80.7%	Staff

5. DATA ANALYSIS

5.1 Application Areas of Smart Face Recognition System for Real-Time Academic Attendance Management

Table VII outlining the application areas of a smart face recognition system for real-time academic attendance management

Table VI: APPLICATION AREAS FOR SMART ATTENDANCE SYSTEM

S. No.	***Application Area***	***Description***
1	Attendance Management	Automatically records attendance of students and faculty members in real-time.
2	Identity Verification	Verifies the identity of individuals by comparing their facial features with stored data.
3	Access Control	Controls access to restricted areas within academic institutions based on facial recognition.
4	Security Enhancement	Enhances campus security by monitoring the presence of authorized personnel.
5	Time Management	Helps in efficient scheduling and tracking of academic activities based on attendance data.
6	Student Engagement	Provides insights into student attendance patterns for improving engagement strategies.
7	Resource Allocation	Aids in optimizing resource allocation based on attendance trends and demand analysis.
8	Data Analysis	Facilitates data-driven decision-making through the analysis of attendance trends.

Thus, in **Fig 23**, the occurrences of AI in Smart Attendance System, as discussed in Table 7, are relatively rare. However, these emerging issues cannot be overlooked and demand attention regardless of their rarity.

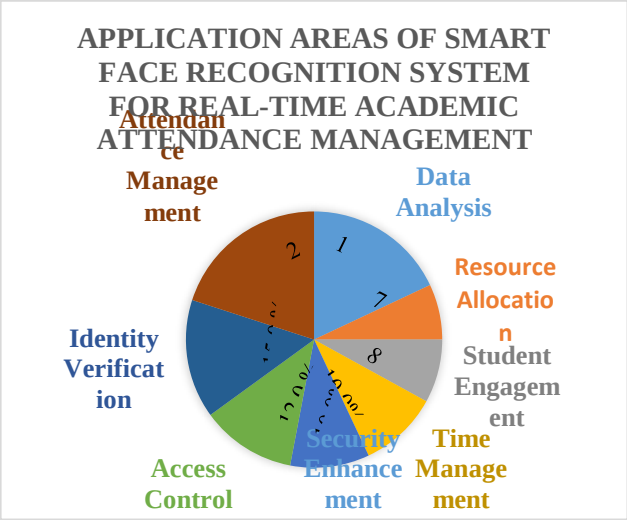


Figure 23: Application Fields of AI- Based Smart Face Recog Attendance Systen

5.2 Taxonomy of AI Facial Recognition Attendance System

Table VIII down below provides a comprehensive overview of the various components and functionalities of an AI Facial Recognition Attendance System.

Table VII: TAXONOMY OF AI FACIAL RECOGNITION ATTENDANCE SYSTEM

Category	***Subcategory***	***Description***
Facial Detection	Face Localization	Identifies and locates faces within an image or video frame.
	Facial Landmark Detection	Identifies key facial landmarks such as eyes, nose, and mouth.
	Face Tracking	Tracks the movement of faces in real-time video streams
Facial Recognition	Feature Extraction	Extracts unique facial features from detected faces, such as distances between eyes, shape of the nose, etc.
	Face Matching	Compares facial features of detected faces with stored templates to recognize individuals.
	Identity Verification	Verifies the identity of individuals based on facial features.
Attendance Management	Attendance Recording	Records attendance based on facial recognition matches.
	Real-Time Monitoring	Monitors attendance in real-time, allowing immediate action in case of anomalies.
	Data Storage and Management	Stores attendance data securely and efficiently, with capabilities for retrieval and analysis.
	Reporting and Analytics	Generates reports and provides analytics on attendance patterns and trends.
Security Features	Privacy Protection	Ensures compliance with privacy regulations by anonym zing or encrypting facial data.

	Access Control Integration	Integrates with access control systems to regulate entry based on recognized identities.

6. DISCUSSION ON THE RESULTS

Smart Attendance System is quite a simple approach for any Organization and yet increases the work efficiency. The above result illustrates that by using CV Technique for Extraction, Training & Classification for Facial Detection we can identify or predict any Person through their Facial Features because FR techniques uses a special computer generated filters for the transformation of Face Images categorically into numerical expression by using certain Algorithms such as LBPH, Fisher Faces and Eigen Face that can be compared for the determination of similarity between two faces or in search for a face among a large collection of existing images.

In this research study we have been go through certain efforts for the identification of a face and automatically marking of Attendance of particular Student or Staff Members. Here we are generating several Analysis Function likewise as composed in Method Section in this research study.

Initially we have selected an image datasets of 4 people including both the Students & the staff members. Now the above system will automatically work once the registration of individual Student or a newly admitted Staff Members is created by the administration. To initialize the above system, the Administrator or HR-Professionals of any Organization will firstly registered their Students and Staff Members along with their particular set of information i.e. provided in Registration process. We've build a Training dataset of 4 candidates/ teachers (approx. 400 snaps). Now we will split these datasets randomly 90% for Training and 10% for testing purpose. Now for the detection of a faces, it first undergoes to some pre-processing Techniques. Now for training the model it then compares or matches the similar faces with existing database. Now for the Model Prediction or Classification we will test our model by proving a random input image that will be captured by a webcam or any camera.

Hence the above three models are then further calculated or combined by using Ensemble Fusion with Weighted Aggregation for the overall one final predicted output and later on the basis of these final predicted facial images , the identification of Students, Staff or an Employee will be done and it will mark attendance automatically on a Google Sheet API and in the last step the Feedback or Notification will be generated by that particular organization to both the Staff, Students or an Employee.

6.1 Step#1: Input Image

The **fig 24** down below shows the sample of an unprocessed input image dataset of each individual

Figure 24: Unprocessed Input Inage Captured By WEBCAM

6.2 Step#2: Training Images

After the pre-processing & detection of a face, it then undergoes to the Training Process. Where the above three models will be trained by recalling the images from Facial Database. This whole procedure will be done on Grayscale Image. The following **fig 25** shows some Training Images of our Proposed System.

Figure 25: Training Images Folder

6.3 Step#3: Final Image

Finally, after the completing the whole process, the model will predict its final predicted identified image. **Fig 26** illustrates the Final Predicted Output of an Image of one of our Staff.

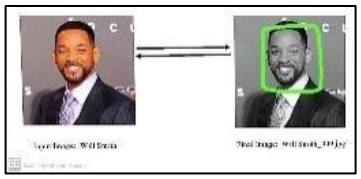


Figure 26: Final Predicted/ Identified Image of a Person

6.4 Student Attendance Record on Google Sheet API on the basis of Face Identification

So, on the basis of Facial Identification, the Attendance will automatically be updated and will marked as "present" or "absent". The **Fig 27** represents the Attendance Record of each individual in our system.

Name of Student/Employee	Gender	Reporting Time In	Attendance Marked	Student/Staff	Image Type	Date	Day
Angelina Jolie	Female	8:14:00	Present	Student	Angelina Jolie_001.jpg	5/17/2023	Wednesday
Johnny Deep	Male	8:30:05	Absent	Student	Johnny Deep_615.jpg	5/17/2023	Wednesday
Tom Cruise	Male	8:00:01	Absent	Staff	Tom Cruise_029.jpg	5/17/2023	Wednesday
Will Smith	Male	8:40:03	Present	Staff	Will Smith_548.jpg	5/17/2023	Wednesday

Figure 27: Student Attendance Record on Google Sheet API of our System

7. CONCLUSION

The motive of designing Smart Attendance System is to resolve all the problems occurs in existing manual systems. We've exploited the concept of face recognition to update the attendance of candidates or employees & execute sufficiently in distinct posture & alteration. However, it may sometime fail to identify the person at some distance & has some refining limitations. Working on a network of high processing may outcome finer accomplishment of this system.

- *Recommendations*

The use of a Smart Attendance System has now become a necessary part of our lives especially in the Field of Education or in growing of a Career i.e. either in a job or a business. When we are running a Business as an owner, we are going through many Tasks throughout a day. This business can either be in the form of School, Universities, Banks or any Institutions or Organization. So, in order to overcome from all this they have implemented a smart attendance system in their organization.

The main purpose of developing our proposed system is: Firstly, to register, documentation, detect & maintain a candidate attendance employing Facial Recognition Approach & Secondly finding Accuracy of all the Three Models and combining those Accuracy by Ensemble Fusion with Weighted Aggregation for the overall one final predicted output for the identification of a Students & Staff Members through facial probe AI for the accurate identification of each of an Individual. On the basis of these facial identification, the Attendance will automatically be updated and Feedback or Notification will be then further being generated on the basis of Attendance Record.

We also have some previously existing Traditional System which performs on the basis of Paper work and also on website basis, where the instructor and administrators have to enter the attendance of student or teachers by themselves. Hence, it consumes work force requirement, duplication of efforts and inefficiencies. On the other side, various kind of SAMS like a barcode, magnetic stripe, biometrics, & Radio Frequency Identification (RFID) attendance system are also enhancing for distinct requirements & demands.

Thus; our prefer architecture bestow provision for both candidates & staff by diminish time to grab absence, besides, feeding a database approach that contain the entire candidate's information. From the administration to a Student point of view, it would be much simple to peruse the notification or feedback by just clicking the desired candidate name. Also, through Facial Recognition, it will get faster and convenient approach for getting the identification of a person so there will be no chance of getting the duplication of efforts especially in Attendance Marking.

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