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AI-Based Techniques for Real-Time Face Recognition-based Attendance System- A comparative Study

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***Abstract* - Face recognition is a powerful tool for a biometric system that takes data from both images and videos. The traditional attendance system can be replaced by the automatic attendance system to utilize class time more effectively. In this paper real-time, attendance monitoring uses a web app that can be operated remotely by using a local server and Amazon Web Service (AWS) cloud recognition Application Programming Interface (API). The first approach follows five sections which are face detection, preprocessing, training and, face recognition through which attendance will be recorded and mailed to the respective teacher. The second approach is based on AWS recognition API which processes the data in the cloud.**

Keywords—Face recognition, AWS, Image processing, Deep learning, OpenCV

I. INTRODUCTION

Humans walked a long way from the Stone Age to this era of technological wonders. But one thing never changed. That is the curiosity of making a thing that is capable of human intellect. And one of the essential parts of human intellect is recognizing another human being. To make this possible in 1965 Helen Chan, Bledsoe, and Charles Bisson tried to make a computer system for face recognition [1] [2]. It was a secret project but based on available information, they used some important face landmarks such as nose tip, mouth, and eye centers. As it uses biometrics of humans, it also raises a privacy issue. But it is the best application made on image processing techniques. In the past several years, the use of this technology is increased significantly. Nowadays there is a competition going on in the mobile sector to make the best algorithm for this technology. There are two main reasons behind the sudden increase in the use of such technology. One is an increase in commercial and govt. application and the second one is the ease of available technology. This is now possible because of more than 30 years of research. The technology which is used today is getting its maturity. Still, its success is limited as in real-life applications there are many conditions affect. For example, face recognition in an indoor environment and outdoor environment is different [10][11]. Illumination, the pose of the face is still an unsolved problem. The system used now is far away from the human capacity to face recognition. After a vast study is to know that their human identifies other humans by seven types of information. Those are identity- specific semantic, labelled pictorial, name, structural, visually-derived semantic, facial speech code, and expression. Face recognition is used for various purposes like finding missing persons, identification of exploited children, and tracking of criminals, support on investigations, health care, retail marketing, and other large projects.

For face recognition, a functional model is being made where fundamental encrypt processes give details which is suitable to analyze the speech of the person [17]. This is done to analyze the facial expression. To recognize similar faces it matches between structural encoding with the previously present structural encoding of the products which defines the appearance of similar faces from face recognition unit. First, it identifies the semantic nodes, and then it identifies the structural nodes from the face, and then it fetches the name codes. Many different factors influence such types of decisions.

Recognition of face in a video is a very difficult task as it does not have proper accuracy. It can achieve 100% accuracy only by training the system about all the factors which affect such as darkness brightness, the different pose of the face from different angles, etc. Many algorithms are there which is used for face recognition like Eigenfaces, Fisherfaces, LBPH (Local Binary patterns Histogram) [4], Scale Invariant Feature Transform (SIFT), LBP, HAAR [9], Speed up Robust Features (SURF), etc. In all the usage of these technologies, security is the major reason. Face recognition is being used by a lot of people for a smart home [20] [21]. In such a system face recognizer is being used in the door to smart unlock the house or it is added to every CCTV camera so that if any suspicious activity happens then it differentiate the owner from the intruder [19]. Face recognition can also be used for a smart attendance system in the school and colleges. As social distancing becomes a new normal, fingerprint scanner is being removed. For such a situation, face recognition technology can be used that can identify all the students present in the classroom without any human intervention. Haar cascade and LBP algorithms can be used for this.

II. RELATED WORK

Face recognition is counted as one of the few biometric systems having high accuracy. This technology is been used for commercial purposes such as security identification, surveillance system, psychological analysis, etc. The technology is reliable with both image and video sequences. Many options are there in the market which can recognize the face. That can be divided into three types. One is Holistic, the second one is feature-based and the third one is a hybrid approach. In the holistic approach, it takes the whole face into account whereas in a feature-based approach some parts of the face are given as input to the classifier. The hybrid approach deals with how to combine and which features combine to maximize the accuracy of face

recognition. Matthew in his work explained about eigenfaces of two-dimensional images. He proposed an idea regarding the above scenario. He wants to launch images of the face to a special space that encrypts the difference of pictures which is known. These are called eigenfaces. Eigenfaces can be defined as the eigenvectors of the face set. For real-time face recognition, they built a simple motion-detecting tracking system that helped to detect faces while people are constantly moving. The proposed method can recognize faces in real-time with an unstructured environment [1-2].

Principal Component Analysis has been an efficient method for pattern recognition and image analysis. Like eigen and fisherface the PCA has proven to one the best algorithm for facial image analysis [3]. Likewise adjusting polynomial kernel, the main factors can be calculated in the limited space stretched over by higher-order correlation of incoming pixels creating facial pictures, by that making a better performance. But it has demerits of computational cost memory-requirements. To overcome this Haitao proposed a new method of Incremental PCA based on singular value decomposition. IPCA can also be extended to the kernel version. When an algorithm is implemented in the real-time scenario application then many difficult challenges arise. It has been a challenge for face recognition to work with low light. To tackle this challenge Xiaoyang combined the power of booming brightness standardization, native face representation based on texture, matching based on distance movement, extraction of characteristics based on the kernel, and multiple characteristics merger. He introduced Local Ternary Patterns which is less sensitive to noise which improved the performance [14] [15]. Mayank S. discussed integrating the algorithms of face recognition to a system of real-time recognition of face using an open-source computer vision library well known as OpenCV that uses HaarCascade to identify individual faces [4] [5]. Unlike traditional face recognition, CNN can efficiently extract features from the image and classify it with greater accuracy. Models like ResNet, AlexNet, etc. can give near about 99 percent accuracy using deep neural networks [6]. Companies like Amazon and Microsoft use a very deep neural network to provide service to customers. They use their API to access the face recognition remotely.

Erfan Zangeneh proposed a novel technique for enhancing the resolution of the face image for better recognition using a deep convolutional neural network [7] [8]. They divided the algorithm into two parts where the high-resolution image consists of 14 layers whereas the low resolution includes a 5-layer super-resolution network that is connected to a 14-layer network. In this method, the accuracy in low-resolution images improved to 5% while recognizing the faces. One of the disadvantages of commonly used in traditional algorithms for face recognition system is that the system can be fooled by showing a picture of a person in front of the camera. To overcome this problem Yasar proposed a technique using a convolutional fusion framework that can detect the liveness of the image. His shared in his paper that for liveness detection convolutional feature at the lower layer is more suitable. A kernel of 3 x 3 performs better than other kernels. Another approach is shared in the paper of Muhammad Zeeshan Khan using an edge device. The use of both deep learning and the Internet of Things (IoT) can efficiently process a large amount of data with great accuracy. The IoT based system achieved 97.9% accuracy to recognize faces [6-8].

III. FACE DETECTION

A. Haar cascade

The OpenCV library is used as it contains a Haar Cascade Classifier which helps us to detect a face from the image or form a video. In 2001 Paul Viola and Michael Jones have discovered this great technique in which they have used the using Haar wavelets [9] [16]. The haar wavelets are formed by the composition of two high and low-value intervals. In two magnitude, a reactionary square aspect wave shows them in the form of detached into binary parts which are luminous and dark. The Haar-Cascade helps us in identifying the region of the face i.e. eyes, mouth, nose, eyebrows. As the position will help us in identifying the person and in which it can differentiate people using their face matrics.

Haar Cascade has initially differentiated it into three different forms i.e. it has three different features and that is known as a two-rectangle feature, a tree-rectangle feature, and a four-rectangle feature. That are edge features, linear features, and center-surround features that extend the features of Haar-Cascade. The edge feature is categorized into 4 variety, and the linear feature is again categorized into 8 categories, and the center-surround feature is again extended to 2 categories. HaarCascade feature serves the contrasting value of the gray level bulk amidst the corresponding fields of the dark rectangle and the luminous rectangle [10]. The cost of each feature is contrived up by the total count of the pixel cost in the analogous rectangle portion that is shown as:

$$feature_j = \sum_{1}^{N} \omega_i . rectSum(r_i) \quad (1)$$

Where the $rectSum(r_i)$ represents the gray-level alliance of picture block off by rectangular r_i .

N represents the estimate of matrices that compose features and ωi represents the weight of the rectangular field.

B. YOLO face detection

The next detection process used in this work is YOLO. It is made for the early which is for a one-stage detector which is based on CNN. YOLO [12] is being made by using a single layer neural network for working in the prediction of the bounding boxes that are generated by detecting the faces and the probabilities of the classes that it belongs to in the direction from the input images in one evaluation. This method actually breaks downs the image that has been taken as input into grid cells, and after taking the grid cells then it helps in calculating the coordinates and made the classification for each cell directly. Although it speeds up the approach as speed is much more time speedily rather than the 2-stapes indicator, but the discloser certainty is lower than that of analog.

YOLO v2 has been made with so many improvements that have been included using the deeper network architectures, and it also helps in learned automatically the anchor boxes, and especially improved the loss function, and has data enhancement, multi-scale training, and many more. The modified with much more enhanced adaptions of

YOLO have given tremendously nice depictions on PASCAL VOC and the continued fast speed, which helps the process will be able to meet the performance desire for actual time finding in the application. YOLOv3 comes with a more improved version and has applied the new neural network backbone i.e. called darknet-53 and it got so ravishing and gave a more desirable conclusion on the COCO datasets.

YOLOv3 's architecture is used as the simple structure of the network and gives better performance in the most different ways, the system is tested on the FDDB data set and WIDER FACE dataset and it gives tremendous and surprisingly better results. This proposed model can help us in face detection procedure in a variety of scales in the real-time environment [11].

The working of the input image is differentiated. And is convert into the S*S uniform grid, and every cell has been consisting of (*x, y, w, h*) and C is for the confidence (Object). Those coordinates (*x, y*) helps in getting the location of the middle point of the boundary that is for detection i.e. the middle point of the container comparative to the framework. (w, h) where 'w' is width, 'h', and is the height of that detection of the boundary box. Every framework anticipates the likelihood of C classifications. The assurance score gives a reflection of the probability of the replica which includes those ambitions goal bodies and the certainty of the guessing of the finding box. Here Pr (Object) gives the idea that if there is an aimed body descending into that cell. Whether there is assurance, it is described as:

$$C(Object) = \Pr(Object) * IOU(\Pr ed, Truth) \quad (2)$$

If it is determined that the cell does not have a target object, the confidence score should be zero C (Object) = 0

IOU is the coinciding rate of obligated and grounded truth created by the candidate, that is to say, the ratio of their junction and merger.

$$IOU(\Pr ed, Truth) = \frac{area(box_{truth}) \cap area(box_{pred})}{area(box_{truth}) \cup area(box_{pred})} \quad (3)$$

The actual input image size that needs to absorb in the model is 416*416. So, the Output image also in the same size i.e. 416* 416. The input image is in the fragment i.e. 32 times, three times, 8 times, and 16 times and the multi-scale properties map which is attained afterward an array of loops and group standardization actions on the incoming picture. Subsequently thirty-two times down-examining, the property map is too short, so that YOLO V3 works with the up-examining with a stair size of 2 to grow two times the size of the culminating property map, that evolves into sixteen times of down-examining. Likewise, the property map inspected on sixteen times is inspected with stairs of size two, and the property map which has an examining size of eight times is acquired, so that wide property may help find an examining size of eight times is observed, therefore the wide property helps find.

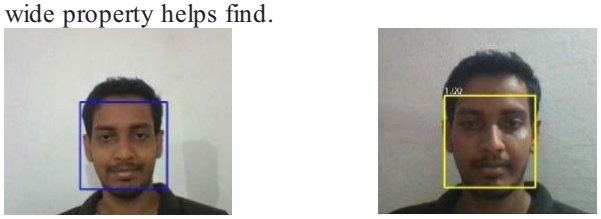

Fig 1. Face detection using s(a) Haar cascade (b) YOLO face

The first figure represents the detection of face using haar cascade and the second figure shows the detection using YOLO. While working with a real-time scenario the camera captures the face from various angles. Both the face detector with frontal face, 45^0,60^0, and 90^0 faced to the camera are tested, which results in the following.

TABLE I. Comparison of YOLO and Haar-cascade

	YOLO	Haar Cascade
Frontal face	100	100
45^0 Rotation	100	78
60^0 Rotation	100	58
90^0 Rotation	100	32

IV. FACE RECOGNITION

A. Local Binary Pattern

The Local binary histogram patterns (LBPH) is a parallel model which require to do the considerable computation in time and a colossal amount of the data [18]. Therefore, the features reduction for the face depiction is required in the face recognition model [13]. LBPH usually helps in the different inclination methods in the vastness of computer perception, and in picture processing, also in the field of pattern recognition. It helps us in the appropriate form of property excavation. As it characterized the fabric, format of a drawing, or a picture.

When that LBPH model is applied, it is observed that bit extracts the structure of the picture by differentiating the image through the local parts. It extracts the two patterns for every local part. Obtained face image then reduced the dimension of the image. Initially, when it started i.e. when the LBP has formed the LBP-operator, it helps on the 8 neighbors of one pixel. It was discovered by Ojala. Cells are the small parts that are known in the images. Further proceeding every pixel that is present in the cell has contrasted with its eight neighbors. The middle value of the pixel will use in the threshold value. If the threshold benefit is bigger than or the same as the pixel of the center than the neighbors i.e. eight-neighbors-pixel will update as to one. Else the cost-benefit is fixed to 0. So, according to the coding file of LBP, the main middle pixel is created by the connection of the 8 acquaintance pixel amounts (1s or 0s) and convert to binary. The binary code again converted into a 256-dimensional decimal. As it helps in the convenience for as a texture heading and of the middle pixel. The authentic LBP driver is displayed in Image.

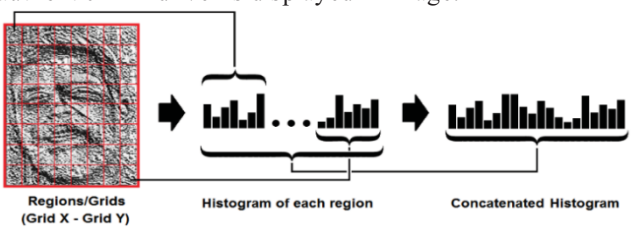

Fig 2. Local Binary Pattern Histogram operator

The mathematical formulation of the LBP operator is given by:

$$LBP(x) = \sum_{i=1}^{8} s\left(G(x^i) - G(x)\right) 2^{i-1} \quad (4)$$

$$S(t) = \begin{cases} 1 & t \geq 0 \\ 0 & t < 0 \end{cases}$$

A modified operator of the LBP operator is known as a consistent design. The uniform pattern is nothing but the number of the transition i.e. bitwise changeover in from 1 to 0 and again. As that name suggests as alike LBP, it means the uniformity scale is at most 2. The image dimension is reduced from 256-d to 59-dso the histogram is used. As the histogram contains knowledge about local patterns. The histogram model is very useful. As it uses all differentiated basket for every alike pattern. 1-one unique basket for all the nonsimilar structures. So, in that 8-bit number, it contains 58 similar structures. So, 58 bins are required for all of them. Then 1 basket for all the non-similar patterns. All those regional histograms are in are integrated to achieve the global interpretation of the face image. In the histogram model, the overall rate of LBPH can be conveyed as:

$$H(k) = \sum_{i=0}^{n}\sum_{j=1}^{m} f\left(LBP_{P,R}(i,j),k\right), k \in [0,k] \qquad (5)$$

where P stands for the sampling points and R stands for the radius.

B. Face recognition library

Further moving to explore other techniques that is a well-known library known as face_recognition library. This library is broadly used. This library is created by adam GitGray. He uses Dlib's state-of-art. It provides the accuracy of 99.38 percent as on the labeled faces in the dessert benchmark. C++ is a well-known language in the world of programming. This language is used to build the Dlib library. This Dlib is completely designed for so many roles i.e. so many roles for face recognition. And some of them are threads, graphical user interfaces, networking and data structures, and machine learning, linear algebra, data mining, and image processing, and text parsing, XML and Bayesian networks, numerical optimization, and Its arrangement is highly aroused by the designs from constructed by the agreement and the software engineering based on component. While installing this library you just give it a single line command. And this face recognition library helps in recognizing the faces from an image. From videos and so many images. The working of this library starts by providing a path of the folder to the python. This library should contain the images of the people with their names as it will help in the training procedure.

C. Working Principle

Dataset is a crucial part of the face recognition system. The captured dataset will be used for feature extraction. It is divided into three parts, in the first part for face detection two different detector harr cascade and YOLO face detector is used. The next step converts the face RGB to grayscale and crops out to 50 x 50 resolution. The propose of the cropping image is not to store unnecessary data present in the image except the face region of the user. While cropping the detected region of the face it is taken care not to have any significant loss of the face data. Finally, the cropped and grayscale image is stored in the SQ-lite3 database.

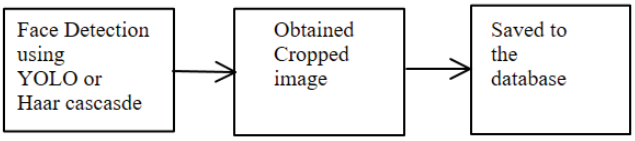

Fig 3. Block Diagram for creating face database

Fig 4. Sample dataset created using YOLO and haar cascade face detector

The microframework flask is used for the deployment of the model on the server. The administrator needs to login to the web portal of face recognition and manually enters the class or session details as shown below.

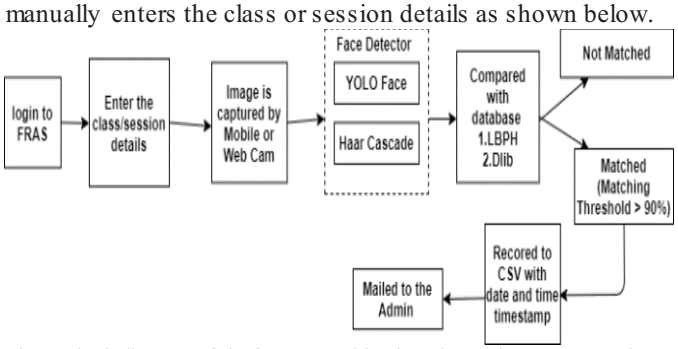

Fig 5. Block diagram of the face recognition based attendance system using the LBPH algorithm and face_recognition library [5]

The session details are saved for further analytics. Then the image of each person is captured and ready to compare with the database. The database contains all the face data of authorized persons. If the face matches with the database then the presence of the person is noted to a CSV file with the exact timestamp as well as the name of the person with the unique ID. Here the threshold of matching two faces is taken as greater than 90%. Finally, the recoded data will be mailed to the administrator at the end of the session. The mail contains all the detailed information retrieved from the database for that session only such as person name, email, year, branch, subject name, branch name, and the name of the respective teacher. The information of the class is analyzed at end of the month. As well as the presence of the person in a particular class or different classes is easily measured by using a real-time based face recognition attendance system.

D. AWS Face recognition

Further implementation of the face recognition system uses for the Amazon Rekognition API. This AWS recognition is nothing but a cloud-based Software. This software provides its service as a service (SaaS)in the computer vision field. This AWS recognition is a type of API which is been called and only performed face recognition. This Rekognition also provides the vision capability to several computers. This recognition is also divided into two-part. The first part works as an algorithm that helps in pre-training the data. This data is collected by

Amazon or its partners. The second part algorithm helps in a user i.e. the user can train on a custom dataset.

1) Pre-trained algorithms

This section explains about the pre-trained algorithms that are being used by the recognition. In all of the algorithms, these are few pre-trained algorithms of AWS. These are some of the that is popular services provided by AWS are recognizing the faces of Celebrity in images, detection of the age range, detection of emotions (e.g. happy, calm, disgusted). In the world where the COVID-19 pandemic is an issue and where people are maintaining distance with a mask, this recognition system helps in detecting and recognizing the faces. It can help in recognizing the faces instead of the mask. Beard, spectacles, different hairstyles and different dresses, or indifferent emotions. Similarly, the inquired Faces facilitate with every user to build up a different and unique database. This database is of images that contain the faces that are alreadylabeled. To train the model i.e. the machine learning model with this database. And to disclose the model in a cloud base service that contains an API. Then, every user can put all unfamiliar and familiar images to the API. This API gets the information about these familiar and unfamiliar new faces in these images. This API helps in exposing several capacities, including the work of identifying the faces of prelabeled known people. It also helps in comparing with all faces. It also helps in finding similar faces in the database.

Custom data set is used for the FRAS system. The recognition image uses the deep neural network models which help in detecting and labeling the thousands of all other objects and all the scenes in the images. It creates a face ID for the unique face detected in the image and creates a feature vector and encodes it. When a new face is given as an input it encodes the image and matches with all feature vectors having a unique face ID and gives the best match as the result. To create the face ID or it is called as collection ID in AWS the image needs to store in the S3 bucket. S3 bucket is a cloud storage provided by AWS. The block diagram of the real-time based face recognition system using AWS is presented below.

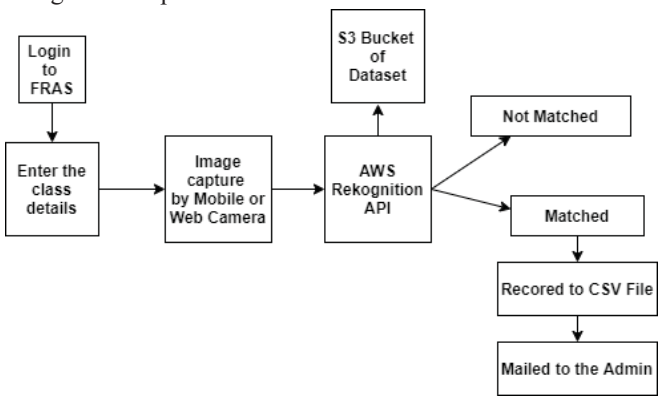

Fig 6. Block diagram of the face recognition based automatic attendance system using AWS recognition API.

V. RESULT ANALYSIS

For comparing both the face detector multiple experiments are done with 20 different people. YOLO can detect a face from 30 feet apart whereas haar cascade failed to detect after 15 feet with a 2 M.P laptop camera. When it comes to detecting in low illumination YOLO have also greater accuracy than haar cascade. Similar results in various angles where haar accurately detected face with 78 percent accuracy while the face is 90 degrees to the camera. The performance of YOLO is nearly 99 percent from various angles within 10 feet of distance.

While comparing the recognition accuracy AWS performance is greater among the face_recognition library and LBPH classifier. The Face_recognition library is also easy to use and uses Dlib to perform its task which achieved 99.38 percent accuracy. LBPH preformed low having 70 percent of accuracy. The AWS recognition API capable of working with low illumination and even a person wearing a mask can be recognized. But in the case of the other two methods, they both need resolution enhancement algorithms to work with low light and if a person appears with a mask on the face it won't be able to recognize. For tests in real-time, the Flask framework is used to deploy the different models.

TABLE II. The performance measure of (a) YOLO and haar cascade (b) face_recognition, LBPH, and AWS.

Face Detection Algorithm	Face Recognition Algorithm	No of faces for training	No of faces for testing	Accuracy (%)
YOLO	LBPH	30	20	89
YOLO	Dlib face_ recognition	30	20	99
Haar Cascade	LBPH	30	20	81
Haar cascade	Dlib face_ recognition	30	20	95
aws	aws	0	20	100

The image shown below is the result of face recognition based attendance system using flask framework which uses python language. The flask is a micro framework that is easy to handle web pages compared to others. The image is captured using HTML and javascript and compared with the amazon web service recognition API in real-time. If the face matches with the stored image in the cloud it returns the name of the person as well as the recognition confidence of the face match and finally displays a message which shows the user that attendance is recorded successfully. When it is successfully recorded the time stamp and date of the attendance of the person is recorded to the SQlite3 database. The same procedure is also applied to the LBPH algorithm and face-recognition based library. Different API is created and deployed on the cloud for ease of access. The purpose of API is that future work can be extended for mobile apps using an android or ios platform. For each API tested on the face recognition web app, the AWS has greater accuracy as well as speed.

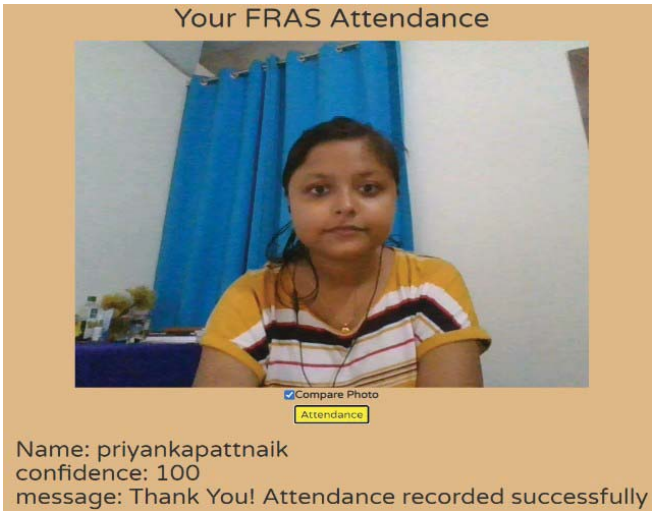

Fig 7. A result of real-time face recognition system in the Web App Using a flask framework.

VI. CONCLUSION AND FUTURE WORK

New techniques of AI and the latest libraries can also be advantageous in its way. For example, detecting the face every algorithm can produce good results according to the consideration of distance. It is difficult in working with the real-time dataset as it requires a lot of effort and it also gives a minimum time limit to check the error. But, it is suggested that in the flourishing stage of artificial intelligence the necessary step is to move forward and need to learn how to take advantage of this new world of data and digitalization. The goal of the work is to make a system where the attendance system cannot be a problem for any educational institute or any organization. It should be a handy way for all and it should not take much time to mark the presence of a person into the record. It can be further implemented for criminal detection so that humankind can get more help from an AI-based face recognition system. It can also be enhanced by doing a new auto-encoder hybridization technique that will be beneficial for face recognition.

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