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Algorithmic Analysis of Automatic Attendance System Using Facial Recognition:
A Revolutionary Approach for Future Education

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ABSTRACT

Attendance management can become a tedious task for teachers if it is performed manually. This problem can be solved with the help of an automatic attendance management system. But validation is one of the main issues in the system. Generally, biometrics are used in the smart automatic attendance system. Managing attendance with the help of face recognition is one of the biometric methods with better efficiency as compared to others. Smart attendance with the help of instant face recognition is a real-life solution that helps in handling daily life activities and maintaining a student attendance system. Face recognition-based attendance system uses face biometrics which is based on high resolution monitor video and other technologies to recognize the face of the student. In project, the system will be able to find and recognize human faces fast and accurately with the help of images or videos that will be captured through a surveillance camera. It will convert the frames of the video into images so that the system can easily search that image in the attendance database.

KEYWORDS

Convolution Neural Network (CNN), Face Recognition, HAAR Classifier, HAAR Classifiers, LBPH Recognizer, OpenCV, Viola-Jones

INTRODUCTION

Nowadays, Attendance monitoring and marking is considered as one of the important tasks for the student and teacher of an institution.

As we can notice continuous progress in the field of technology and innovation, it is possible to create an ecosystem that itself can detect the presence and absence of the student and can maintain a proper record.

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Usually, the attendance of all student can be taken in 2 different ways:

- Manual Attendance System (MAS)
- Automatic Attendance System (AAS)

In the Manual Student Attendance Management system, the concerned faculty needs to call out the name of the particular student and in response, that student indicates his/her presence.

Nowadays, the Manual attendance marking system is a time-consuming process and it comes with various disadvantages.

For example:

1. A teacher can miss calling out someone's name.
2. A student can indicate its presence multiple times, etc.

To overcome all these problems we go with the Automatic Attendance System.

In the Automatic Attendance System (AAS), the system can detect the existence of students' by using face recognition technology. The automatic detection of presence or absence of the students can be identified by registering the students' face on a HD camera device.

The two Human Face Recognition approaches are:

1. Feature-based approach is also called the "local face recognition", it points to the key facial features like ears, nose, eyes, etc.
2. Brightness-based approach also called the "global face recognition", and it is much better than the previous approach. It recognizes all the characteristics of a face (Chokkalingam, S. P. et al, 2019), (Eleyan, A., 2017).

IOT and Its Applications

IOT (Internet of things) is a base on which different hardware of specific capabilities are integrated along with the internet to perform one or more tasks and exchange data with each other to achieve a goal.

IOT is getting acknowledged for its capabilities and the areas to which it can be applied to revolutionize an industry in terms of efficiency.

Applications of IOT

1. It can be used in the maintenance of traffic.
2. It can be employed in homes to have smart electricity and water management.
3. It is nowadays tried to use it in the field of agriculture to maximize the profits with less damage to soil.
4. It can be used to secure the surveillance and security systems.

Security and Challenges of IOT

Security is one of the most important pillars of the internet and at the same time it is the biggest challenge for the IOT. The number of devices are increasing all over the world and with this increases the opportunity to exploit the security of these devices. Use of Outdated hardware and software is another big challenge. These devices are most vulnerable to hackers as they contain bugs and these devices do not get regular updates. Connectivity issues are also one of the major challenges which IOT faces among many other challenges. A large number of firms find connectivity issues as one of the biggest challenges that comes in the path of IOT deployment.

Machine Learning

The concept of machine learning came with the development of artificial intelligence. It is, ability of automatic learning and improvement from experiences provided by the system.

The main aim of ML is to create computer programs that can work in a manner to get better each time it produces some results which may be correct or incorrect.

Artificial Intelligence

AI refers to the methodology in which such machines are created which can work similar to the human brain. This is usually focused on creating artificial neurons which can behave similar to the human neuron. This technology can be used to solve the most complex and redundant problems that we all face in daily life.

OBJECTIVE

To develop an independent system that can enable classroom control and recording presence of students by detection and identification of students' faces in photos or video taken by a webcam.

To help teachers to utilize their time efficiently and to get rid of that old tedious way of attendance marking and maintenance.

PROBLEM IDENTIFICATION AND DEFINITION

Marking attendance is a long and tedious process for a teacher and it is very challenging and time consuming, chiefly when it involves a large group of students. This is also very troublesome and disturbing if attendance is to be marked in an exam. Also, it loses control of invigilators to students. Moreover, the attendance sheet can be damaged and lost while getting used (Selvi, K.S. et al, 2014); (Sarvan, A. et al,2017).

In some cases, the number of students of a certain class is large, the faculty tends to call the names of students indiscriminately or maybe they can miss some of the names or a student can miss its name, which is not an optimized student presence recording process. This process can be easy and effective when students are less but in the case of a large population, it is inefficient and may lead to some problems also (Sharmila, R. et al., 2019).

Thus, to overcome or decrease all these problems we need a robust method of attendance monitoring and marking which may cover all the limitations of manual attendance marking and also can save plenty of time. To achieve this, the "face detection and identification" technique to record the existence of a student (Cassell,J. et al,2000); (Khatoun, R. et al, 2017).

FACE RECOGNITION

Face recognition is a way of identifying a face with the help of technology. A face recognition system uses biometrics to map features of the face from a photograph or video. Algorithms used in face recognition systems compare the captured image with a database of already known faces to find a match. So face recognition technology is a kind of biometric software that with the help of mathematics outlines a person's facial features and then stores the faceprint in the database and then compares between the stored faceprint and captured image and then verifies the true identity(Chowanda, A. et al, 2016),(Bures, T. et al, 2017).

Application of Face Recognition

Facial recognition technology can do more than just identifying people. Today face recognition is being used in many places to make things easier:

1. **ATM:** The software which is used inside the ATM's are capable of quickly identifying a customer's face.
2. **Security:** Face recognition is used widely to compare surveillance photographs to know the terrorist.
3. **Residential Security:** To alert the owner of an approaching person (Harshada Badave et al., 2021).
4. **Voter Verification:** To verify the correct identity of voter.
5. **Crime control:** To locate wanted criminals and offenders roaming in public areas (Alex, K. et al, 2012); (Thomas, C. et al, 2019).

RELATED WORK

Fingerprint Based Recognition System

Fingerprint based systems identify the person with the help of their thumbprint or fingerprint. Fingerprints/Thumbprints can never be the same for two different persons, they are always unique. In this system students have to mark their attendance by putting their fingers or thumbs on a small machine. This machine will scan the imprints of the students and it will mark the attendance. The disadvantage of marking attendance with this system is that during the class hours it may distract the students and disturb the flow of the class (Jadhav, A. et al., 2017); (Zhu, l. et al, 2017).

RFID (Radio Frequency Identification) Based Recognition System

RFID based systems work on the principle of radio frequency. Digital data of the students is stored inside the ID cards which are issued to the students. These cards transmit radio waves and these radio waves are read by the card reader machine. Once the card reader reads the ID cards then the attendance of the students are marked and saved into the database. There are chances of fraud attendance or proxies in this method. Some students may put another student's ID or their friend's ID to mark their presence (Lukas, S. et al., 2016); (Liang, M. et al, 2015).

IRIS Based Recognition System

IRIS based systems scans the iris of the person or student whose attendance is to be marked. This system then performs various computations and matches the scanned image of the iris with the data of students which is already stored inside the database. Fake attendances or proxies can be avoided with the help of this system. This method helps in automating the attendance taking procedure and at the same time reduces the manual work of the teacher (Lad, P. et al, 2017); (Uricar, M. et al, 2012).

Face Based Recognition System

In the face based recognition system, the captured image of the student or any attendee is analyzed and facial features are extracted from the captured image. The image is captured with the help of a high resolution camera. Facial features of captured images are then compared with the dataset of already existing images. If an algorithm finds a similarity between the facial features of captured images and already existing images then attendance of the attendee is marked. This technique requires a good quality high definition camera otherwise it may capture blur images (Selvi, K. et al, 2016), (Pradhan, A. et al 2012).

Accuracy of Face Based Recognition System

Accuracy of face recognition systems has improved significantly in only a few years. In ideal conditions these systems can have nearly perfect accuracy. Algorithms which are used to differentiate images like passport photos can achieve as high as 99.97% accuracy (FRVT). This kind of verification is so dependable that even banks are using it.

However, accuracy of face recognition systems depends on many factors like lighting conditions and clarity of captured images. System will yield good results if facial features of the images are clear and unobscured (Duraimurugan, N. et al, 2019); (Toygar, O. et al, 2003).

Security of Face Recognition System

Security of this attendance marking system totally depends upon the security of the local/remote database which contains all the information as well as critical data such as ID's, names and images.

Available Software for Attendance Marking

Fingerprint Based System

In this system, a student has to save his fingerprint in a small fingerprint device. This machine will scan the imprints of the students and it will mark the attendance (Jadhav, A. et al., 2017); (Viola, P. et al, 2001).

RFID (Radio Frequency Identification) Based Recognition System

In RFID based recognition systems students need to bring a radio frequency ID card with them.

Once the card reader reads the ID cards then the attendance of the students are marked and saved into the database (Lukas, S. et al., 2016); (Viola, P. et al, 2004).

IRIS Based System

The IRIS based system first of all scans the iris of the attendee. The scanned iris is then compared with the dataset of already stored students to mark their attendance (Lad, P. et al, 2017); (Tripathi, R. et al, 2014); (S. W. Arachchilage et al., 2019).

Face Recognition Based System

In the face recognition based system, a high resolution image is captured with a camera. Facial features along with other parameters of the captured image is then matched with the data of students present in the database to mark their attendance (Duraimurugan, N. et al, 2019); (Rastogi, R. et al, 2017).

METHODOLOGY

In this framework, this methodological framework is instantiated by the system. And the framework starts processing the picture for which we need to check the attendance. The image capturing stage is the first essential stage where the framework begins instantiating. After capturing the picture we check for the requirements like lightning, separating, thickness and other 52 features of faces. Format of the picture should be in png or jpg.

We take different frontal instances of the face to get precision at a higher extent. Each individual has been ordered in the context of names for the training database. After capturing images of the frontal faces we recognize faces from Viola-Jones method in which identifiers check for frontal face features and recognize and remove each different part other than face. These recognize faces put in the database for further test and then go for features extraction stage. Identified features questioned to search for feature extraction and other removable features stored in the matrix (Selvi, K.S. et al, 2014); (Kaelbling, L. P. et al 1996).

SYSTEM DESIGN

Use Case Diagram

(As Fig. 1), the diagram depicts the actions taken by different entities of the system.

Figure 1. Use Case diagram

In the proposed methodology, we have various entities which play vital roles in the process of attendance marking.

As a very first step, each student has to record his/her facial information in the form of pictures.

When all the students have finished their parts. The teacher can use the prototype to records the attendance of students automatically and all the information gets stored in the attendance sheet.

Flow Chart

(As Fig. 2), the diagram depicts the separate steps of the process of storing facial data of students in sequential order.

The student will provide its "ID" as well as its "Name" and after that he/she will use the camera to get his/her details recorded.

(As Fig. 3), the diagram depicts the separate steps of the process of "marking attendance" of students in sequential order.

The teacher will use the camera to record the attendance of all the students automatically.

Data Flow Diagram(DFD)

(As Fig. 4), the diagram depicts the flow of data in the "Automatic attendance marking" system.

The data gets created or stored when either of two (student or teacher) performs some task of their part.

If a student creates the data set of his/her own then his/her facial information gets created and stored in a database (local or remote).

Similarly, if a faculty member marks the attendance of the students, a database gets accessed by the system and a new data gets created which contains all the information about the presence of the students.

Activity Diagram

(As Fig. 5), the diagram depicts a sequence of actions in the "Automatic attendance marking" system. Diagram represents all the activities of both the entities (i.e. student and teacher) from recording facial information to marking attendance.

Figure 2. Flow Chart - Student's End

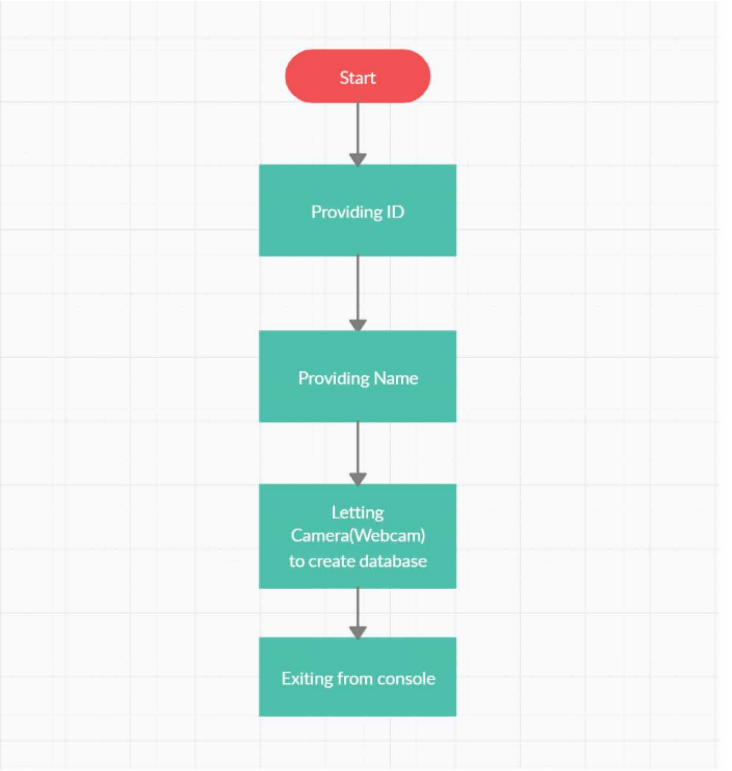


Figure 3. Flow chart - Teacher's End

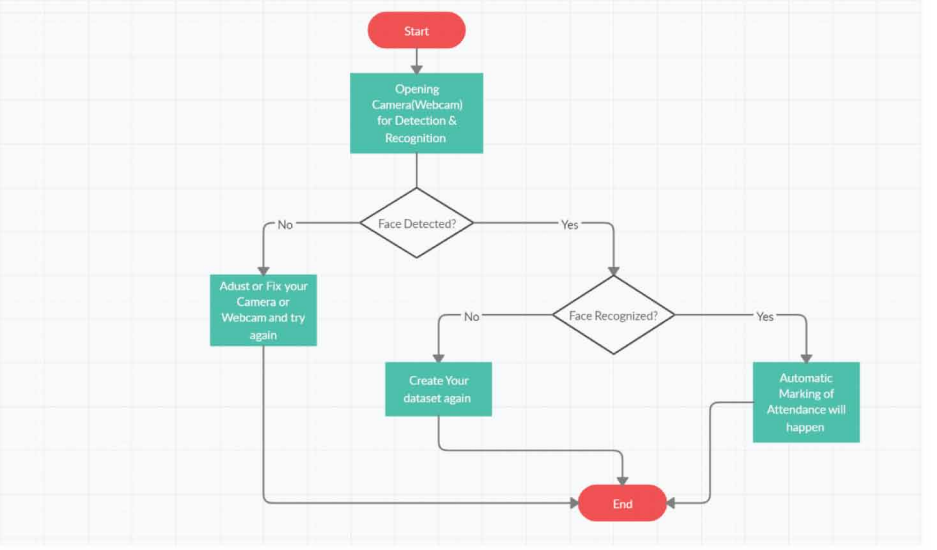


Figure 4. Data Flow Diagram

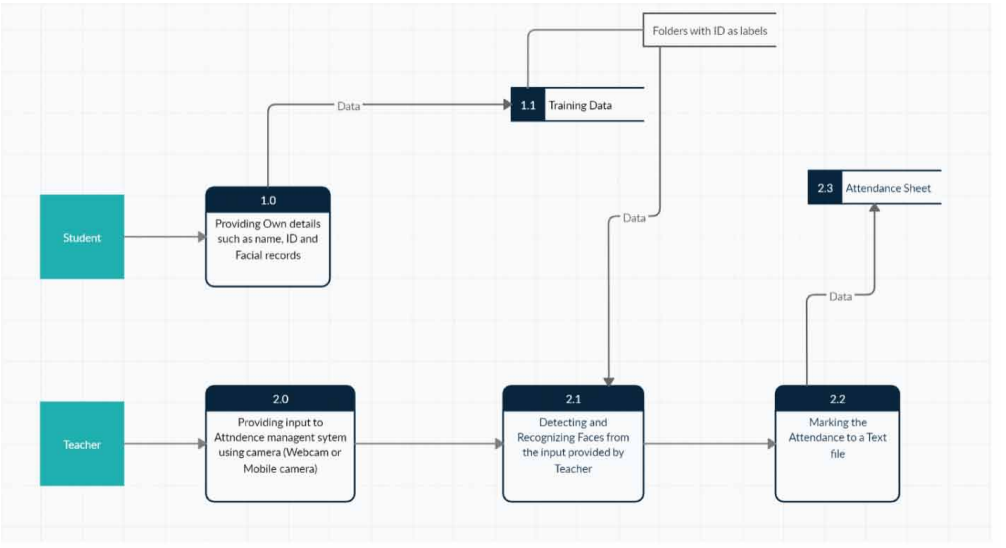
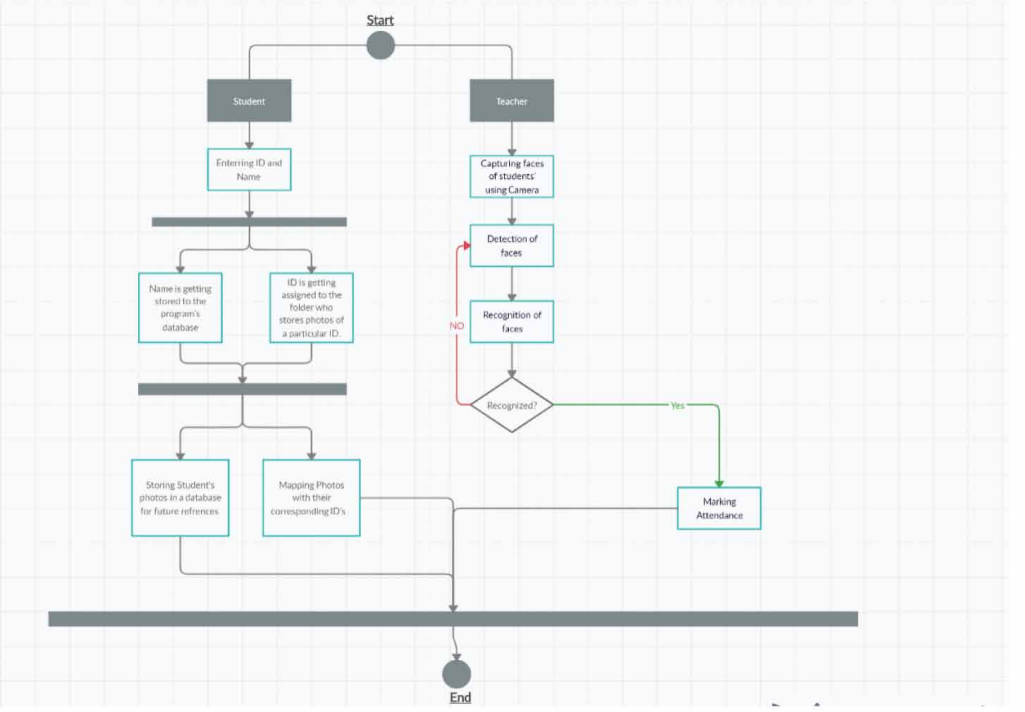


Figure 5. Activity Diagram



EXPERIMENTAL SETUP AND ALGORITHMS USED

Technical Requirements

Hardware Requirements

1. A good resolution camera.
2. A well configured computer device.
3. RAM – 4GB or above.

Software Requirements

1. Latest version of python installed.
2. Latest version of OpenCV installed.
3. Windows 8 or above.
4. Any code editor.

Data Set

This prototype involves the use of a HAAR Cascade classifier.

It is a machine learning based mechanism where a cascade function is taught using a set of positive and negative images.

Initially, the algorithm needs positive images (containing faces) and negative images (without faces) to teach the classifier.

For the HAAR classifier, we took help of Github and we took an "XML" file of "haar cascade-frontal face".

Metadata

Haar-Like Features are the features of a digital image which can be used in the process of recognizing an image.

Different Haar-Like Features

1. Rectangular Haar-like features.
2. Titled Haar-like features.

Haar-Features

All objects of the same kind have some similar properties. These regularities can be collated using the Haar classifier.

As we are working with faces, few of the properties can be:

1. The eye region is little darker than the cheeks.
2. The nose region is little brighter than the eyes region.

Some of the main features/areas that a Haar classifier considers can be eyes, mouth, bridge of nose etc. Different combinations of these features leads to different features.

Algorithm

Haar Cascade and Its Implementation

(As Fig. 6), we have used a HAAR classifier of "OpenCV" for face detection.

Figure 6. HAAR Classifier Usage

```
def faceDetection(test_img):
    gray_img=cv2.cvtColor(test_img,cv2.COLOR_BGR2GRAY)
    face_haar=cv2.CascadeClassifier(r'C:\Users\abhinav tyagi\Desktop\Face-Recognition-master\haarcascade_fronta
    faces=face_haar.detectMultiScale(gray_img,scaleFactor=1.2,minNeighbors=3)
    return faces,gray_img
```

Haar Cascade is a machine learning object detection algorithm used to identify objects in an image or video and based on the concept of features proposed by Paul Viola and Michael Jones in their paper "Rapid Object Detection using a Boosted Cascade of Simple Features" in 2001(Viola, P. et al, 2001).

We have used the HAAR classifier of the frontal face, which takes up a lot of positive as well as negative images for training and detects the human face based on that training (Priya, TS. et al, 2018); (Ren, K. He et al, 2017).

Proposed Algorithm

Viola-Jones Face Detection Algorithm

```
input: original test image
Output: image with face indicators as rectangles
For j =1 to num of scales in pyramid of images do
Downsample image to create image
      Compute integral image, image
For k=1 to num of shift steps of sub-window do
for l=1 to num of stage in cascade classifier do
form=1 to num of filters of stage l  do'
Filter detection sub-window
                        Accumulate filter outputs
 End for
                If    Accumulation fails per stage threshold  then,
 Reject sub-window as face
break this l for loop
End if
        End for
if Sub window passed all per stage checks  then
             Accept this window as face
 End if
    End for
End for (Asani E.O. et al, 2020)
```

DISCUSSIONS AND OBSERVATIONS

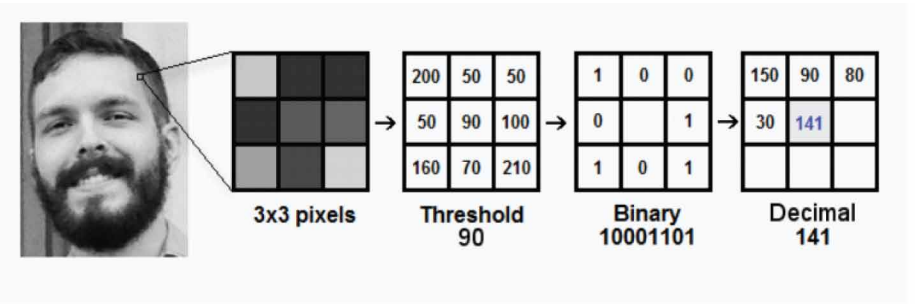
HAAR Cascade Classifier

It is a successful object detection method which was suggested by "Paul Viola" and "Michael Jones" in a paper published in 2001.

In this methodology, we need a huge number of positive as well as negative photos to teach the classifier.

Positive images are images which are very similar in terms of features to the kind of images which we are interested to detect in future. And the dissimilar ones are referred to as negative images.

Figure 7. Concept Behind LBPH Based Face Recognition



Source: https://towardsdatascience.com/face-recognition-how-lbph-works-90ec258c3d6b

For face recognition, we have used "OpenCV", Specifically we used "LBPH Face Recognizer".

LBPH (Local Binary Pattern Histograms)

Local Binary Pattern (LBP) is a type of signifier which is used for categorization in the field of computer vision. It is the simplest yet very efficient technique which labels each pixel of a part of an image by thresholding the neighborhood of each pixel and at the end it contemplates the result as a binary number. It performs the same thing for every part of the image, thus recognizing the image very efficiently. We have provided an image below that makes explanation a little easier and simpler.

IMPLEMENTATIONS AND RESULTS

Confidence Level Graph

According to Figure 8, we have a graph showing a variation of confidence with respect to decrease in relevant features during the course of time.

X axis represents variations in face movements during the course of time and Y axis represents the confidence value. In OpenCV we have a method called "predict" which gives back two values (Confidence and label).

Comparison of Face Recognition Approaches

Usually, all the face recognition employed systems operate in the two modes:

1. **Verification/ Authentication of image:** In this, it compares the input image with the image related to the user which is required for the authentication. It is some sort of 1*1 comparison.
2. **Identification/ face recognition:** In this, it compares the input image with the all images in the dataset. Main aim is to seek for the user that matches the face. It is some sort of one to 1*N comparison.

If we talk about the various face recognition algorithms, then the available options are (As per Fig. 9, Fig. 10, Fig. 11):

1. Eigen faces
2. LBPH (Local Binary Pattern Histograms)
3. Fisher faces
4. SIFT (Scale Invariant Feature Transform)
5. SURF (Speed Up Robust features)

Figure 8. Confidence Level Graph

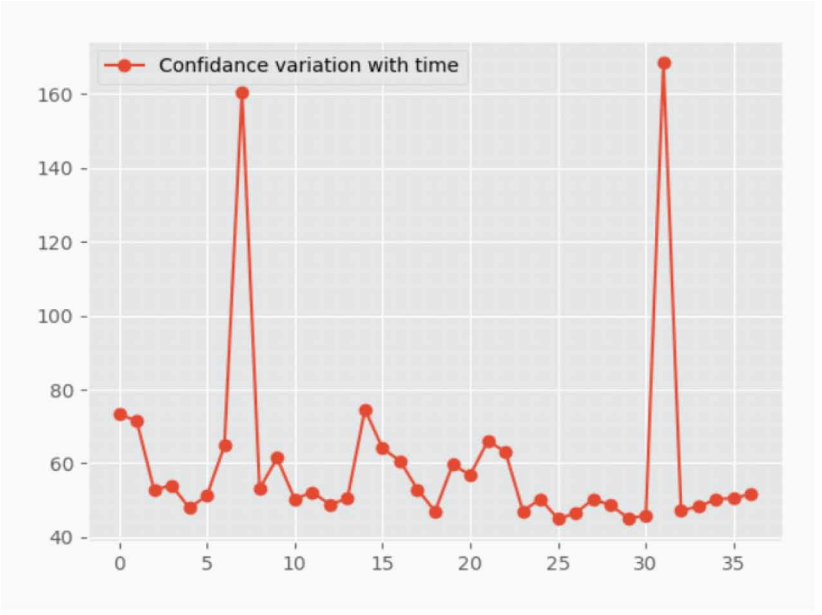


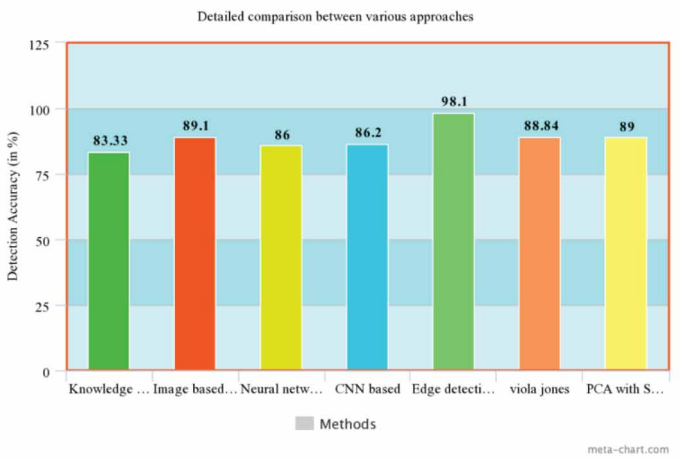
Figure 9. Comparison between Various Face Recognition Algorithms

Algorithm	Based on	Working
Eigenfaces	Apperance based approach	Seeks for the variation in data
LBPH	Texture spectrum model	Classifies the data
Fisherfaces	Apperance based approach	Uses PCA to get Eigenfaces
SIFT	Local Feature Detection	Feature matching is based on Euclidian distance
SURF	Local Feature Detection	Uses an integer approximation of the determinant of Hessian blob detector

Figure 10. Comparison between Various Face Recognition Approaches

METHOD	DETECTION ACCURACY (%)
Knowledge based method	83.33
Image based method	89.1
Neural network method	86
Convolutional neural network (CNN) based	86.2
Edge detection based	98.1
Viola Jones	88.84
PCA with SVM	89

Figure 11. Detailed Comparison between Various Approaches in a Bar Graph



In these available options, the manner of operation of Eigen faces & fisher faces and SIFTS and SURF is almost similar.

RESULTS

In the proposed prototype, the author team has a system, which can automatically detect and mark the presence or absence of students with the help of ML object detection and recognition technique.

More specifically we used a "HAAR cascade classifier" of "OpenCV" to train our model and recognize faces and "LBPH Face Recognizer" for face recognition.

After successful execution of all the tasks, we have full facial data of all the students in the database (local or remote) and marking of their presence or absence in a separate document with date (As per Fig. 12 and Fig. 13).

Code

According to Fig. 14, the image taken from the webcam (through imread) gets passed to the "cvtColor" method which converts the image to grayscale.

Figure 12. Recognition of Face

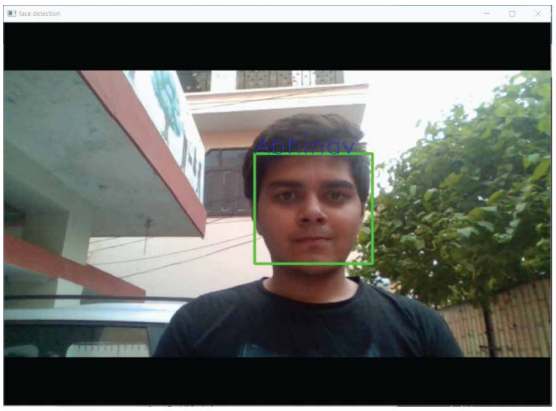


Figure 13. Marking of Attendance

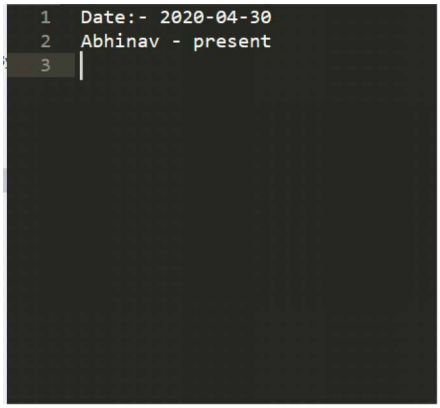


Figure 14. Use of HAAR Cascade Classifier

```
def faceDetection(test_img):
    gray_img=cv2.cvtColor(test_img,cv2.COLOR_BGR2GRAY)
    face_haar=cv2.CascadeClassifier(r'C:\Users\abhinav tyagi\Desktop\Face-Recognition-master\haarcascade_front
    faces=face_haar.detectMultiScale(gray_img,scaleFactor=1.2,minNeighbors=3)
    return faces,gray_img
```

Then we have another function "detect Multi Scale" which returns all the faces which the function has found.

According to Fig. 15, we have used LBPH classifiers to recognize the image which is labelled against face id.

According to Fig. 16, we have every face turn by turn and this function predicts the name of a person through the predict method of openCV.

Confidence is that number value that shows how much our recognizer is confident that the image is of label.

After all this if confidence is less than 70 then the name will be marked as present.

DISCUSSION ON RESULTS

Confidence is that number value that shows how much our recognizer is confident that the image is of label. 0 confidence means that the recognizer is 100% sure that the image is of a person with an identity as "label" which is not possible.

Figure 15. Use of LBPH Cascade Classifier

```
def train_classifier(faces,faceID):
    face_recognizer=cv2.face.LBPHFaceRecognizer_create()
    face_recognizer.train(faces,np.array(faceID))
    return face_recognizer
```

Figure 16. Use of Haar Cascade Classifier

```
for face in faces_detected:
    (x,y,w,h)=face
    roi_gray=gray_img[y:y+h,x:x+h]
    label,confidence=face_recognizer.predict(roi_gray)
    print ("Confidence :",confidence)
    print("label :",label)
    fr.draw_rect(test_img,face)
    predicted_name=name[label]
    if(confidence>70):
        continue
    fr.put_text(test_img,predicted_name,x,y)
```

In figure 8, we can see two peaks, these are those instants when I removed my face from the front of the webcam, thus showing very large values. Also the team tried to make some variations in lighting and face angles just to trick the recognizer and get some different results.

In the proposed prototype, the authors' team has shared a system, which can automatically detect and mark the presence or absence of students with the help of machine learning object detection and recognition technique.

More specifically, team has used a "HAAR cascade classifier" of "OpenCV" to train our model and recognize faces.

LIMITATIONS

There are few limitations in the proposed approach. The image which is captured by the camera has to be frontal and upright. Second, the accuracy of the proposed approach might be affected due to illumination problems:

1. This prototype can work for a small population only (ex A class of 50-60 students) and can give different results on a large population.
2. It requires a good configuration device.
3. Lighting conditions may alter the results.
4. Camera must be of high resolution.
5. The accuracy of this system is lower than the Iris recognition systems and fingerprint recognition systems.
6. Because of low configuration the system accuracy is little low but can be increased by increasing configuration.

RECOMMENDATION AND NOVELTY

Recommendation

A better camera should be used to capture the image as it can reduce the illumination problem. The trained images and test images which are used in this approach are highly related to each other and are highly dependent on the device which is used to capture the images. The device to capture images has to be the same for better accuracy of the system.

Novelty

Capturing the images from the camera and then using the proposed system for face recognition can decrease manual work. It is an efficient method to identify or recognize the person. The proposed system can also be used in other areas such as worker attendances, security agencies, police stations for finding the robber. It saves a lot of time and effort, especially when there are a large number of students/ person. The proposed system does not require high-end hardware specifications.

FUTURE RESEARCH DIRECTIONS

As we all know that face provides an original and unique identification of a person. Face can be used to verify a person's identity. Face recognition provides a non-intrusive way to recognize a person. This system reduces the chances of proxies, fake attendance and other wrong methods of marking attendance. The problems such as lightning issues and head pose will be overcome using eigen faces method. A high resolution camera and a proper light source can also be used in future to avoid blurry images and to overcome the problem of poor light. However, the system accuracy is still not competent especially in those cases where there is a problem of head tilt. We have to look for some better face detection methods. Other supervised methods may provide better results. The team will develop an android application for this system in near future.

CONCLUSION

In this prototype, we have created an automatic and automatic system that provides classroom control and automatically predicts and marks the attendance of students. It gives great classroom control and saves time & effort especially when there are a large number of students.

While pointers such as the quality of the camera, ambient lighting and configuration of device are problems that will eventually fade as adoption of good technology increases, the head-tilt issue is something that needs to be addressed going forward as it reduces the applicability of the algorithm significantly.

The authors' team has also done a detailed analysis of all the methodologies and technologies which were used for this purpose in the past. Also by using that analysis we created a feasible solution which can do this task in an efficient possible manner.

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