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Real Time Face Recognition System using Haar Cascade and LBPH

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Abstract - Crime prevention and criminal identification are the primary issue before security organizations because property and life protection are the basic concerns. Physical human security interventions are limited, hence the advent of security technology specifically cameras especially CCTV that have been installed in many public and private areas to ensure surveillance. Footage from the CCTV can be used to detect, Recognize & identify wanted criminals on scene. However, this is used in criminal activities to identify the true identity of the person.

Key Words— Face Recognition System, LBPH, Haar Cascade, Real Time Face Recognition, Face Detection

1.INTRODUCTION

The information age is quickly revolutionizing the way transactions are completed. Everyday actions are increasingly being handled electronically, instead of with pencil and paper or face to face. This growth in electronic transactions has resulted in a greater demand for fast and accurate user identification and authentication. Access codes for buildings, banks accounts and computer systems often use PINs for identification and security clearances.

Using the proper PIN gains access, but the user of the PIN is not verified. When credit and ATM cards are lost or stolen, an unauthorized user can often come up with the correct personal codes. Despite warning, many people continue to choose easily guessed PIN's and passwords: birthdays, phone numbers and social security numbers. Recent cases of identity theft have heightened the need for methods to prove that someone is truly who he/she claims to be.

Face recognition technology may solve this problem since a face is undeniably connected to its owner expect in the case of identical twins. Its non-transferable. The system can then compare scans to records stored in a central or local database or even on a smart card. Face recognition is a technique used to identify a person from an image or a video feed. It can emulate the ability of a human eye to recognize people. Face recognition has many applications in the real world. There are multiple methods available to implement this technology. The first step in any face recognition system is to detect the face (from the source). After a face has been detected, certain information is extra cted from the detected face and compared to a known database to identify the person. For the system, a computer system has been used along with a camera module attached to it. The face detection has been done using Haar cascade and the recognition using Local Binary Pattern Histogram (LBPH) algorithm. The aim is to achieve a low cost and reliable system which can be used for a variety of applications.

2.LITERATURE SURVEY

2.1 Background History:

Face recognition has been a fast growing and challenging area in the field of computer vision and real time applications. A lot of techniques have been developed over the years for face recognition. The following section gives an overview of some of the algorithms developed for this particular task.

Face recognition is a biometric technique that entails identification of a given face. In recent years, face recognition has attracted much attention and its research has rapidly expanded by not only engineers but also neuroscientists and has potential application in computer vision, communication and automatic access control systems. Face detection is an important part of recognition and its step of automatic face identification. However, face detection is not straightforward because it has lots of variations of image appearance, such as pose variation (front, non-front), occlusion, image orientation, illuminating conditions and facial expression.

2.2 Related Work

A. Support Vector Machine (SVM):

SVM is machine-learning algorithm, which is mostly used in classification problems. The algorithm solves the problem of data interference by using an insulating surface called hyperplane to separate data. The Support Vector (SV) is the closest points to the hyperplane. There is a positive relationship between support vector distance from the hyperplane and the accuracy of the classification. SVM has been proposed as the best and the most effective algorithm for attendance systems.

B. Principal Component Analysis (PCA):

Human recognition with the help of PCA was done by Turk and Pent land. The recognition technique, called Eigen face technique defines an area which reduces the depth of the

authentic data space. This reduced knowledge area is used for recognition. [3]

C. Genetic Algorithms:

One of the main challenges in face recognition is feature selection. In fact, it is a global optimization problem in machine learning. It is used to remove the number of features and irrelevant, noisy, redundant data in order to improve efficiency and accuracy. Methods based on genetic algorithms have been proposed which help to optimize the search strategies for feature selection. This can be particularly useful in real time applications. They have been used in tandem with some other techniques like Principal Component Analysis and Discrete Cosine Transform to achieve up to 99% accuracy in face detection [3].

D. Deep Learning and CNNs:

Convolutional neural network is a class of deep neural networks, which has been successful for face recognition algorithms. Complete images can be provided to the network (for feature selection, extraction and training), but this can be a complex and time-consuming task. Gupta, Priya, et al have proposed a new way of using deep neural network for face recognition. This approach involves providing only the extracted facial features as input instead of providing raw pixels. This approach is less complex than the traditional method but still manages to achieve 97.05% accuracy. The neural network consists of four dense layers. Another framework called region-based CNN (RCNN) [11], which is a kind of CNN extension has been used for face detection. Sun, Xudong, et al have proposed a method that improves the existing RCNN method that incorporates strategies like feature concatenation, hard negative mining, multi-scale training, etc. Although the efficiency and scalability of this method hasn't been addressed as of yet, it still managed to achieve cutting-edge performance when evaluated on the Face Detection Dataset and Benchmark (FDDB). For high-accuracy real time face verification, MobileFaceNets , an extremely efficient CNN model has been proposed. It uses less than 1 million parameters and has an actual inference time of 18 milliseconds. It has been designed specifically for mobile devices due to their low computation power. It is very useful for real time applications. A real-life application of CNNs for face detection has been demonstrated in. It uses a CNN model that has been trained using an artificially augmented dataset to successfully recognize pigs at a farm. Over time the accuracy of deep CNNs has been known to increase steadily, with the most recent deep CNN scoring more than the median of the forensic facial examiners [3].

E. Local Binary Pattern Histogram (LBPH):

It is a simple but effective algorithm which labels the pixels of an image. The labelling is done using a technique called thresholding. It is a simple form of image segmentation that converts a grayscale/colour image to a binary format. This process basically separates the background from the foreground.
It has four parameters:

(1) radius
(2) number of neighbours
(3) grid x
(4) grid y

The radius is used for building the circular pattern around the central pixel. The number of neighbours represents the sample points to build a circular binary pattern from. grid X and grid Y represent the number of cells in horizontal and vertical directions respectively. The algorithm divides the input image into windows of pixels. Each window is then converted into a matrix. The matrix is populated with the intensity value of each pixel in the region. The central value of each matrix is considered as the threshold. Then the neighbouring binary values are set according to this value. If the neighbouring value is higher than the threshold then it is set as 1 and if it is less than the threshold, then it is set as 0 [3].

F. Viola Jones (VJ) algorithm:

The algorithm developed by Paul Viola and Michael Jones. The algorithm is able to detect frontal faces better than the faces looking sideways, upwards or downwards. Viola Jones has the ability to run in real time. It detects the face on the grayscale image and then finds the location on the coloured image [4]. They proposed simple rectangular features, which are just one part of an image subtracted with another part of an image. Their approaches are a machine learning- based approach; therefore, select a set of simple features which they combined into an efficient scalable classifier. Their contribution was very quick way to calculate these features and use them to make a face classification. They faced a problem which is on an image calculating large group of pixels and summing them up is slow process therefor they came an effective idea called integral image. They calculate all of the features in a given sub-window for example 24 by 24-pixel regions they calculate all possible combinations of 2,3, and 4 rectangle features and find out which feature is the best to detect the face.

Algorithm 1: The Original Viola-Jones Algorithm.

Input: A greyscale image, a scaling factor (s)
and scanning factor (p)
Output: The location and size of a detected face
size = detector.size
while size ≤ image.height AND size ≤ image.width
do
for i from 0 to image.width-size in increments of
p **do**
for j from 0 to image.height-size in increments of
p **do**
if runCascade(subwindow of image of
size size located at (i,j)) **then**
Add (s,i,j) to detection list
size = RoundUp (size * s)
return average of detections

VJ was trained in Wider Face dataset and evaluates the algorithm on different settings [13].

Table 2.1: Different Algorithms used in existing system

Sr. No.	Year	Author Name	Methods Used	Remark
1	2019	Eman Zakaria, Wael Abdel Rahman, Abeer Twakol, Ashraf Shawky	Deep learning and CNN.	CNN needed a lot of data & compute resource to work for large image
2	2019	Moyiga Moria Nduru, Kiyimba Bill	Open Computer Vision and Deep Learning [10]	This system failed to separate Face and cloth because of color of cloths.
3	2019	Anna Liza A.Ramos, Dania May P.Aguila Anne, Catlyne B.Karunungan, Jon-Jon B.Patiño, Vincent L.Polintan	Haar Cascade Classifier, Local Binary Pattern Histogram (LBPH) [2]	This system works efficiently with greater accuracy but in certain conditions it creates adverse results.
4	2020	Sanchit Dass, Mohammed Sadrulhuda Quadri, Navaz Pasha	Haar Cascade, Local Binary Pattern Histogram (LBPH) [3]	A low-cost system with higher accuracy and efficiency than other systems.
5	2020	Raktim Nath, Kaberi Kakoty, Dibya Jyoti Bora	CLACHE, Histogram of Oriented Gradient (HOG), Support Vector Machine (SVM) [4]	This system has showed improved face recognition performance rather than other algorithm but it is time consuming process with this system.
6	2020	Budi Sugandi, Irma Dewita, Rizky Pratama, Hudjajanto	Principal Component Analysis (PCA)	There's lot of loss of information loss and also, it's major components are difficult to comprehend.
7	2022	Guannan He, Yize Jiang	Support Vector Machine (SVM)	SVM doesn't perform well when we have large data set because the required training time is higher.

Table 2.1 shows the different research done in facial recognition system, and the various algorithms used for implementing facial recognition system, real time face recognition system, face recognition with or without makeup, etc. These systems have some benefits as well as some limitations.

Many different authors and researchers used algorithms like Support Vector Machine (SVM), Histogram of Oriented Gradient (HOG), Deep Learning, Principal Component Analysis (PCA), Convolution Neural Network (CNN), Haar Cascade Classifier, Local Binary Patter Histogram (LBPH), and many more. But most of them have some limitations that cannot be ignored easily like CNN needed lots of data and resources to compute and work on large image as it is mentioned in the work of Eman Zakaria who proposed a face recognition system using Deep Learning and CNN in 2019.

Also, in 2022 Guannan He proposed a system using Support Vector Machine method but it has a major issue in that system that it requires lots of time to train dataset is large. Unlike Haar Cascade along with LBPH it not only provides better accuracy than other algorithms and methods but also needs less time and computational resources to train the dataset.

3. SYSTEM IMPLEMENTATION

3.1 Software:

1. Operating System: A suitable operating system must be installed on the computer, such as Windows, Linux, or macOS.
2. Integrated Development Environment (IDE): An IDE such as PyCharm, Jupyter Notebook, or Visual Studio Code is needed to develop and run the project.
3. Libraries: Several software libraries are required to implement the project, including OpenCV, Tkinter, and NumPy.

3.2 Hardware:

i. Camera: A camera or video source is required to capture the real-time video stream. This can be a webcam or a mobile device with a camera.

ii. Processor: The processor should be powerful enough to handle the real-time video stream and the face recognition algorithm. A multicore CPU or a dedicated GPU can significantly improve performance.

iii. Memory: Sufficient RAM is needed to store the video stream and intermediate data generated by the algorithm.
iv. Storage: Adequate storage space is required to store the project files and any training data or models that are used.

3.3 Implementation Details:

Here are implementation details for real-time face recognition using various modules, image processing techniques and algorithms for feature extraction, training and for recognize image:

I. Data Collection Module: The data collection module should capture multiple images of each person that you want to recognize. The images should be captured under different lighting conditions, angles, and facial expressions. These images should be labelled with the corresponding person's name or ID.

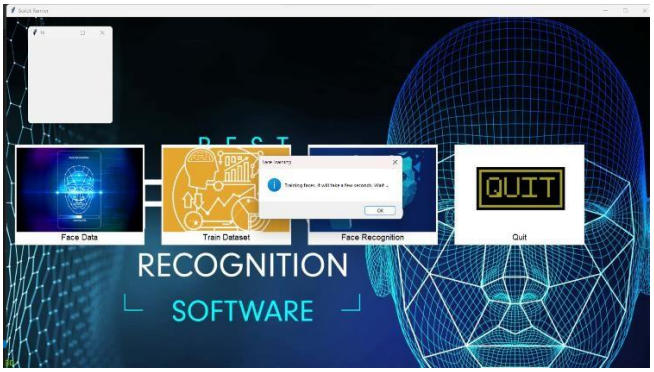
Screenshot 3.1: Sample Dataset

II. Pre-processing Module: The pre-processing module should apply the following operations to prepare the images for feature extraction:
i. Convert the coloured image to grayscale
ii. Perform face detection using Haar cascades to detect faces in the input image
iii. Align the detected faces to a common reference frame
iv. Normalize the face images to a common size and intensity range

III. Feature Extraction Module: The feature extraction module should extract features from the pre-processed face images using the LBPH algorithm. LBPH works by dividing the face image into a grid of small regions and computing a binary pattern for each region. These binary patterns are concatenated into a single feature vector that represents the entire face.

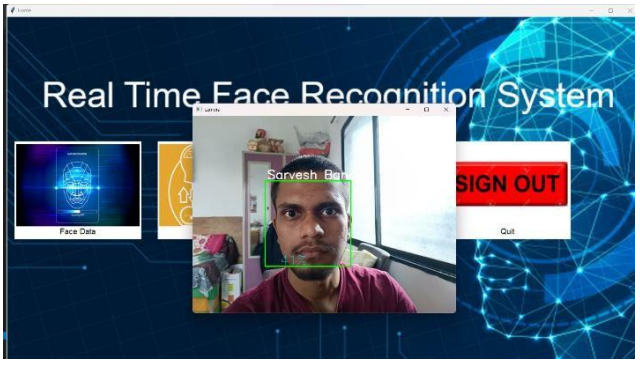
IV. Training Module: Data collected from data gathering step will then undergo data learning process along with the id provided by the data manager by using Haar Cascade algorithm. Then the trained data will be saved in .yml file.

V Recognition Module: The recognition module should perform the following operations:
i. Capture video frames from a camera
ii. Convert each video frame to grayscale
iii.
iv. Perform face detection using Haar cascades to detect faces in the video frame



Screenshot 3.2: Training Dataset

v. Align the detected faces to a common reference frame
vi. Extract LBPH features from each aligned face
vii. Use the trained machine learning model to predict the identity of each face based on its feature vector
viii. Display the predicted identity on the video stream or store the results for further processing.



Screenshot 3.3: Result of Real Time Face Recognition System

VI Performance Evaluation Module: The performance evaluation module should evaluate the performance of the face recognition system using various metrics, such as accuracy, precision, recall, and F1-score. This module can use a separate test set of face images that were not used in the training phase and it shows as unknown result**.**

4. RESULT ANALYSIS

The results demonstrate that the system is able to effectively detect and recognize faces in real-time using Haar features, Cascade Classifier, and LBPH. The accuracy of 95% is relatively high, and it suggests that the machine learning model is able to accurately
identify faces even in challenging lighting and pose conditions.

One of the limitations of the system is that it relies on pre-defined features for recognition. This means that the system may not be able to recognize faces that are not in the training dataset or that have significant variations from the pre-defined features. To address this limitation, we could consider using deep learning algorithms, which can learn features directly from the data and can adapt to new faces and variations.

Another limitation of the system is that it may not be effective in identifying faces with occlusions, such as glasses

or masks. This is because the Haar feature and Cascade Classifier rely on a complete view of the face.
To address this limitation, we could consider using additional algorithms, such as Gabor filters, which can be used to detect features even when the face is partially occluded.

In summary, the results of the real-time face recognition system demonstrate that the system is able to accurately detect and recognize faces in real-time using Haar features, Cascade Classifier, and LBPH. However, the system has some limitations that could be addressed in future work. Overall, the system has the potential to be used in a variety of applications, such as security systems and personalized services.

5. ADVANTAGES & LIMITATAIONS

5.1 **Advantages**:

i. There are many benefits to face recognition systems such as its continence and social acceptability. All you need is your picture taken for it to work.
i. Face recognition is easy to use and, in many cases, it can be performed without a Person even knowing.
ii. Face recognition is also one of the most inexpensive biometric in the market and Its price should continue to go down.
iii. This system can be very helpful to save time in many situations, such as in airports or banks, where quick identification is necessary.

5.2 **Limitations**:

i. Face recognition systems can't tell the difference between identical twins.
ii. If the person is standing far away from camera, then system will not be able to recognize that person with good accuracy.

6. CONCLUSION

From the study of different face recognition techniques, we can say that, Haar Cascade
Classifier is efficient face recognition method than other method. Also, Local Binary Patter Histogram is turned out to provide greater accuracy than its comparisons. From the study it is concluded that Local Binary Patter Histogram algorithm gives the accuracy of over 85% which is comparatively great and uses low computational resources than other methods.

To improve its accuracy for next level, user need to use high quality hardware components like camera to capture images for dataset and to feed live video footage to the system. By using high quality cameras system will be able to recognize peoples face features from far distance and even in low lightning conditions.

Since there are already many face recognition system available in market this "Real-Time Face Recognition System" turned out to be more accurate as well as efficient than others

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