Real Time Face Recognition Using LBPH Algorithm

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***Abstract*—Face recognition is a crucial aspect of computer vision with widespread applications in various domains such as security systems, human-computer interaction, and surveillance. This research focuses on real-time face recognition using the OpenCV2 library and the Local Binary Patterns Histograms (LBPH) machine learning algorithm. OpenCV2 provides a powerful and flexible platform for image processing and computer vision tasks, enabling efficient face detection and recognition. The LBPH algorithm, known for its robustness and effectiveness in recognizing facial patterns, is utilized to classify faces and achieve real-time face recognition. This research implements a comprehensive framework that includes face detection, feature extraction using LBPH, model training, and real-time recognition. The proposed system demonstrates promising results in terms of accuracy, efficiency, and speed, making it a valuable contribution to the field of face recognition and its practical applications.**

***Index Terms*—Local binary pattern histogram; Face recognition; Deep Learning; augmentation; Cascade classifier**

I. Introduction

Face recognition, a fundamental component of biometric technology, plays an integral role in modern society by offering diverse applications that enhance security, convenience, and efficiency. It involves identifying or verifying individuals based on unique facial features extracted from images or videos. In recent years, the integration of face recognition technology into various real-world systems has surged, demonstrating its relevance and potential impact on security, customer service, marketing, and more.

In the domain of security, face recognition is employed extensively for access control systems in commercial and government facilities. For instance, airports utilize this technology to enhance security measures by identifying individuals on watchlists, thereby ensuring safe travels. Similarly, smartphone manufacturers have embraced face recognition as a secure means for device authentication, replacing traditional passcodes or fingerprint recognition. This innovation simplifies the unlocking process while safeguarding user privacy.

Beyond security, face recognition has revolutionized customer experiences in retail and marketing. Retailers employ it to analyze customer demographics and behavior, tailoring marketing strategies and product offerings accordingly. For instance, smart billboards use facial analysis to determine a viewer's gender and age, delivering personalized advertisements. Additionally, social media platforms utilize facial recognition for automated tagging of individuals in photos, enhancing user engagement and ease of sharing.

To achieve real-time face recognition, this research leverages the power of the OpenCV2 library and the Local Binary Patterns Histograms (LBPH) machine learning algorithm. OpenCV2 provides a versatile platform for image processing, enabling efficient face detection and analysis. The LBPH algorithm, renowned for its accuracy and efficiency in facial pattern recognition, is employed to classify faces and facilitate real-time recognition. The integration of OpenCV2 and LBPH presents a robust framework capable of achieving accurate and rapid face recognition, aligning with the increasing demand for real-time applications in various domains. This paper delves into the methodology, implementation, and results of this integrated approach, demonstrating its potential for widespread practical use.

II. Literature Survey

In [4] the authors have implemented Local Binary Pattern Histogram (LBPH) and Haar cascade to improve the tracking and monitoring of the attendance systems based on face recognition as it was more secure and saving time also. The paper takes into account the false-positive rate for that as well as the false-positive rate with and without employing a threshold in detecting unfamiliar people to access the system.They have achieved rate of 77% and FPR of 28% and can detect the students wearing spectacles or having a beard.

The authors in [1] aims to to develop a real-time system that will enable visually impaired individuals to identify persons nearby by proposing a mobile personal assistant. The system uses the camera of the android smartphone and implements LPBH algorithm to identify or recognise the people in surrounding.The system gave 87% accuracy in 10 trials.This system was able to detect one person only at one time and was in a nascent stage.

Related Work	Year	Key Contributions	Technology Used	Merits	Demerits
[4]	2020	To improve the tracking and monitoring of the attendance systems based on face recognition	LPBH and Haar Cascade	Can detect the students in glasses or in beard and also unknown people with good recognition rate.	Prone to overfitting when the dataset is too small ,require a better dataset to improve accuracy of unknown people.
[1]	2019	To develop a real time system for blind people to identify people in surrounding	LPBH	Having good accuracy for different heights of people.	The system is developed to detect one person at a time.
[8]	2016	Developed Pattern recognition on FPGA based chip	FPGA,LBPH, SoC	Having a good accuracy and good execution time.	Poor resource utilsation and small dataset.
[2]	2023	Evaluting different techniques to identify the best algorithm for pattern recognition.	Eigenface, Fisherface and LBPH.	High Accuracy with different techniques.	Small dataset and ethical practices are not followed.
[6]	2022	Processing of images to avoid identity theft and avoid unauthorized entry.	Eigenface, Fisherface and LBPH.	High Accuracy and confidence level for 3 methods.	Security of the images is comprised and prone to attacks.
[3]	2005	Recognising facial movement on the spontaneous behaviour.	SVM,LDA,AdaBoost.	Able to implement on both videos and images with good accuracy.	Execution time and older methods for facial recognition.
[7]	2021	Facial Recognition for marking attendance.	LPBH	Achieving High accuracy and storing the results in CSV format.	Small dataset and performing not good in backgrounds other than white.
[5]	2023	To detect face from poor and high quality images.	LBPH and Haar Cascade	Getting Good Accuracy on poor images.	The algorithm does not give good results in different position and certain illumination conditions.

TABLE I
RELATED WORKS

In the paper [8], the authors have implemented face recognition System on the chip (SOC) which is merged with FPGA. They have utilised Local Binary Pattern Histogram and used Manhattan distance to calculate the distance between the matrixes and able to retrieve correct match from the database. All the calculation are implemented on the FPGA while receiving the input stream and displaying the output result utilising the measured distances is the responsibility of the SoC. The authors have achieved accuracy of 79% and the time of execution was 8.6 ms. The dataset contained of 100 images of 20 different people.

In [2] the authors have surveyed various methods for face recognition like CNN, PCA, SVM for feature extraction of the data and processing on LBPH and Random forest or neural networks for model training. The have ensured the ethical and no misuse of privacy while implementing the facial recognition techniques. They have evaluated Eigenface, Fisherface and LBPH on a specific dataset. The dataset have achieved 96% accuracy on Fisherface while 60%on LBPH.

The paper [6] focuses on processing of images for unauthorized entry avoidance to increase security with adequate protection measures using facial recognition techniques. Authors have implemented the LBPH, Eigen Faces and Fisher Faces to capture and analyse the facial expressions and movements using the images and portions of videos also. The results in the paper show LBPH achieving the accuracy of 95% and achieving better facial recognition and confidence level.The paper have focused to implement this technology in bio-metric verification and avoid identity theft.

In [3] the authors have done a systematic comparison of various machine learning techniques for facial recognition like Support Vector Machines, Linear Discriminant Analysis and AdaBoost. They have used Cohn-Kanade dataset for exploring the expressions. They have achieved an accuracy of 94.8% on applying the system to voluntary facial expressions.They have developed methods to identify the image in the 3D model in the video at certain frames. They were able to identify the spontaneous movements made the by the subjects.

In [7] the authors have worked on developing a model which uses pattern and facial recognition techniques to mark the attendance in an automated way. They have implemented it using Local Binary Pattern Pattern Histogram(LPBH) and Haar Cascade. The average accuracy was found to be 89% and was more in the white background. The attendance was stored

in a CSV file. They are currently working on the system to implement to get access to the attendance anywhere.

In the paper [5], the authors have explored the field of facial recognition and pattern analysis and implemented a system which recognises the face directly from the database or captures the new face from the videos. They have used Haar Cascade and LPBH for feature extraction for identification of the humans. The author has yeild 92% accuracy on the poor quality images and has a confidence level between 2 and 5.

III. Technologies Used

1) Machine learning is a branch of artificial intelligence (AI) that equips computers with the ability to learn and improve their performance on a task as they are exposed to more data. Unlike traditional programming, where explicit instructions dictate the behavior, machine learning algorithms learn from data patterns. The process involves identifying these patterns, making predictions, and refining their predictions over time based on feedback, ultimately becoming more accurate and proficient at the given task.

   At its core, machine learning leverages statistical techniques to enable computers to recognize patterns and make informed decisions or predictions. These patterns are derived from training data, which the model uses to generalize and apply its learning to unseen data, allowing for adaptability and scalability across a wide range of applications. From image and speech recognition to recommendation systems and autonomous vehicles, machine learning is transforming various industries by providing powerful tools to solve complex problems and drive innovation.

2) The Linear Binary Pattern Histogram (LBPH) is a versatile and effective image processing technique commonly used in pattern recognition and texture analysis. It operates by dividing an image into regions and encoding the local patterns within each region. In essence, LBPH computes binary patterns by comparing pixel intensity values with the central pixel's intensity, resulting in a binary code. These binary patterns are then transformed into histograms, capturing the frequency of occurrence for each unique pattern. By analyzing these histograms, LBPH can effectively represent and differentiate textures and patterns within an image, making it a powerful tool for applications like face recognition and facial expression analysis.

   One of the key strengths of LBPH lies in its ability to capture texture information robustly. The binary patterns and subsequent histograms generated by LBPH offer a compact yet informative representation of local image textures. Additionally, LBPH is relatively computationally efficient, making it suitable for real-time applications. These characteristics, combined with its accuracy in texture analysis, make LBPH a popular choice in various domains, including computer vision, biomedical imaging, and material inspection, where texture analysis is a critical aspect of data understanding and interpretation.

3) Linear OpenCV2 refers to the application of linear algebraic operations within the OpenCV2 library, a powerful open-source computer vision and image processing framework. Linear algebra plays a crucial role in various aspects of computer vision, including transformations, linear filters, feature extraction, and more. OpenCV2, as a comprehensive library, offers a wide array of functionalities rooted in linear algebra, enabling the manipulation, analysis, and interpretation of visual data in a linear algebraic context. Operations such as matrix transformations, convolutions, and eigenvalue calculations are pivotal in image processing, and OpenCV2 provides an efficient platform to perform these operations using optimized linear algebra routines.

   By harnessing the power of linear algebra within OpenCV2, complex image processing tasks can be efficiently and effectively accomplished. Matrix manipulations, transformations, and operations are fundamental in tasks like geometric transformations, image enhancement, edge detection, and image filtering. The integration of linear algebraic principles within OpenCV2 ensures that these operations are optimized for performance and accuracy, providing a versatile framework for researchers, developers, and practitioners to explore and implement advanced computer vision solutions.

4) Linear Alblumentation is an innovative Python library that offers a wide range of image augmentation techniques, primarily aimed at enhancing datasets for training machine learning models. Unlike traditional image augmentation libraries, Linear Albumentation focuses on providing augmentations that follow linear operations. These operations include geometric transformations such as scaling, cropping, and flipping, along with color manipulations like brightness adjustments and contrast modifications. By adhering to linear operations, Linear Albumentation maintains consistency in augmentations, which is beneficial in ensuring that augmentations don't alter the semantic content of the images drastically. This feature is particularly advantageous in scenarios where preserving the ground truth information in the images is crucial, such as in object detection or segmentation tasks.

   The linear nature of augmentations in Albumentations allows for easy integration into machine learning pipelines. It ensures that augmentations can be applied in a consistent and predictable manner, making the

library a valuable tool for researchers and practitioners. Additionally, Linear Albumentation is highly efficient and performant, making it suitable for processing large datasets efficiently during training. Its ease of use, versatility, and emphasis on linear operations make it a popular choice for enhancing and diversifying datasets, ultimately improving the performance and generalization of machine learning models.

IV. Architecture

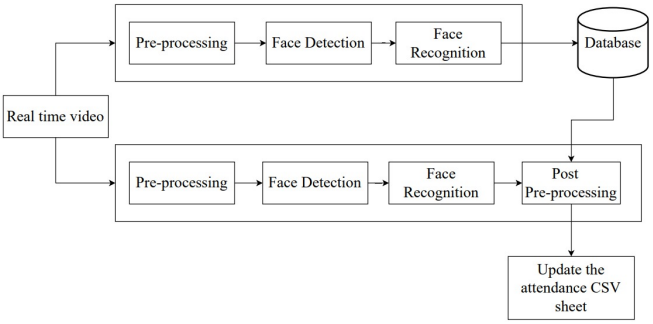

Fig. 1. System Architecture

Algorithm 1 Face Recognition Attendance System

```
Input:live video stream
Output:attendance record
procedure SIMPLIFIEDFACERECOGATTENDANCE
    Initialize face detection and recognition models
    Open the video stream
    for each frame in the video stream do
        Convert frame to grayscale
        Detect and extract features from faces in the frame
        Compare features with database
        if a match is found and identity is not already marked
then
            Mark identity as present
            Record the current time
        end if
    end for
    Close the video stream
    Export the attendance record
end procedure=0
```

The proposed automated attendance management system is based on haar cascade for face detection and the LBPH algorithm for face recognition.

This system offers features including photographing employees and recording their identities for the database, training the photos on the camera and in the database, and beginning to track persons entering the office. This system recognises the faces of employees coming into the office from the webcam and pre-processes them for further processing. The stages in the proposed system are shown in Fig. 1.

We produced our own dataset with 10 photos for every individual.For further accuracy, these 10 photos are then supplemented with 500 other photographs from the albumentation library. To assess the ability to recognise unknown people, an additional 10 people are taken into consideration. We used a live, real-time video to test our system, having both known people and staff go up to the camera and stand in front of it. Fig. 2 shows a few images after the pre-processing stage.

Fig. 2. pre-processed amd augmentated faces of employees

The frame is first turned from colour to grayscale. We employed a haar cascade classifier, which trains a cascade function to recognise features in other images, to distinguish faces. Edge, line, and four-rectangle haar characteristics are used for this.

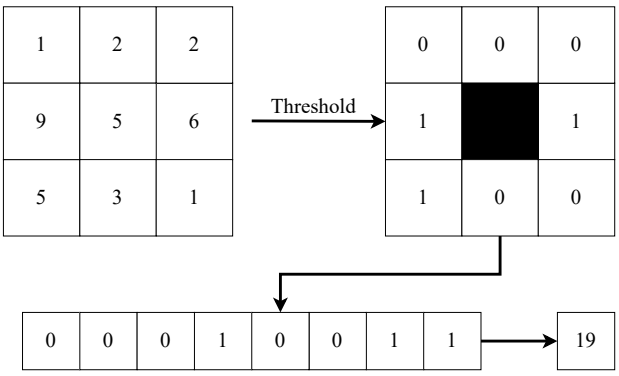

Fig. 3. LBP method on 3X3 matrix

We made the decision to employ the LBPH algorithm for face recognition.An image that more effectively highlights an image's qualities is produced by the Local Binary Pattern (LBP) technique. It makes use of the radius, neighbours, and the sliding window concept. In Fig. 4, it is depicted. The frame is first transformed into a matrix of 3X3 pixels. If a

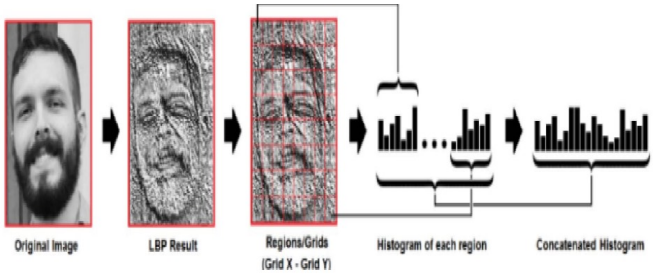

Fig. 4. LBP process on an image

neighbouring pixel in a matrix is bigger than the matrix's median pixel, set 1 instead of 0, otherwise. Now that we have recorded the values of adjacent pixels in a line, we have a binary number. Change that binary number to a decimal number, and then replace it with the matrix's median pixel value as depicted in Figure 3.

After detecting the faces of employees it is being updated into a CSV file in which there are 3 column. ID, Date and time is being stored in CSV file for each day a new CSV file will be created shown in fig. 5.

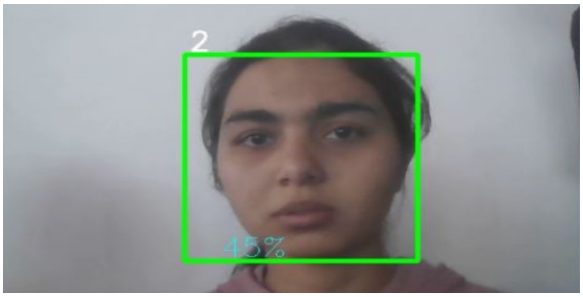

Fig. 5. Face Recognized as ID 2

ID	Date	Time
4	05/03/23	14:35:37
27	05/03/23	14:38:35

Fig. 6. Attendance of the workers stored in a CSV file.

V. Result

We considered 3 feet as the distance of an object for recognition. The Face recognition rate of employees is 77% and its false-positive rate is 28%. This system is recognizing employees even when they are wearing glasses or grown a beard. Face Recognition system also sometimes give false results as they recognize unknown person. This is mainly because of face detection algorithm detects background entities. The algorithm has a threshold value, person is recognized only when it is matched with greater than 50% from our training dataset otherwise it is named as unknown and doesn't store into our attendance file.

VI. Conclusion & Future Scope

Technology breakthroughs have benefited the field of facial recognition by making solutions that were before unfeasible possible.It is increasingly necessary to have face recognition systems with high accuracy and short processing times. The system proposed in this paper is specifically based on the organization's or institution's attendance policy for workers and students. A popular face recognition technique is the local binary pattern histogram. When it comes to spotting workers who unintentionally alter, such glasses wearers or beard growers, our method is effective. Our study led to the development of a more efficient, user-friendly approach with an accuracy rate of over 78%. This case's small dataset raises questions.In the future, a more accurate practical outcome might be generated with a better dataset. We can improve the haar cascade classifiers' capacity to identify unknown individuals by producing more and fresher training instances. A voice and visual system alarm may be used if an intruder is found in the class.

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