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Smart Surveillance System using Face Tracking

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Abstract— The face is seen as a key component of the human body, and humans utilise it to identify one another. Face detection in video refers to the process of detecting a person's face from a video sequence, while face tracking refers to the process of tracking the person's face throughout the video. Face detection and tracking has become a widely researched issue due to applications such as video surveillance systems and identifying criminal activity. However, working with videos is tough due to problems such as bad illumination, low resolution, and atypical posture, among others. It is critical to produce a fair analysis of various tracking and detection strategies in order to fulfil the goal of video tracking and detection. Closed-circuit television (CCTV) technology had a significant impact on how crimes were investigated and solved. The material used to review crime scenes was CCTV footage. CCTV systems, on the other hand, just offer footage and do not have the ability to analyse it. In this research, we propose a system that can be integrated with the CCTV footage or any other video input like webcam to detect, recognise, and track a person of interest. Our system will follow people as they move through a space and will be able to detect and recognise human faces. It enables video analytics, allowing existing cameras to be combined with a system that will recognise individuals and track their activities over time. It may be used for remote surveillance and can be integrated into video analytics software and CCTV security solutions as a component. It may be used on college campuses, in offices, and in shopping malls, among other places.

Keywords— Face detection, Face tracking, Face Recognition, LBPH Face Recognizer, Haar Cascade

I. INTRODUCTION

Video processing has become a major requirement in today's world, and with the rapid advancement of computer vision research and the growing demand for security, computing devices are becoming more intelligent. A great deal of research has been done on computer human interaction, which demonstrates the raw manner by viewing people via camera. Face recognition has several stages, including face detection, feature extraction, and face tracking.[1] Several studies have been conducted in order to suggest a new algorithm for various phases. Because of the immensely diverse nature of situations such as variation in stances, changes in facial expressions, occlusion, variations in lighting conditions, and background complexity, recognising faces or objects from video sequences or still photos is a tough challenge. As a result, several facial recognition systems have been developed during the previous few years. Face tracking tracks the recipient's face in every frame of the video. In the field of computer vision, tracking is a major topic. Face tracking, tracing pedestrians, virtual reality, motion trailing, traffic monitoring and military operations are some of the uses of tracking in the field of computer vision.

The application presented in this paper can be used for advanced surveillance purposes on college campuses, schools, malls, offices, etc. It captures the faces of the people to be tracked and saves it into the database. Then using that data, the footage of webcam, CCTV or any other video input can be analysed for real time multi-person face tracking on the campus. Our proposed application identifies the people whose faces have been saved into the database and records the timestamps where the particular person was last located for effective tracking mechanism. It also detects other people as unknown in the video data from the surveillance. Our system is easy to setup and install as already existing CCTV surveillance cameras can be integrated to the desktop application.

The paper has been organised into 7 sections. The first section introduces the readers to the importance and relevance of face tracking technology in today's world and our contribution. The second section elucidates the existing work done in this domain. The two main algorithms used in our system, namely Haar Cascade and Local Binary Patterns Histogram have been explained in the third section. The fourth section outlines the methodology in detail of the planned system. The fifth section illustrates the experimental setup required for the system. The last two sections throw a light upon the results and discussion, and the final conclusion respectively.

II. RELATED WORK

In the recent few years there has been lot of research in computer vision domain. Richa et al. [2] applied a tabular approach to assess several video face detection algorithms like Haar cascade and Adaboost, and tracking approaches as well as their outcomes and research needs. Kruti Goyal et al. [3] discovered that Haar cascade is the most effective method of face detection and provides improved facial expression accuracy as compared to other algorithms. They have also compared OpenCV and MATLAB for face detection and recognition application and have found OpenCV to be the more preferable one because it is free of cost and it can run on any machine which runs on C irrespective of the operating system. Suad Haji et al. [4] have

compared real time face recognition system using Eigen Face algorithm and Local Binary Patterns algorithm, and found that Local Binary Patterns gives better results in terms of repeated alterations in the lighting condition. After studying related papers and research work, we have found that Haar Cascade algorithm and Local Binary Patterns Histogram algorithm are the best suited for our application for face detection and recognition modules, respectively.

III. ALGORITHM

We have used mainly two algorithms in our system i.e., Haar Cascade for face detection and LBPH (Local Binary Patterns Histogram) for face recognition.

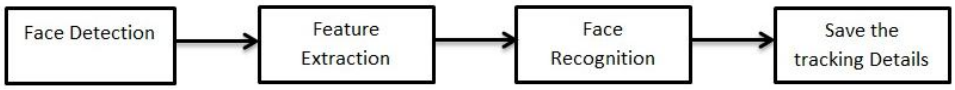

Fig. 1 Low-level diagram

Haar Cascade classifiers are a viable option for object detection, which was given by Michael Jones and Paul Viola. This method can recognize objects in photos independent of their size or placement in the picture. This method can also run in real-time, allowing it to recognize objects in video streams. The goal of this algorithm is to identify faces in images. It's a machine learning based method that uses a large number of positive and negative inputs to train the classifier. As long as you have the necessary XML file, you may use it to identify any kind of object. We can also design our own XML files from scratch in order to identify any type of object. Negative images are those that do not include the object we want our classifier to detect or identify, whereas positive pictures are those that have the object we want our classifier to detect or identify. We may train a classifier to determine if a given region of an image contains a face using these positive and negative data points. Using a pre-trained Haar cascade, OpenCV can do face detection very well. This eliminates the need for us to give our own positive and negative samples, train our own classifier, or worry about fine-tuning the parameters. Rather, we just load the pre-trained classifier and use it to identify faces in photos.

LBPH is a simple but yet efficient algorithm which is used for feature extraction in face analytics. It was first described in 1994. It's texture classification feature makes it powerful. LBP (local binary pattern) is defined as the efficient feature extractor which labels pixels of images by comparing the pixel of each neighbourhood in binary format. LBP combined with histograms are used in face recognition for feature extraction. In the LBPH, a series of steps are followed on the images. The very first step is dividing grayscale images into standard cells of size (3 x 3) pixels for the purpose of encoding features. Next step is finding the next 8 neighbour's values by using the central value. The value of each neighbour's intensity is compared to the central pixel. If the value of neighbour's intensity is greater it will be assigned as 1 and if its intensity is less and central ones, it is assigned as 0 [10]. Now matrix will have 8-bit binary value. Fig. 2 shows comparison of middle element value with its neighbourhood elements. By converting these binary numbers into decimal numbers, we get an actual pixel for the image. It gives better features of the original image. With the use of new pixels, histograms are plotted. Feature vectors are calculated by values of all cells and connect the histograms. Unique Id is assigned to pictures. With the use of the same procedure, feature extraction is done on input images.

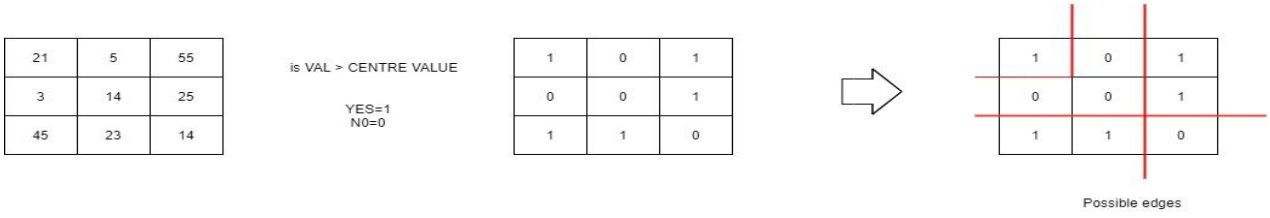

Fig. 1 Local Binary Patterns Histogram Algorithm creates 8-bit number

IV. METHODOLOGY

The proposed face tracking model has basic four modules: image data acquisition, feature extraction module, training database module, recognition and tracking module.

A. Face Detection

System uses a Haar Cascade classifier for face detection. The classifier of the Haar Cascade is one of the simple and popular models which uses the Adaboost algorithm to locate image facial features [1][3]. System follows several steps for face detection.

When the system captures images from the camera, the very first step is conversion of image into grayscale. After that Haar Cascade classifier is applied on that image. If classifier detects face in image, it extracts facial feature and draws a rectangle around it. All the other parts of image are ignored.

B. Feature Extraction

Feature extraction is done by LBPH algorithm. LBP is a visual descriptor which combines with histogram to extract features from images. LBP calculates threshold of the neighbourhood of each pixel and with the use of these pixels' histograms are plotted. By combining all histograms, we get our desired output which is image-representing feature vector and used to train a facial recognition classifier. Following Fig. 3 represents the process of extraction of LBP feature from image.

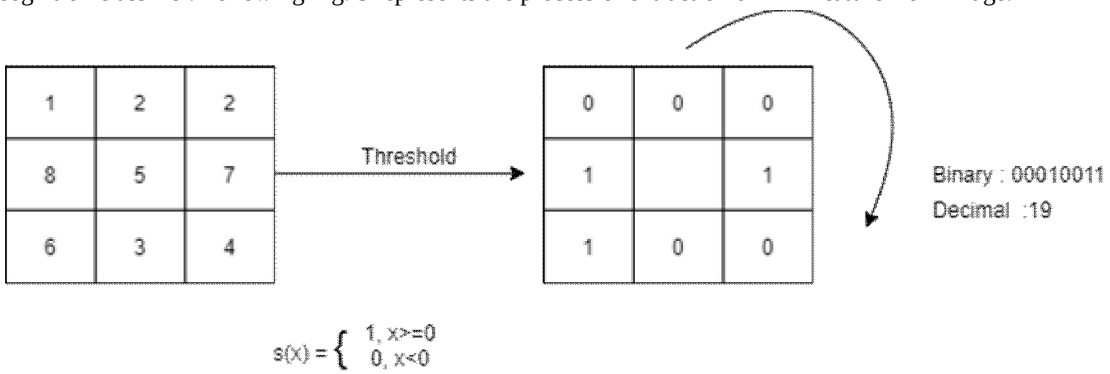

Fig. 3 LBP feature extracted from the image

C. Dataset

We have created our own dataset of images containing 60 images of each individual for training. Images are pre-processed and stored in a database with a unique id for face recognition and tracking purposes. Pre-processing of images includes cropping, converting to grayscale, etc. Standard techniques for noise reduction, position scaling is used on them for better results of recognition and tracking.

D. Face Recognition and Tracking

For recognition, the recognizer is already trained with images using LBPH algorithm. When face of person gets detected, LBPH creates histogram of current image and compare it with trained images. If match is found face gets recognized with its ID or else it is flagged as unknown image/face. After the recognition of image, location or the instance of time gets saved in the database.

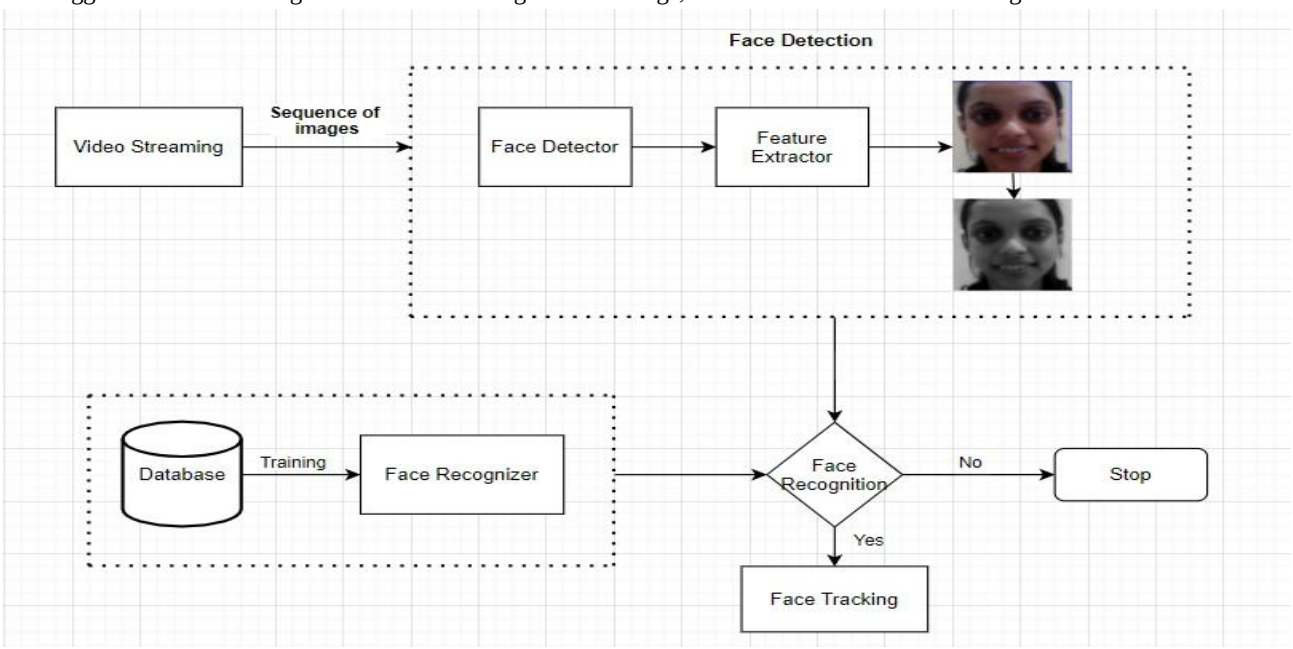

Fig. 4 System Architecture

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V. EXPERIMENTAL SETUP

Python programming language is used to develop this system. OpenCV library and other tools like VS Code are used in this system. Visual Studio Code is a code editor redefined and optimized for building and debugging modern web and cloud applications. Tkinter is desktop application development tool used to create UI. The whole project is divided into four parts: facial detection, training face images, the recognition and tracking of the faces. These all 4 operations are performed in VS Code and information regarding a person is kept in a CSV file.

VI. RESULT AND DISCUSSION

For the development of a face tracking system, we have to give input of face images to a face detector which will detect the faces from a live video stream or camera and store it in the database file. The system asks the unique id, name of person to be stored in the system. Then these images of persons are detected and provided as input to LBPH for facial feature extraction. With these extracted features recognizer gets trained. Whenever face of multiple persons or a single person comes in front of camera, system detects the face and recognizes it. If the match is found then respective information of tracking gets stored in database and if match is not found then the person is detected as unknown.

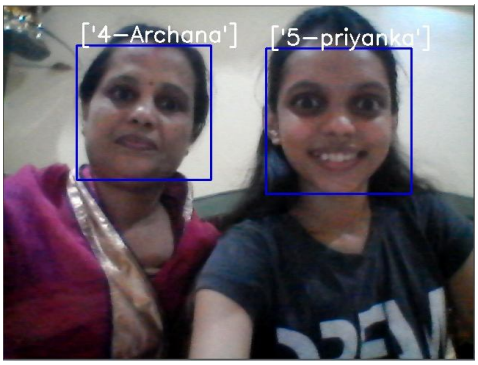

Fig. 5 Multi-person face tracking

For the tracking part, the system gives accuracy ~80%, which is very good for real time face tracking where there are lots of factors affecting the quality of image like brightness, clarity, etc. System can recognize multiple people in front of the camera and track the person whose images are already in the database.

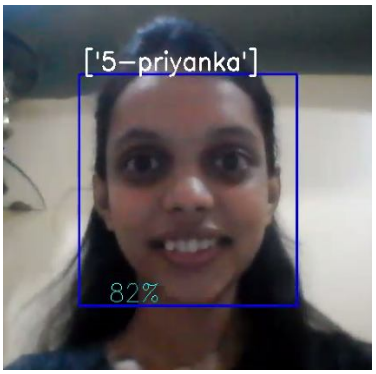

Fig.6 Accuracy

VII. CONCLUSIONS

In conclusion, the developed application serves as an effective Smart Surveillance System employing face detection and face recognition technologies. It uses the Haar Cascade classifier for face detection and LBPH algorithm for face recognition. Based on the results as discussed above, it gives an accuracy of around 80%. We have used OpenCV library along with Python programming for developing this application. Our system will collect multiple images of each individual to be tracked and store it into the database for training the dataset so that it will be used in future for tracking that person by integrating it to the CCTV footage. This system can be used on college campuses, in offices and schools among other places to maintain security.

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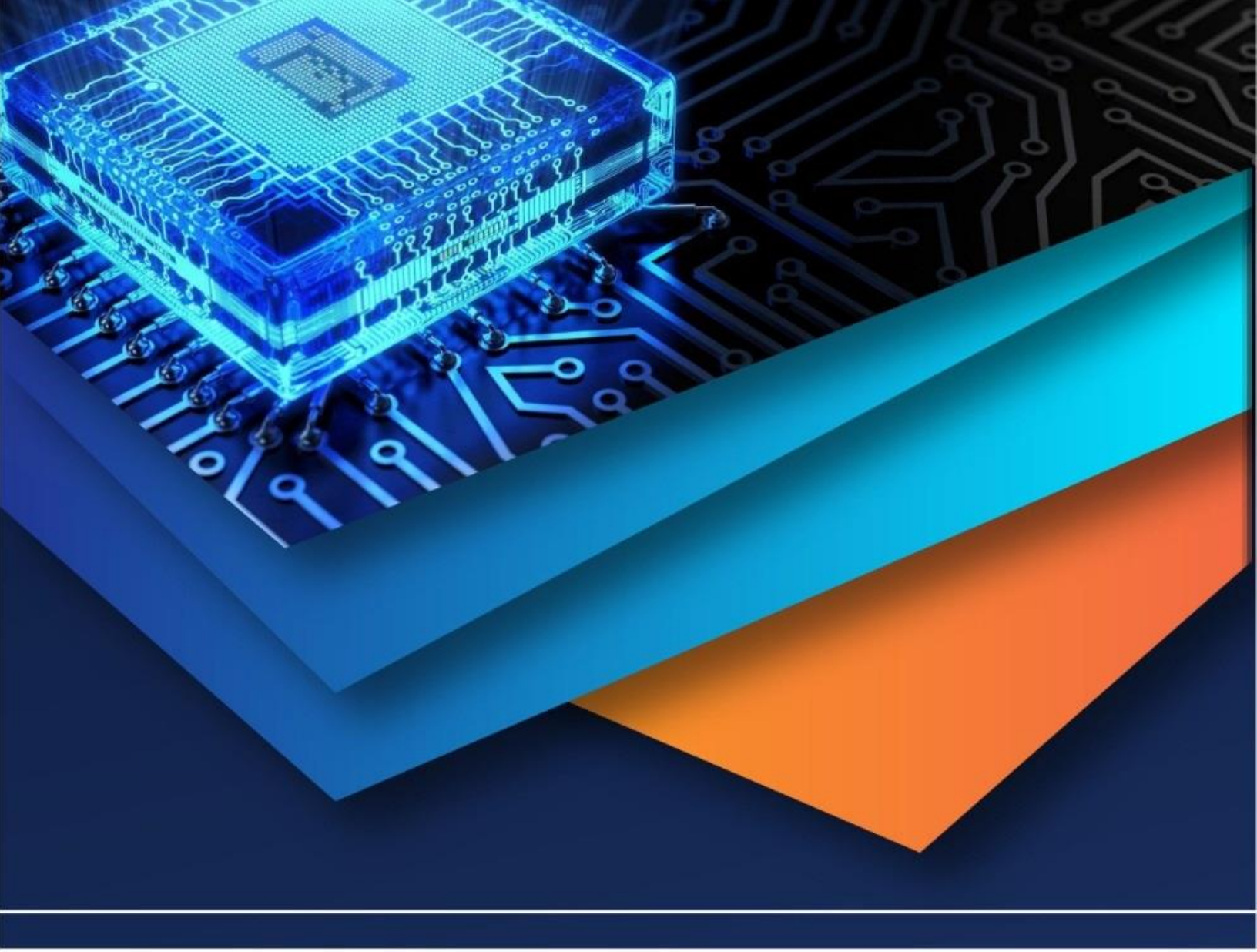

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