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Review of Facial Recognition Techniques

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Abstract: ***Facial Recognition, the biggest breakthrough in Biometric identification and security since fingerprints, uses an individual's facial features to identify and recognize them. A technology that seems too farfetched taken straight from a science fiction novel is now available in smartphones in the palm of our hands. Facial Recognition has gained traction as the primary method of identification whether its mobile phones, smart security systems, ID verification or something as simple as login in a website. Recent strides in facial recognition technologies have made it possible to design, build and implement a facial recognition system ourself. Using Computer Vision and machine learning libraries like Facial Recognition and Dlib, we can create a robust system that can detect faces and then match and identify it with a database of pre-loaded facial data to successfully recognize them.***

This study conducted a literature review of these aforementioned technologies and various other advancements in the field of computer vision facial recognition by other scholars in their research papers.

This paper analyzes domains to understand the working of these machine learning models and their different implementations in facial recognition systems. The research conducted by us during this review will be paramount in creating a proof-of-concept prototype facial recognition system.

Keywords: DLib, Facial _Recognition, Machine Learning (ML), Deep Learning (DL), CNN, KNN, Face Detection, HOG, Support Vector Machine (SVM), Face Recognition.

I. INTRODUCTION

Humans distinguish and identify faces based on location, size and shape of the of facial features such as nose, ears, lips, eyes, cheekbones. Face is highly non rigid and there are a lot of details reflecting individual differences. Generally, face recognition involves 2 phases, face detection and face recognition. Face detection means capturing a or discovering a face in the image. Then it is followed by face recognition. Face recognition is the process of finding the matching face by comparing the faces found in a static image or dynamic videos. It is generally used for the purpose of identification. It is a subset of biometric recognition. Computers that recognize faces could be applied to a wide variety of problems, including criminal identification, security systems, image and film processing, and human-computer interaction.

Face recognition researches began in early 1950's. Early in 1966, Bledsoe et.al. Studied on the human facial recognition based on pattern recognition and created a new technology. It was the preliminary development of facial recognition technology. In 1983, Sirovich and Kirby introduced the principal component analysis (PCA) for feature extraction. Using PCA, Turk and Pentland Eigenface were developed in 1991 and is considered a major milestone in technology. Local binary pattern analysis for texture recognition was introduced in 1994 and is improved upon for facial recognition later by incorporating Histograms (LBPH). In 1996 Fisher face was developed using Linear discriminant analysis (LDA) for dimensional reduction and can identify faces in different illumination conditions, which was an issue in Eigenface method.

In 1997, a facial detection system was created which could detect a certain face among the crowd. Face recognition methods based on machine vision has achieved great results in facial recognition. We need to consider the intra-class changes caused by facial expression, posture, age, location and occlusion, and the inter-class changes caused by different factors like lighting and backdrop. These two changes are very complex and non- linear.

Traditional methods often fail to achieve the desired result for complex distribution of intra-class and inter-class changes. Deep learning simulates the cognitive learning of human visual perception, and can obtain more high-level feature which can be used to solve the intra-class and inter-class changes in facial recognition.

This paper summarizes the facial recognition technology based on deep learning and lists the basic model structure of deep learning. This paper will also summarize the research on Dlib library maintained by Davis King and Adam Geitgey's facial recognition model. The network itself was created by Davis King on a data set of 3 million faces. On the Labeled Faces in the Wild (LFW) the network compares to other methods reaching an accuracy of 99.38%. This paper will also summarize other technologies related and used in facial recognition.

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II. DEVELOPMENT STAGE OF FACIAL RECOGNITION AND RELATED TECHNOLOGIES

A. *Face Recognition*

It manipulates the face of a person and recognize from Python. Built using dlib's state-of-the-art face recognition technology built with deep learning. It provides a simple face recognition command line tool that lets you do face recognition on a folder of images from the command line.

1) Find faces of a person in pictures.
2) Import with the face recognition
3) Find and manipulate facial features in pictures.
4) Identify face of a person in pictures and recognize who appears in each photo.

B. *Features of Face_Recognition Module*

1) Command-Line interface
2) Adjusting Tolerance / Sensitivity
3) Speeding up Face Recognition
4) Python Module – You can import the code of face recognition module and then easily manipulate faces with just a couple of lines of codes.
5) Automatically locate the facial features of the person in an image.

C. *Dlib*

Dlib is a modern C++ toolkit containing machine learning algorithms for creating complex software in C++ to solve real word problems. It is used in facial recognition to train the model to be able to recognize the face through digital image.

Major features of Dlib

1) Documentation
2) High quality portable codes
3) Machine Learning Algorithms
4) Numerical Algorithms
5) Graphical Model Inference Algorithms
6) Image Processing
7) Threading
8) Networking
9) Graphical User Interfaces
10) Data compressions and Integrity Algorithms
11) Testing
12) General Utilities

D. *Deep Learning features and Classifying Models*

1) *Support Vector Machine (SVM):* Support vector machine is a supervised learning algorithm specifically for small sample, high dimensional facial recognition problem [6]. In face recognition, we use the extracted face features and SVM to discover the hyperplane for distinguishing different faces.[7]
2) *Neural Networks:* A neural network or artificial neural network is a series of algorithms that try to recognize underlying relationships in a set of data through a process that in which it works in the way the human brain operates. In this sense, neural networks refer to systems of neurons, either biotic or artificial in nature. Neural networks can adapt to changing the input so the network generates the best possible result without needing to redesign the output criteria. The concept of neural networks, which has its roots in artificial intelligence, is rapidly gaining popularity in the development of trading systems.
3) *Deep Learning (DL):* Deep learning is a branch of machine learning which can find out the features needed for classification automatically in the training process without feature extraction steps. That is to force network learning to obtain more effective features for distinguishing different faces. The field of face recognition has been completely mutated by the help of deep learning [9]. Deep learning is widely used in face recognition and is divided into the following aspects. A face recognition method based on convolutional neural networks (CNN) is the first aspect. CNN uses the locality of data and other features to

optimize the model structure by merging local perception areas, shared weights, and down-sampling of face images [10]. CNN is very similar to ordinary neural networks. They consist of neurons with learnable weights and biased values. A dot product calculation for each neuron is performed after receiving input data. Then output the scores of each classification. It is the most widely used deep learning framework [11].

4) OpenCV: OpenCV (Open-Source Computer Vision Library) is an Application Peripheral Interface (API) developed by Intel which can be used for many images processing and computer vision applications. OpenCV officially launched in 1999. OpenCV is used for analyzing the high-definition images and for feature extraction in facial recognition. OpenCV helps in identifying the face through digital images.[8]

III. INNER WORKING OF THE FACIAL RECOGNITION MODULE

The face recognition process is divided into 4 parts -:

1) Detection of face(s) in the input most probably still images or live stream video.
2) Framing and projecting faces to differentiate between different faces.
3) Extracting Facial Features and encoding it in a facial profile.
4) Comparing different facial profiles to one another to identify and recognize the person.

A. Facial Detection

The technology used in facial detection is called Histogram of Oriented Gradients or HOG. The input is converted in black and white color scheme since color data is not required. Then each and every pixel is observed and the pixels surrounding it are taken in consideration, based on the shift in color gradient from light to dark, a arrow or line is drawn. This process is repeated for every pixel and gradient shift in the image. The arrows or line that replaces the pixels are called Gradients and plots the flow of light in the input. By only considering the direction of gradients shift an image of the same person whether bright or dark will be represented exactly same. To decrease the level of details to save up space and get the forest of tree, we just consider the higher level of gradient. The image is divided into 16x16 pixel squares and in each square, the gradients are counted and the major direction of arrows is considered to draw one large arrows for a square. The end result will represent the basic structure of a face. This representation is called HOG representation and is compared to the most similar known HOG pattern to detect faces.

B. Framing and Projecting

Faces when detected and isolated are then posed in a pre-defined manner so that face of the same person in different angles, turns and orientation are not distinguished as different people. This is done by wrapping the image so that the eyes and the lips are positioned in the same place. An algorithm called Face Landmark Estimation is used to do this. The algorithm will try to find 68 specific points defined on a face called landmarks, these points are located on a face on various points- edges of the eyes, the chin, eyebrows, contour of the mouth, etc. When these landmarks are discovered and the location of eyes and mouth are known, the image is rotated, skewed, wrapped and scaled so that these features are centered as much as possible without distorting the image. This transformation of the image is called Affine Transformation.

C. Extracting Facial Features and Profile Creation

This process is the main backend work of the model as a Deep Convolutional Neural Network (CNN) is trained to extract relevant features from the image. The model is trained to generate 128 measurements for each face. The training of the network is done by feeding the model 3 face images -

1) Training image of the known person
2) Another picture of the same person
3) An image of a different person's face

The algorithm generates measurement for all the three images and tweaks the neural network so that the measurement for image #1 and #2 are closer while making sure the measurements for #2 and #3 are further apart. This process is repeated millions of times on millions of images so that the neural network learns to generate 128 measurements on faces of different people. The Dlib library is trained on millions of faces and the facial recognition module is built upon this neural network to accurately give out these measurements in efficient times. The process of generating 128 measurements is called Embedding. After Embedding, the measurements are stored in form of numerical data readable by the model in a profile. This facial profile is the final data that is compared with other profiles to identify similar profile and recognizing faces.

D. Recognizing Faces by comparing facial profiles

A simple machine learning classifier is used to compare profiles. Facial Recognition uses a linear SVM Classifier that is trained on embedded measurements from the input image and compare it to the stored profiles and find the closet match. The classifier after comparing different profiles stored in the system with the new input then outputs the name of the person.

IV. CONCLUSION

After a deep, in-depth analytical review of these technologies and understanding the inner working of these algorithms, we can summarize the various use cases and implementation of these technologies. Computer Vision is a broad field with many areas of interest and implementations. Multi-platform libraries like DLib can be a huge bridge between software and hardware incompatibilities. Dlib certainly has the capability to extract features from a still image as well as a stream of images like in a video or live stream, extraction of features in a specific way so that to differentiate between the minute of details in the facial features. Being a library created in C/C++, it's use in a python environment certainly makes it a faster medium of feature extraction. The Facial Recognition module in python takes care of the rest of the process by creating individual facial profiles and storing them the model for comparing later. All this is just possible with a snap of a picture, the only input required. [5] This ease of input and use and the efficiency of the process makes these two technologies a perfect match to be implemented in a light weight software heavy facial recognition system. Using just the camera of a smartphone, laptop, webcam of a desktop or just a dedicated camera, this robust system can extract features, create a facial profile to be stored in the system, compare previously created profile with the new one to recognize the face in the input, all from just a single snapshot of a face.[8]

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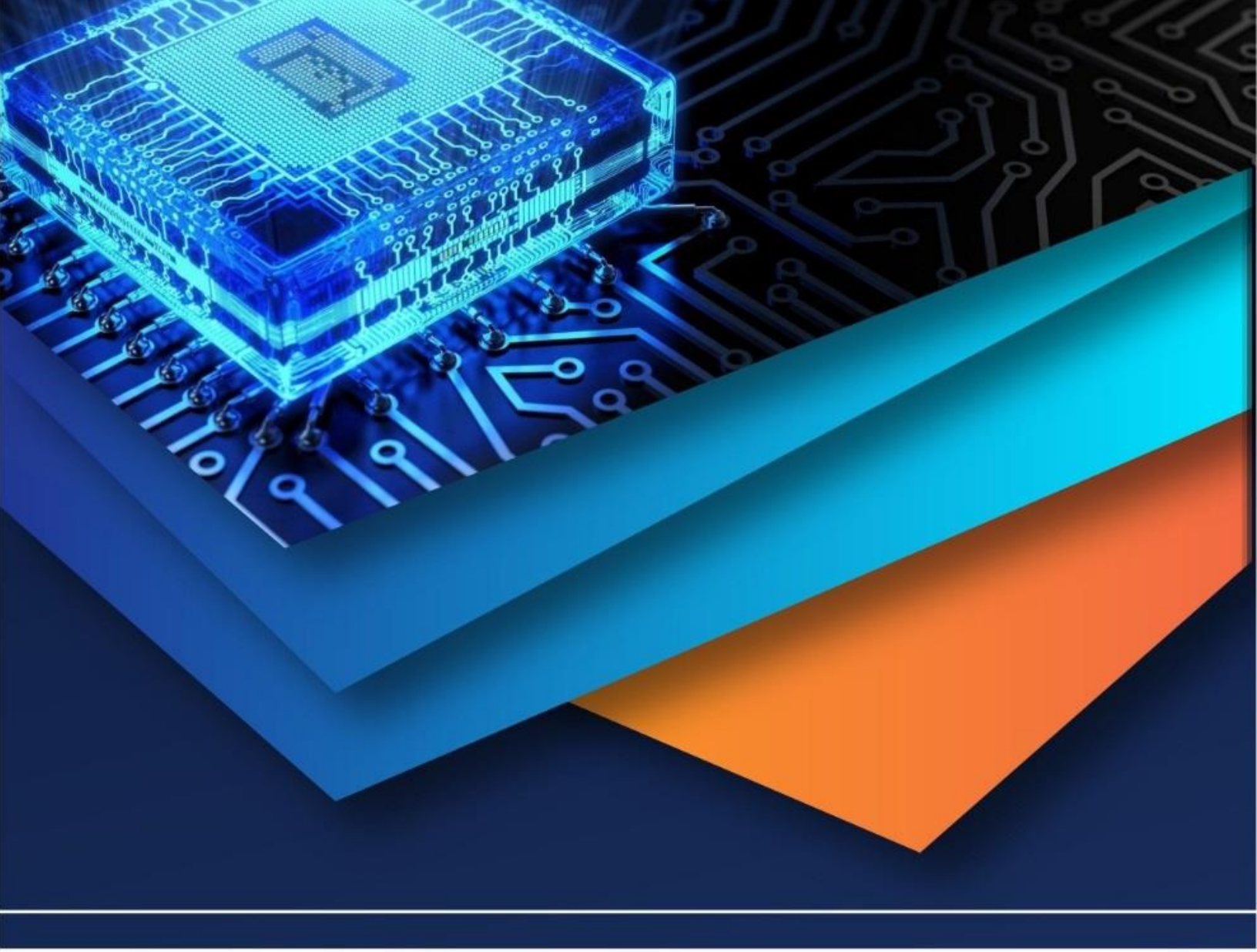

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