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Evolution of Face Recognition Technologies

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Abstract— We, humans, identify each other by recognizing faces and we are doing this since ages. Now, we want our computers to do the same. Geometric models were used primarily in old algorithms used for face detection, but now the methodologies have changed. We have various efficient scientific approaches and mathematical representation for the process of matching. All the researches in the previous decade have brought the face recognition technology into the limelight. It is an emerging technology which can be successfully used for identification, verification and various other new domains like sentiment analysis.

IndexTerms— machine learning, Support vector machines, Kernel, convolutional neural network, quantization.

I. INTRODUCTION

The first attempts in developing facial recognition systems were made in the early 1970's. A major boom happened around 1988 with the development of PCA or eigenfaces methods which are still used for benchmark purposes to compare the more recent algorithms. With time the increase in computational capacity lead to major potential development in this field with the emergence of sophisticated algorithms and machine learning capabilities. Any face recognition system can be broadly divided into two categories –

1. Face verification:It is also known as face authentication. It proceeds by following a one-to-one matching approach and thus matches the face given as query against the facewhose identity is already revealed. It is used to verify whether the query face is of the same person as that of the template face whose identity is already known.
2. Face identification:It is also known as face recognition. It follows a one-to-many matching approach where it matches the query face against all the faces stored in a given database and reveals the identity of the query face from the face in the given database which matches with it.

If proper illumination conditions are provided then nowadays it is possible to perform feature extractions and recognition of faces in real time basis like from live video streams of surveillance cameras. Most of the recent papers show high accuracy in identifying faces if the variations in facial expressions are minimalistic. However if the variations are related to factors like poses, aging and excessively high or low lighting conditions then the machines still lag remarkably to mimic the human abilities to recognize faces.

II. PROCESSING FOR FACE RECOGNITION

The face recognition is a pattern recognition task where different three-dimensional features of the face such as illumination, expressions, and profiles are needed to be matched with its two-dimensional representations.It comprises of four modules: localization, normalization, feature extraction and matching.In this the localization and normalization forms the processing steps for the recognition phase mainly comprising of the feature extraction and matching part. The localization part segregates the face areas of the image from the background while the normalization phase is aimed at mapping facial components such as nose, eyes, eyebrows, lips and facial outlines using geometrical properties like morphing to identify the size and pose. Photometrical properties like illumination and gray scale further normalizes the face. After this the feature extraction is performed to differentiate between faces of different persons. This involves using feature vectors to represent the input face and match with the feature vectors of the faces from the given database. If a match is found with a good confidence score then the system outputs the identity of the face or an unknown face is indicated otherwise.

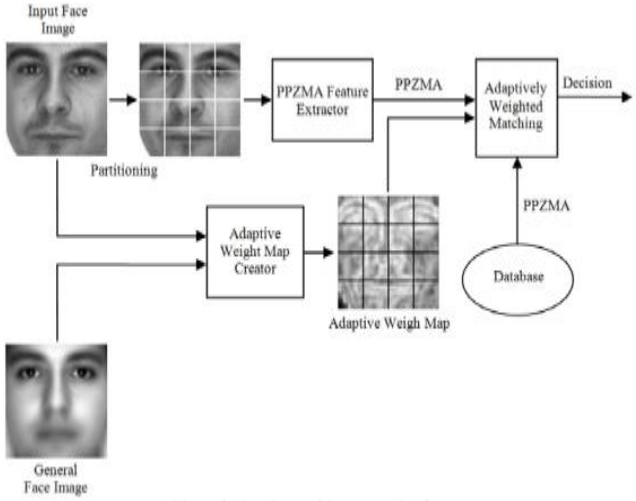

Figure 1. Processing flow of face recognition

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III. APPROACHES TO FACE RECOGNITION

The major approaches to face recognition are shown below:

Template based methods
This is a kind of holistic approach which recognizes the faces using global representations. This type of approach uses the entire face and tries to extract features from the entire face before applying some classifier to it for pattern recognition.

B. Statistical approaches
There are some techniques that determine, parameterize and analyze linear subspaces. Aside from linear subspaces there aresome applied mathematics based face recognition techniques that are supported by non-linear subspaces like kernel PCA, Kernel LDA, Support vector machines.

C. Neural network based approaches
Artificial neural network is extremely useful for pattern recognition based problems. Research shows that it gives accurate recall and highly efficient output even when the input image is noisy, of low resolution and some parts of the image is missing.

C1. Single layer adaptive NN
A system named Wilke, Aleksander and Stonham's recognition devise (WISARD) was developed which used 200 to 400 presentations per classifier where the training set consisted of translation in facial expressions.

C2. Multilayer perceptrons
Auto associative neural networks were used to reduce the first 50 principal components of face images to five dimensions after extraction in (D. Demers, 1993). Then it was classified using a multilayer perceptron.

D. Self Organizing Map
It provides dimensionality reduction and uses convolutional neural network for partial invariance to translation, scale and rotation through quantization of the face image sample into a topological space near the output space.

E. 3-dimensional recognition
It uses 3D-sensors to map the face by capturing the contour of the eye-sockets, face and chin to generate detailed information about the shape of the face. This information is used to identify unique features of the face at surface level. It is less affected by bad lightning conditions. Dozens of image sensors are placed into a single CMOS chip which throws structured light onto the face to detect different spectrums.

IV. PRESENT TECHNIQUES AND RELATED WORKS

Some of the most efficient algorithms of facial technologies were developed during 2001-2017. Among them the four popular techniques are discussed below:

A. Viola – Jones Algorithm(2001)

Invented by Paul viola and Michael Jones , it is one of the first efficient face detector that detected faces in real-time basis on a webcam feed. It was one of the most stunning demonstration of computer vision and its potential at that time. In this the end features like the location of the mouth, nose and eyes as well as their relations to each other were hand coded and fitted into a classifier. The classifier is mostly a linear classifier like a support vector machine. The features used were mainly the Haar features. It is seen that all human faces shows some similar features like-

- The upper-cheeks are lighter than the eye region
- The nose bridge region is brighter than the eyes

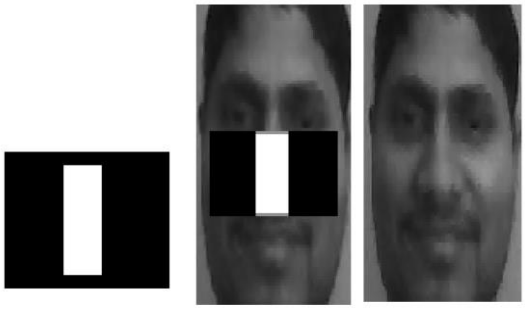

Figure 2.Haar feature representing the bridge of the nose is applied onto the face.

B: (HOGs)Histograms of oriented gradients(2005)

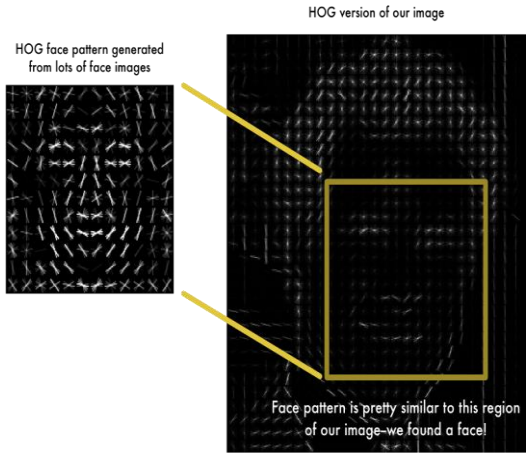

Figure 3. HOG representation of an image

NavneetDalal and Bill Triggs invented “HOG” for pedestrian detection. Their feature descriptor outperformed any algorithm in this task. For every pixel it selects the pixels surrounding it and compares how dark a current pixel compared to other pixels. It represents each pixels with an arrow indicating that at which direction an image is getting darker. The process is repeated at every single pixel in the image. Every pixel is represented by an arrow called gradient. At the end this helps in generating a similarity matrix of the image for mathematical representation and compares it with the query image for finding a match.

C.R-CNN(2012)
R-CNN creates bounding boxes, or regain proposals, using a process called Selective Search. At high level, Selective

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Search looks at the image through windows of different sizes, and for each size, tries to group together adjacent pixels by texture, colour or intensity to identify objects.

1. Generates a set of proposals for bounding boxes.
2. Not a traditional classifier represented for object detection.

Runs the box through a Linear Regression model to output tighter coordinates for the box where the object has been classified

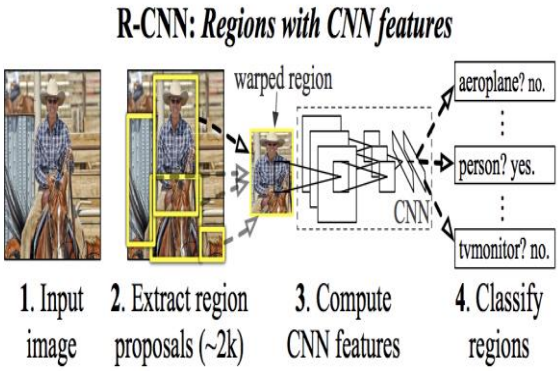

Figure4: R-CNN representation

D.YOLO(2017)

Figure5: divides image in 13x13 cell

Figure6: Thick bordered boxes has greater

YOLO outputs a confidence score and tells us how certain it is that the predicted boundary box actually envelopes some object. Score does not say anything about what kind of object is in the box, but is the shape of the box any good. Higher the confidence score, thicker the box. YOLO takes a completely different approach. It is not a traditional classifier that is represented to be an object detector. YOLO actually looks at the image just once (hence its name; you only look once) but in a clever way. YOLO divides up the image into a grid of 13 by 13 cells

V. APPLICATIONS AND FUTURE SCOPES

- Biometric facial recognition is now a regular technology rapidly replacing the finger print authentication technology rapidly. It is more efficient as replaces the need of possessing something like password.
- It can be useful for someone with Alzheimer's, dementia or any type of cognitive disabilities. It is helpful for healthcare providers as they can provide more patient security. If a patient wanders away from the facility by not carrying any physical identification then it can help to identify the patient quickly and get them back to safety
- Facial recognition technologies can be used in a classroom environment for unobtrusive attendance management as well asalarming the teachers if a student's attention level falls. It can be used to find out whether the students are happy, disgusted or angry. It can also help in analyzing the performance of the teacher.
- Emotion recognition by analyzing facial recognition through collaboration of facial recognition algorithms with machine learning has a big future in business. It can be used by banks to determine whether applicants are willing to repay loans before granting them any loan amount.
- Emotion detection will also allow store owners to find out what customers are feeling as they are shopping and thus providing those with offers they are more likely to appreciate based on their shopping patterns.
- Social media platforms can use it to target user specific advertisements, detect crimes from live video streams and can also use it create a map of an individual's mental health

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by analyzing the facial expressions of his or her posted images.

VI. CONCLUSION

Face recognition is a revolutionary technology and its use will only become more widespread as it will be used in various domains. In this paper the work modality of facial recognition systems has been explained. Also various approaches to face recognition and also the techniques that are currently used for the process have been discussed; in which each has its own complexity level and efficiency. This technology has the potential to completely replace the need to carry a physical ID. The fact of getting identified unobtrusively raises privacy concerns but as the potential of this technology is huge and therefore simultaneous development of guidelines and proper regulations will ensure a healthy use of this technology in the near future for the betterment of mankind.

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