Understanding Facial Recognition and Detection with use of EmguCV and Haarcascade Files

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Abstract—Facial Detection is a component of data analysis where computer technology is able to identify the presence of a human being's face within a digital images or digital frames. Facial Recognition is a subset of Facial Recognition System where the technology is capable of matching a human face from a digital image or a frame against a database of human faces, these are used typically to authenticate humans for ID verification services. The following research aims to proliferate the knowledge about Facial Detection and Recognition along with its foundational technologies, this is the future and has given directions to many application prospects as inculcating these would bring upon advancement in the software domain.

Keywords: Facial, Recognition, Detection, Frames, Images, Processing, Classifier, Face, System

I. Introduction

When we consider Facial Detection and Recognition we think of sci-fi movies and high-end security technology leading to a certain kind of vault. These terms are a subset of a broader term known as image processing, which is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing where the input is an image, and the output may be an image, or a certain characteristic/feature associated with the image. It is a rapid growing technology and forms the core research area within computer science and engineering. Facial Detection is an artificial intelligence (AI) based computer technology used to find human faces in digital image or frame. Recognition is considered as a stem or branch of detection where a found human face or facial pattern is compared to a database of human faces. These technologies have progressed from rudimentary computer vision techniques to advancement in machine learning (ML) to increasingly sophisticated artificial neural networks and related technologies & the result has been continuous performance improvement. These play an important role as first step in many key applications – including tracking, analysis, and recognition.

II. Objectives

1) To gain knowledge on history of face detection.
2) To understand the fundamentals of facial detection and recognition.
3) To demonstrate facial detection and recognition using EmguCV and Haarcascade files.
4) To understand the new technologies arising in the following field.
5) To understand its applications in the present and the future.

III. Methodology

1) Primary Data: The research is done through various observations and interview from industry professionals and proletariats.
2) Secondary Data: This data is collected from various journals, articles, books, websites, and magazines to develop and demonstrate the theory.

IV. History of Facial Recognition

As young leaders and scientific minds we are keen to learn about the growing technology of facial recognition but only few really thrive to understand the history that led to invention of such amelioration in mankind. The earliest pioneers of facial recognition were Woody Bledsoe, Helen Chan Wolf and Charles Bisson. In 1964 and 1965, Bledsoe, along with Wolf and Bisson began work using computers to recognise the human face. Much of their work was never published as they were funded by an anonymous intelligence agency. In the 1970s Goldstein, Harmon and Lesk extended the work of Bledsoe by including 21 specific subjective markers including hair colour and lip width in order to automate the process. In 1988, Sirovich and Kirby began applying linear algebra to the problem of facial recognition. This significant breakthrough was hindered by technological and environmental factors, however it paved the way for future developments in Facial Recognition technology. The Defence Advanced Research Projects Agency (DARPA) and the National Institute of Standards and Technology (NIST) rolled out the Face Recognition Technology (FERET) programme in the early 1990s in order to encourage the commercial facial recognition market. The project involved creating a database of facial images. Included in the test set were 2,413 still facial images representing 856 people. The hope was that a large database of test images for facial recognition would inspire innovation and may result in more powerful facial recognition technology. Back in 2010, Facebook began implementing facial recognition functionality that helped identify people whose faces may feature in the photos that Facebook users update daily. The feature was instantly controversial with the news media, sparking a slew of privacy-related articles. Facial Recognition technology advanced rapidly from 2010 onwards and September 12, 2017 was another significant breakthrough for the integration of facial recognition into our day to day lives. This was the date that Apple launched the iPhone X – the first iPhone users could unlock with FaceID – Apple's marketing term for facial recognition.

In response to booming demand for varied biometrics, NEC has expanded its traditional range of face recognition applications from law-enforcement and security provision to new areas, and now boasts more than 1,000 active systems in over 70 countries and regions spanning police, immigration control agencies, national ID, banking, entertainment, stadium, conference venue systems, and many more.

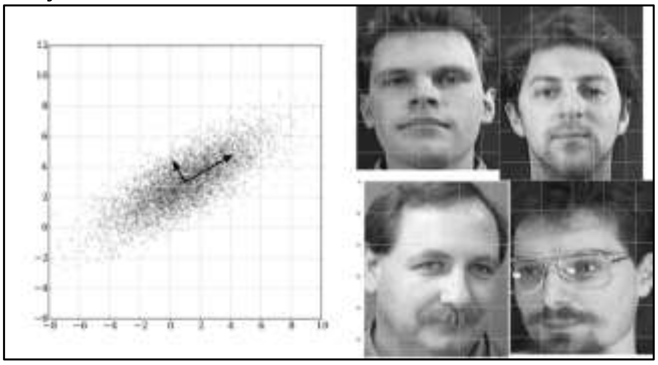

Fig. 1: Linear Algebra in Facial Recognition

V. BUILDING BLOCKS OF FACIAL RECOGNITION

All the systems in the existence of humanity are made up of fundamental building blocks i.e., the blocks form up the essential components of the system. The Facial Recognition System consists of such fundamental blocks which are:

A. *Face Detection*

This component of the system works on determining the faces from an image, frame or a live feed. There are special devices such as cameras that work towards the detection of a face, either alone or in a crowd. The face is best detected when the subject is looking into the detection device. The technological variations have enabled variations into those facial detection systems.

Fig. 2: Example of Face Detection

B. *Face Analysis*

This component captures and analyses the image, frame or live feed, most of the facial recognition technologies rely on 2D figure rather than a 3D because it is more conveniently matches the facial database. Distinguishable point or nodal points make up each face pattern used in face detection. Each human face has several nodal points some of which are displayed in the Fig 3. The system software looks for all these nodal points and analyses the same such as distance between eyes, lip curves, cheekbone shape, etc.

Fig. 3: Example of Face Analysis

C. *Face Alignment*

The goal of this component is to scale and crop face images in the same way, using the reference points implemented in Face Analysis. The process typically requires a face set to be cropped and scaled to a level matched by face database. The following can be demonstrated in the Fig 4. This scaling is performed in order to provide a high level of accuracy to the system, the ratio of these scaling factors play an important role in determining the accuracy of the system. The following process is 2D based and not 3D for coordinated convenience with facial database.

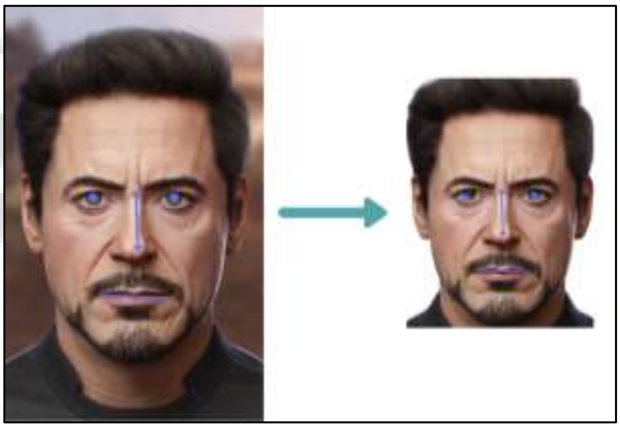

Fig. 4: Example of Face Alignment

D. *Face Image Analysis*

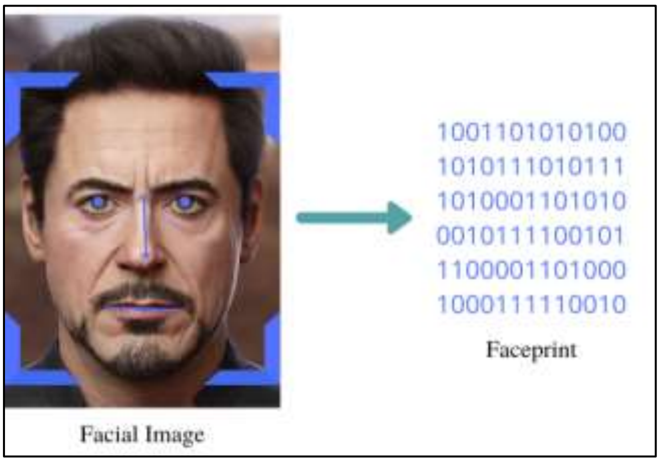

Fig. 5: Example of Face Image Analysis

This component performs analysis on the scaled or cropped image from the previous process i.e., it converts the scaled image into a mathematical formula. These facial features become numbers in a code. This numerical code which is generated by the system is also known as faceprint, similar to unique structure of a thumbprint, each person has his own faceprint. These prints help us in recognizing a face from a dataset of thousands in a span of few seconds.

Another method of face image analysis is through the pixel values of a face image which are transformed into a compact and discriminative feature vector, also known as a template. Ideally, all the faces of a same subject should map to similar feature vectors.

E. Face Recognition

This is the most important component in the facial detection and recognition, this process uses two different types of sets for comparison with the facial database. First, the vector-based pixel value is compared to a stored image in the database, or a faceprint from an image is generated and compared to a set of faceprint database. A facial database consists of an image and its generated faceprint.

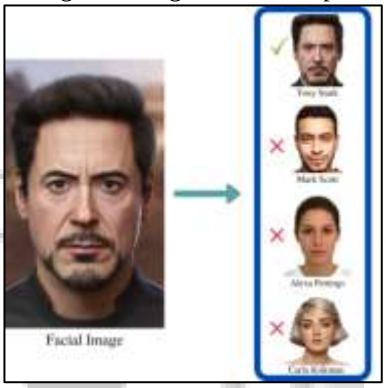

Fig. 6: Example of Vector Based Recognition

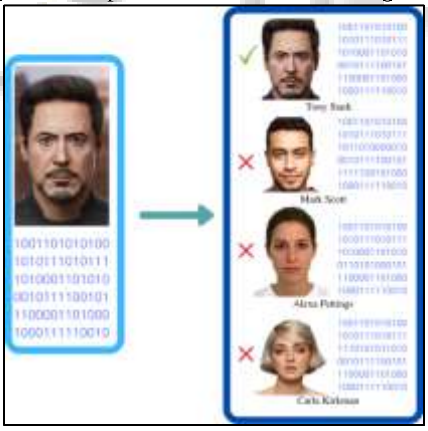

Fig. 7: Example of Code Based Recognition

VI. FACE RECOGNITION USING HAARCASCADE

The Face Recognition system developed with the help of haarcascade files is one of the simplest methods of face detection and recognition and is built on the foundational blocks of face recognition. The way and image or a frame behave with the system or vice versa demonstrates the core functionality of the system which is also known as Face Recognition Pipeline (FRP).

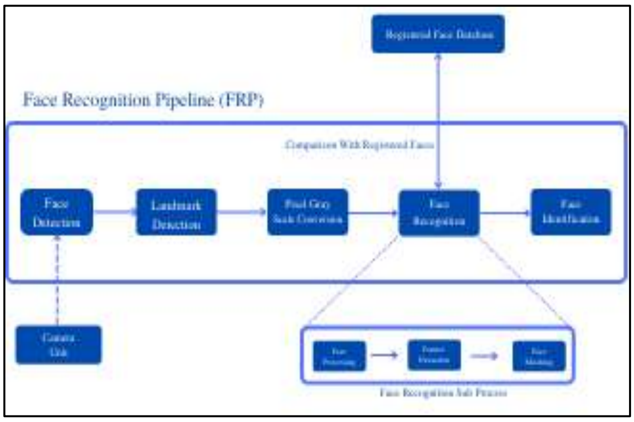

Fig. 8: Face Recognition Pipeline

Haarcascade files are an important part of the following process because these are the crucial files which follow machine learning based approach where a lot of positive and negative images are used to train the classifier i.e. It is an Object Detection Algorithm used to identify faces in an image or a real time video. The algorithm uses edge or line detection features.

Step 1 : As we initialize the system, we load the current stream of image from a camera unit to a image or picture box and the event handler takes care of running the process every micro second. The system then uses Haarcascade files to help detect faces in the frame or an image. After the facial features are detected in a frame, then the algorithm works on resizing the image according to the designated scale embedded in the system.

Step 2 : Now we convert the resized image / frame into a grayscale image, the following operation is performed as a classifier or recognizer gives enhanced level of accuracy when compared to use of a full-scale coloured image. A grayscale image only consists of limited number of colours hence it makes the process faster. To explain a grayscale image requires approximately 8 bits to store information about a single pixel, but if it's a coloured image it may be stored in RGB or RYBB format which makes it 8 x 3 = 24 bits or 8 x 4 = 32 bits respectively, hence we use grayscale images a s it requires less space to calculate.

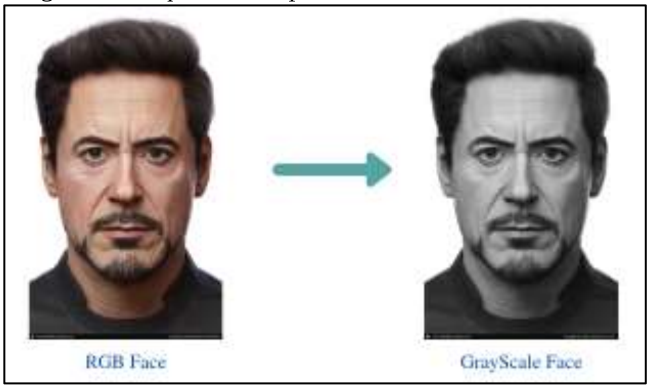

Fig. 9: Example of RGB Conversion

Step 3 : Now the Face Classifier or Recognizer uses the following grayscale image and compare them with the existing set of faces available in the database. The classifier uses parameters such as:

1) *Gray Scale Variable:* The grayscale image extracted from the RGB based image.

2) *Scale Factor:* This value specifies the ratio in which the image has been scaled.
3) *Face Set Variable:* The set or database of existing images that are used for purpose of detection.
4) *MCv Term Criteria:* This variable defines the termination criteria of the detection algorithm.

After a successful detection of a face in the frame the classifier or recognizer returns a Boolean result, further using the above result data related to the above face can be extracted from a central database.

Step 4 : The data extracted from the data reservoir is then displayed on the screen which prompts a successful identification of the face from a given image or frame on real time basis. This data may further be used for various other process and tasks such that it's existence produces a true set of information which may be used by various organizations for in their business amplification or be integrated with other systems or detection and verification.

Fig. 10: Example of Face Identification

VII. OTHER METHODOLOGIES

The methodology demonstrated above was a holistic one which was used since the early advancements of face recognition, but as time has passed scientific minds around the globe has developed various methods which are used today as facial recognition algorithms.

A. *Holistic Matching Method:*

In the following approach, the whole facial region is taken into account as input data into the system. One of the best examples of holistic methods is Eigenfaces (most widely used method), Principal Component Analysis, Independent Component Analysis, etc.

B. *Feature Based (Structural) Method:*

In the following method local features of face such as eyes, mouth and nose are first extracted, and their locations and statistics (geometrics) are fed into the structural classifier. This method is considered to be complex as feature restoration is a challenge for feature extraction methods i.e., when the system tries to retrieve the features that are invisible due to large variations, such as frontal face and a profile face. There are three different extraction methods that are used for the following:

1) *Generic Methods:* These are based on edges, lines, and curves.
2) *Feature Template Methods:* These are based on facial features of face that are pre-existing in the system.
3) *Structural Matching Method:* These are based on geometric constraints of facial features for example radius of eye.

C. *Hybrid Method*

In the following methodology a combination of both holistic and feature based are used by systems where it uses 3D figures or images as input data. The facial features are captures in a 3D format where system can store the utmost details of a face which gives the system algorithm enough information to construct and store the 3D Face. The system is highly accurate using a hybrid method, but it has its own drawbacks, where the system may not provide a true result when a 2D image is provided as input thus an actual or 3D face is required for system to generate accurate results.

VIII. FACE RECOGNITION APPLICATIONS

Many people today still think facial recognition as a futuristic idea its currently being implemented in a variety of ways such as follows:

A. *Device Security:*

Many apps and devices today use facial recognition for the purpose of protecting and individual's data. Even the most secure password can't protect accounts and crucial accounts from skilled hackers which made organizations adapt facial recognition. These apps and devices use your face to unlock and access private data.

Fig. 11: Example of Device Security

B. *Shoplifting:*

Today, many stores have inculcated facial recognition systems that mark individuals as a threat if they have shoplifted. These systems are capable of identifying a shoplifter and notifying the owner or their past discrepancies.

C. *Airlines:*

Airlines like JetBlue and Delta are using facial recognition systems to identify passengers. This feature is optional to travellers but will allow those flying to use their face as their ticket, saving time and preventing the hassle of keeping track of time.

Fig. 12: Example of Airlines

D. Security in School:

Facial recognition is started to be incorporated into schools, where many schools in Sweden use FRT (Facial Recognition Technologies) to call attendance in to the classrooms. Schools in US are starting to test FRT to serve as an "early warning system" against threats from individuals such as sex offenders, the technology also identifies 10 types of guns to prevent acts of violence in school periphery.

Fig. 13: Example of School Security

E. Buying Alcohol:

Some grocery stores and bars in UK use FRT to identify if people are old enough to purchase alcohol. These systems identify and determine age of customers and those identified below legal age need to have their IDs checked.

F. Identifying Genetic Disorders:

There are healthcare apps such as Face2Gene and software like DeepGestalt that use facial recognition to detect a genetic disorder. They analyse faces and compare them to a database of faces of those that contain these disorders.

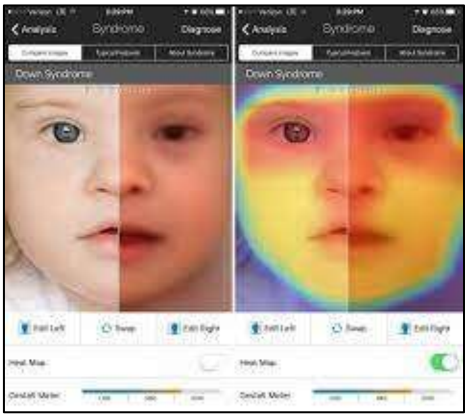

Fig. 14: Example of Genetic Disorder Detection

IX. Conclusion

Today facial recognition is considered to be the most natural of all biometric measurements. Deep learning has become the central component of most face recognition algorithms being developed. Facial recognition algorithms are seeing exponential progress. Despite several practical challenges, facial recognition technology is being widely used across various industries like retail, automotive, banking, and healthcare, marketing, and a lot more. In addition to improving the accuracy of recognizing a person, facial recognition algorithms expand their scope in detecting faces' emotions and behaviour's.

This paper gives a basic ideology of facial recognition to its readers and may help them discover and understand the importance and core foundation of Facial Detection & Recognition.

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