# A SYSTEMATIC REVIEW OF FACE DETECTION AND FACE RECOGNITION TECHNIQUES USING MACHINE LEARNING

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**Abstract**
The purpose of Machine Learning Researcher goal is to introduce an autonomous facial recognition system which can equalize and ultimately outperform individual performance. For this purpose, it is necessary for computer scientists to be aware of the main results of experimental studies on facial recognition by humans. These results furnish understanding of the human face recognition system which depends on to attain a spectacular presentation and give out factor to artificially follow these expertise. In this paper, we have included some methods of face recognition with its implications. Each method is described briefly and provides deep study of particular method.

**Keywords**: Benchmarks, Haar Cascade, Linear Binary Pattern Histogram, Eigenface, Fisherface.

## Introduction

Recognition is an essential and crucial subject of study in image retrieval and schema recognition. influenced by rarity mechanism of the visual processing system and the successful thin coding in image processing, the clustering algorithm based on thin representation received adequate attention and performed well in facial recognition(D. Zhang et. al., 2017). The focus on developing these applications like facial recognition, has not long ago become salient in intelligent cities. Moreover, many scientists and engineers from all over the world has emphasized stabilization of more and more powerful precise algorithms and methodologies for the systems and application in day-to-day life. Personal information must be safeguarded by the security system. Passwords are frequently used for recognition. Many organizations are using biometric factors for recognition process and many are planning to start the use of biometric for recognition. Identification system technology is the solution that has a quality of high precision and low intrusion. Secret services, chip-based access control and smart cards etc. uses face recognition technology (FRT) for security purpose (Y. Kortli et. al., 2020), (X. Tan et. al., 2006 ). In computer vision field a great amount of attention has been experienced in face recognition among all. In 1950s and 1960s the research was carried out which was he first research on FR and it was reported in the literature of psychology and engineering respectively. Due to broad variety of the human faces face recognition technique is still a tough task in spite of convincing development and substantial progress. The methods which lead to a very precise extraction of the characteristics with a great robustness to the variation are critical. FR is one of the main tasks of the human vision system that most researchers have focused on FR in the visible domain. However, the main disadvantage of these studies is the strong dependence on eliminating the even variation in skin color. There have been several suggested illumination invariant FR approaches, which are divided into two categories: passive methods and active methods (S. Farokhi et. al., 2016). Visible spectrum pictures are analyzed in passive approaches to avoid the challenge created by variation in light. Researchers conducted extensive studies of illumination invariant techniques, particularly passive approaches. Categorization of passive method can be done in four groups: illumination invariant features, illumination variation modeling photometric normalization, and a 3D morph able model. However, one significant disadvantage of this strategy is the loss of essential information about facial photos during illumination adjustment. In the research activities, continued attention and efforts are required to eventually achieve the objective of 3-dimensionsal computer vision and to fully exploit the benefits of

 

becoming idle for computer vision(S. Farokhi et. al., 2016), (X. Zhang et. al., 2009). Active imaging techniques are used in active methods to control lighting variance. These approaches are used to obtain illumination-invariant face photographs or to obtain facial images taken under constant lighting circumstances. Active approaches are classified as those that utilize 3D information and those that employ infrared. Thermal infrared and near infrared techniques are the two types of infrared procedures. When 3D pictures are employed, the main disadvantages of active approaches are increased prices and high computing complexity of systems. When thermal images are used, the additional disadvantages of active techniques are their great susceptibility to external temperatures, health problems, and sweat (S. Farokhi et. al., 2016).

Despite substantial research into statistical machine learning algorithms, we still desire a system that can operate well in an unrestricted circumstance whereas, sensor noise, line of sight, and illumination make up the majority of the changes in pointing characteristics that are connected with them. The only system in the human body that seems to function well in the face of these challenges is the visual system. It makes perfect sense to try to understand the methods used by this biological system as a first step towards ultimately translating these approaches into machine-based algorithms. With this goal in mind, we've compiled a list of 19 key findings on human facial recognition. Since these facts do not give a complete concept of face recognition in visual acuity (we basically do not use all of the parts yet), they just provide valuable ideas and restrictions for the one. As a result, we believe they will be helpful to computer visual acuity experts in directing their ongoing work. Of all, vision based systems success is not contingent on exact replication of biological equivalents. Findings into the latter's operation are generally used as possible beginning points for analytical inquiries(P. Sinha et. al., 2006).

The "fourth generation" of information and communication technology will include smart surroundings, wearable computers, and cognitive computing generally. These gadgets will be ubiquitous in clothing, the house, the vehicle, and the office financial and social effect will eclipse that of the previous three phases. They constitute, at the very minimum, amongst the most intriguing and commercially significant research topics in degree of bachelor of technology. However, before coming era of computers can really be largely used, interface designers must devise new means of interaction that do not need the usage of input devices. To get widespread consumer acceptability, these conversations must be pleasant and customized, which means that further generation displays have to be fully conscious of the individuals in their surrounding area, at the very least, recognize who they are. (Alex (Sandy) Pentland et. al., 2000).

**Most anxious biometric: Face**

Amongst most significant subjects in the fields of machine learning and computer vision is identifying faces. The face is among the most common biometrics for person recognition since it is pervasive and can be acquired in unrestricted situations while offering significant discriminative characteristics for recognition. Face recognition is becoming an essential tool for improving the automatic operation of surveillance, visual analytics applications, and many other everyday applications such as enjoyment, sensible purchasing, and accurate face annotating in photo collections. (P. Natarajan et. al., 2019).

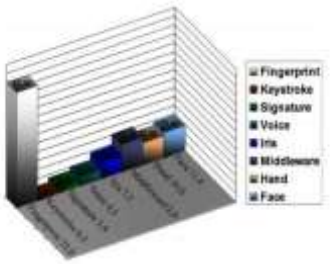


Fig 1. Demand of popular biometrics (A. F. Abate et. al., 2007)

 

Recent occurrences, such as terrorist acts, have shown severe flaws in even the most advanced security measures. Different agencies are now much more driven than ever to develop security data systems associated with physical or behavioral features, sometimes known as biometrics. Biometric systems, in general, process raw data to create a pattern that is easier to handle and store while still containing the majority of the information required. It's a particularly appealing technology because it can be implemented into any application that requires protection or access control, completely reducing the hazards associated with less sophisticated solutions that rely on what a person has or knows rather than who a person truly is. Fingerprints and iris are perhaps the most popular biometrics, although many additional human traits have been examined in recent years: Geometry of the fingers and palms, voice, signature, and face (A. F. Abate et. al., 2007).

**Background information, terminologies, and the problem**

Face recognition is a broad word that may relate to a variety of events. "Recognition" or "identification" is one situation. "Authentication" or "Verification" is one of them. Face photographs of identified people are first enlisted in the record in either case. The "gallery" is a term used to describe this group of people. Photographs of these or other people are afterwards used as "scanner" comparing them to photos in the collection. The matching in a detection situation seems to be one, in the view that a sample is compared against the whole collection to discover the perfect match beyond a certain limit. The probe is checked against the collection record for just a claimed authentication in an authentication scenario, and the declared verification is assumed to be validated if the reliability of the comparison exceeds some criteria.

Technically, the recognition situation is more difficult than the verification situation. One explanation for this would be that in a recognition scenario, a wider gallery increases the possibilities of inaccurate recognition. Another problem is that each time a recognition attempt is made, the whole gallery must be searched in some way (K. W. Bowyer et. al., 2006).

Face recognition and identification have grown from being small to key areas of computer vision research over the past 10 years, and are currently among the more beneficial and efficient uses of image processing and algorithm-based learning. Due to the widely held belief that advancements in computer image processing and understanding research give new information on how our brains function, and vice versa, computer vision was not just a simple computer engineering field of study, but also a subject of neuro scientific and psychological research.

The face identification issue (in computer vision) can be stated in general terms as follows: Using a stored datasets of faces, recognize or authenticate one or more people in a situation using still or video pictures. In the visible realm, face recognition has gotten a lot of press. Deep learning has dramatically evaluated the effectiveness of traditional face recognition to levels that are close to human (S. Emami et. at., 2012), (G. Guo et. al., 2019).

There are several factors that affect the system's effectiveness when image quality is taken into account. You must employ a number of image pre-processing techniques to uniformize the images that one you will provide to a face recognition system. Numerous face recognition algorithms are especially sensitive to lighting conditions; as a result, if a person was taught to be detected by it in a dark room, it would almost likely not be detected in a bright one, and so on. This issue is referred to as "lighting dependent," and There are many further problems, such as being in such a logical location inside the photos with the face (for example, the eyes to be in the same corresponding points), the same size, full makeup, sentiment (happy, upset, etc.), rotation angle and of light’s positions (either to the left or up, etc).

And for this reason, it is crucial to use top-notch photo pre-treatment filters before performing facial recognition. You should definitely remove any unused pixels surrounding the face, like using an elliptic

 

masking to only display the interior facial landmarks, instead of the backdrop and hair, as they affect more than only the face(S. Emami et. at., 2012).

**Face Detection and Recognition**

Face recognition was formerly regarded amongst the most challenging challenges in artificial intelligence and computer vision. That was twenty years ago. Amazingly, a sequence of accomplishments over the last decade has made global personal identification look to be not just technologically viable but also commercially viable.

Face recognition's obvious predictability, paired with the ideal of smart surroundings, and has sparked a great rush of desire from funding organizations and researchers alike. It has also inspired a number of successful commercial ventures. Commercial face recognition software focuses on high-quality recognition with datasets of approximately 1,000 persons is currently available from a number of businesses. These first findings were made possible by a combination of well-known pattern recognition algorithms and a reasonably deep grasp of the picture production process led to these early results. Furthermore, researchers discovered that they may profit from human-specific patterns. Human skin colors, for example, are distributed over a one-dimensional spectrum in colors and space, with color variance owing mostly to melanin content. When humans are gazing at the camera, their face geometry is constrained and virtually two dimensional. Researchers are now exploring on loosening some of the limitations of conventional face recognition algorithms in order to gain resilience in the face of changes in illumination, age, depth rotation, and expression. They're also looking at ways to cope with differences in appearance caused by things like facial hair, spectacles, and cosmetic issues that have selected answers already. (Alex (Sandy) Pentland et. al., 2000).

**Methodologies for Detection of Faceand its Recognition**

The phase of face detection is the initial and is the most major phase while conducting facial recognition. Therefore, we are going to try first to figure out the face detection portion thereafter we are going to switch to face recognition portion.

**A) Haar Cascade**

Over the past few years, numerous studies deal with detecting human face, particularly with Haar Cascade Classifier: Singh, V. et al., investigates about the issue of face detection in the very first attempt by using classifier from the images that contains effortless and complex backgrounds. He performed the method named haar cascade classifier by using the OpenCV library. Haar cascade classifier offers excessive accuracy in spite of the illumination actively influences the image. The classifier technique has revealed most appropriate overall performance with uncomplicated historical past snapshots(Adri Priadana et. al., 2019).Before executing any actions on data, the algo foremost requires to be skilled with the images of high quality (face containing image) and also negative (face barring image)(Shalince Dominic et. al., 2016). At the end of profitable training, properties are evoked out of the images. Later on, the goal image’s size is chosen, that is generally smaller in size than the practicing images, after that it is positioned on the image that is targeted for the calculation of mean estimates of a pixel in every segment. Then after if mean threshold estimates permit then after a fit is put under consideration (L. Dinalankara, 2017). An individual classifier can’t be sufficient and accurate, hence the images are trained by many classifiers (S. I. Safie et. al., 2014). Below are some features from haar cascade:

 

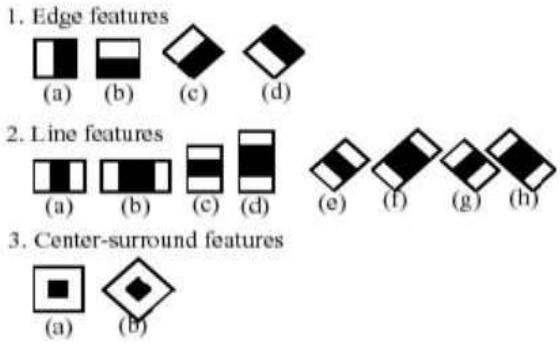


Fig 2. Haar features (Prof. A. M. Jagtap et. al., 2019)

A number of other classifiers are used to make the classifier better. A machine learning algorithm called ADA BOOST picks the most appropriate match that is for goal image, primarily depended on assessments on the chosen pics of several other classifiers. To get higher results it may additionally even undo the system. (L. Dinalankara, 2017).

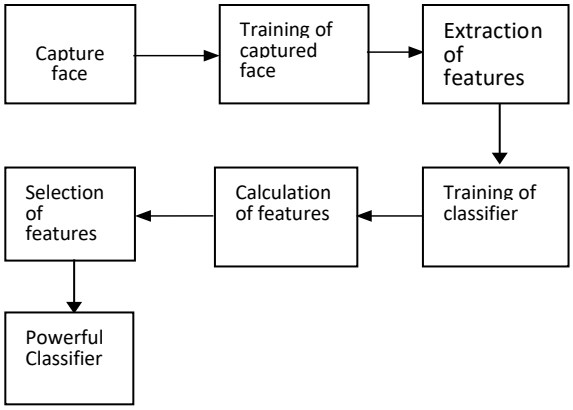


Fig 3. Flow chart of haarcascade(Prof. A. M. Jagtap et. al., 2019)

For optical recognition, a rectangle aggregate is used. These rectangular blocks are no longer what we can call actual haar wavelets, that's why we can refer to them as haar features, as shown in figure 4. We can detect the presence of haar by subtracting the average of both the light and dark portions. If the distinction exceeds the limitation, the haar function is considered to exist (Prof. A. M. Jagtap et. al., 2019).

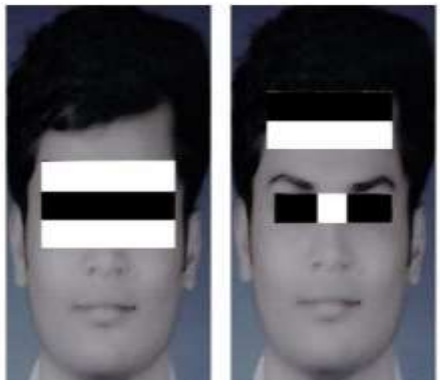

Fig 4. The author's face was matched with a haar-like feature. (Prof. A. M. Jagtap et. al., 2019)

A technique named the integral image was employed by Jones and Violas. The integral image's sole purpose is to confirm if a large number of haar characteristics are present or absent within the image. Following all subsequent training, it is possible to determine whether or not a face exists based solely on the integral image (Prof. A. M. Jagtap et. al., 2019).

**B) Linear Binary Pattern Histogram**

The Local Binary Patterns Histogram(LBPH), presented in the year 2006, is a machine learning algorithm designed for facial recognition, that is on the basis of local binary operator. This algorithm is one of the most prominent algorithms broadly used, due to the fact of its discriminative strength and computational clarity (D. van den Heuvel et. al., 2016).

LBP is an extremely productive texture operator. It takes the boundary value of every adjoining pixel including the middle pixel's data value. It considers the outcome as a binary number (S. I. Safie et. al., 2014). Its parametric endurance and clearness are what propels LBP extra famous method in a range of applications. LBP is foremost described in the year 1994 since then it appears to have come to be an extra effective algorithm for the classification of texture (L. Dinalankara, 2017). Afterwards, it was declared that combining LBP with the descriptor, HOG (Histogram of Oriented Gradients), improves its action on an identical dataset. LBP has outstanding characteristics such as changes in monotonic grey scale and computational clarity, because of which real-time software can examine images (Prof. A. M. Jagtap et. al., 2019).

In terms of functionality, an image of size N x M is used, which is then sliced in regions. A similar size is chosen for both height and width, resulting in m x m regions. In every region, there is the utilization of the local binary operator. When the operator is utilized on the images, it's eight nearest neighbor pixels are compared to a pixel. The comparison analyses if a neighboring pixel's value is higher than a center pixel, resulting in a value of '1' in this considered case and a value of '0' in all other cases. When this procedure is applied to each of the eight neighbors, a total of eight binary values are generated. By combining these values, a binary 8-bit number is produced. The obtained binary value conversion is possible into its decimal representation, known as the pixel LBP value, which ranges from 0 to 255. The procedure is represented by the figure 5. Each pixel in the presented region undergoes the described process (D. van den Heuvel et. al., 2016).

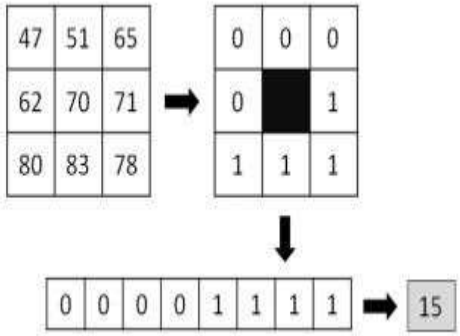


Fig 5. LBP operator example(D. van den Heuvel et. al., 2016)

**C) Eigenface**

Detection of face is one of the important aspects of a face recognition technique. Giving rise to understanding from different input modes like videos and images is a crucial part of this undertaking. The main issue it runs into is that most of the time the information is noisy. Images are chosen arbitrarily, but in such a way that they retain a face, so they are not completely arbitrary. The

 

characteristic trait is referred to as eigenface, and it includes the presence of objects such as eye, mouth, and nose inside a face, and also the relative length among the objects (D. Pissarenko, 2002).

A mathematical means Principal Component Analysis (PCA) is put into consideration for the algorithm of eigenface. It presents aspects for reconstructing and reproducing an actual image from the set that is meant for training by integrating eigenfaces. Only by putting any face in the true commensurate way we can retake an authentic face. The input photos must be equivalent grayscale and pixel size to the trained images. Take a look at an image with n*n pixels. Each concatenated row yields a vector, which then yields a matrix of 1xn^2. Every single image in the training batch of photos is averaged to create the matrix.

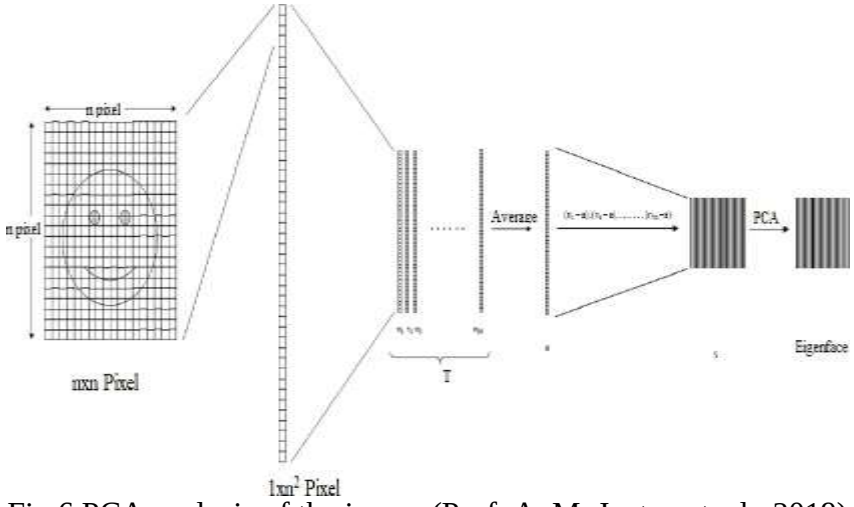


Fig 6.PCA analysis of the image (Prof. A. M. Jagtap et. al., 2019)

By eliminating the average face from every image vector, the unique trait is determined. The resultant matrix demonstrates the property of the average human face. The covariance matrix can now be deduced from the results. Eigen analysis employs PCA. The discovered covariance matrix is now the end result (L. Dinalankara, 2017). It has the most variation because the first and second eigenvectors are in the subsequent eigenvector's route, and is also within 900 of the first, and so on. Every column is thought to have pictures, or matched faces, which is referred to as eigenface. Casting the educed features on the eigenfaces yields the weight values.The image is resized and sourced first in order to adjust the similar measurements of the data to be tested after that comparison is attained on the basis of weights, which corresponds to the similarity between traits obtained out of theimage that is regarded as input and traits obtained from the various image sets. On comparison with the entire dataset, the relevant input picture can simply be specified as a face. In comparison with each subset, we can specify it to the individual. We can set a threshold to monitor identification and detection in order to eliminate falsified recognition and detection. Working of the face recognition function is described below:

cv2.face.createEigenFaceFaceRecognizer()

1. PCA considers components of a wide range when generating eigenfaces. OpenCV archives with 80 images are more suitable for achieving excellent results.
2. When the face recognition threshold price, which is the same as the LBPH, is considered, the result is -1 (L. Dinalankara, 2017).

**D) FisherFace**

The central concept that underlines the enactment of the fisherface method is eigenface. Linear Discriminant Analysis (LDA) is a pattern recognition approach that is the basis of fisherface, which is illustrated in fig. 7. While PCA determines the greatest variance within the observed matrix, LDA is

 

founded on the basis of the labelling concept in just such a manner that whenever there is a projection of the needed dimension on the image, a distinction between class methods could be amplified (L. Dinalankara, 2017).

The key idea is to increase the ratio among both, class scatter as well as its matrices; This is accomplished via LDA.We understand that LDA outperforms the PCA method in lighting conditions. The Linear Discriminant approach of Ronald Fisher, that uses pattern recognition, is used in image variance. In contrast, based on LDA recognition, the fisherface method, minimizes the variance and increases the mean distance among classes. Due of this, LDA can discriminate across trait classes more clearly than PCA. and It also takes up less space, making it a superior method to the PCA method (L. Dinalankara, 2017). The function of face recognition can now be seen in action:

cv2.face.createFisherFaceFaceRecognizer()

1. A fisherface for LDA is created using a number of variables.
2. It will return -1 if the threshold is exceeded, just like eigenface (Prof. A. M. Jagtap et. al., 2019).

Fig 7. Pattern recognition image(Prof. A. M. Jagtap et. al., 2019)

**E) Independent Component Analysis**

While the input data is decorrelated by PCA (Principal Component Analysis) using second-order statistics, compressed data with the lowest error of mean squared reprojection is generated. The corresponding input's second and higher-order dependencies are reduced by ICA (Independent Component Analysis). It is concerned to the issue of BSS (blind source separation), whereas, degrading of an inspected signal in a linear collection of unknown separate signals is the main purpose. ICA is basically a generalization of PCA.

The separation and identification of sources' group with short previous information is the ICA. In order to generate separate fundamental images, from a collection of facial photos, ICA derives the separation matrix. Then, S is a vector of a mysterious source signal, X is a vector of the subject of the investigation, and A is a mystery mixing matrix. The ICA face recognition merging model is as follows:

$$X = AS \quad (1)$$

According to equation (1), every source signals are not dependent on one another, and A is the inverse. Try to find W and A using this ICA in such a way that,

$$S = WX \quad (2)$$

When the corresponding independent source signal is found from equation (2), ICA attempts to achieve W (Rajat Naik et. al., 2018).

**F)EBGM (Elastic Bunch Graph Matching)**

The core concept behind EBGM appears to be that, after first locating facial landmarks' set, recognition of a new face pattern could be accomplished and then calculating the degree of similarity between these landmarks as well as the rest obtained from a collection of each individual's faces. Primarily, EBGM algorithm uses Gabor jets as characteristics for each of two getting a match of localization as well as facial landmarks.

In practice, the HOG-EBGM algorithm degrades in three stages:

(1) Normalization of image.
(2) Face graphs creation.
(3) Matching of graphs.

The first step's purpose is to minimize the variations due to changes in scale, luminance, and rotation.

Following the detection of facial landmarks, the following step generates a face graph. Indeed, the accurate nomination of facial landmarks ensures the success of the recognition algorithm. Specifically, facial landmarks needed to be extremely distinguishable among various people while also being extremely simple to be detected in an entirely automatic system apparatus. As shown in Figure 8, The face graph adheres to the structure approved in the CSU project, including 25 facial landmarks, demonstrating the second order.

It is important to note that not every facial area is equally involved in facial recognition. Numerous researches revealed that, the portion throughout the nose and eyes are extremely crucial for the purpose of recognition, because of this, many of facial landmarks are positioned in these two portions (A. Albiol et. al., 2008).

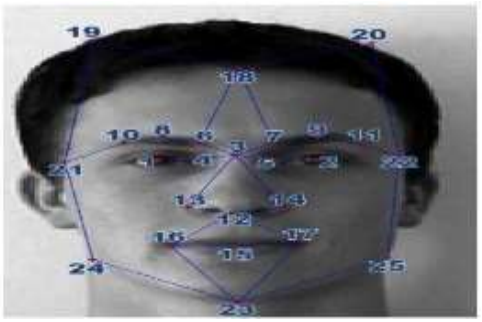


Fig 8. A CVL image containing a face graph and 25 facial landmarks. The numbers also represent the search order (A. Albiol et. al., 2008).

**Face Detection and Face Recognition: A Review**

**A) FaceDetection**

Here, we will interpret the FD technique, which consists of various modules that work together to ensure that the system runs properly. The stage comprises of image capturing and the recognition of faces in the image that was taken. To capture the pictures in real-time, a USB webcam that has a connection with raspberry pi can be used. The purpose of the face detection module deals with clarifying the availability of face for real-time application. FD is achieved by inspecting an image as well as identifying some face-representing patterns. When a face is detected by the system, it generates a sub-image with the face in the center that is uniformly sized. The OpenCV library already includes a number of algorithms for locating faces in videos and images. The input image from the webcam is scanned by the Haar Classifier algorithm and the respective algorithm also produces a box for every face that is displayed into image. Then again, Haar Classifier attempts to find features of facial elements such as the nose, eyes, mouth, and so on in an image. The Classifier examines these characteristics and for each face, it creates a template. The template contains smaller data sets that depict a face bounded inside a box (Sonia Kuwelkar et. al., 2017). The FR apparatus starts mainly with

 

the human face localization in a specific image. The objective of this stage is to deduce whether the human faces are contained by the input image or not. The variations in facial expression and illumination can prohibit adequate face detection. Pre-processing stages are carried out to facilitate the design as well as layout of a future FR system and to make it more powerful (Y. Kortli et. al., 2020).

**B) Face Recognition**

During the characteristic extraction stage, the phase takes into account the characteristics extracted from the background and matches them to the familiar faces stored in a specific database. There are two basic applications of FR, the first is known as verification, while the second is known as identification. At the time of the identification step, a test face is compared to a collection of faces intended for finding the most likely match. Now, in the step of identification, a test face is compared to a face that is known in the database to determine whether it should be rejected or accepted (Y. Kortli et. al., 2020).

This segment focuses on LDA and PCA for FR. First and foremost, we require a collection of images from the database from which the algorithms will then be tested. The image dataset of AT&T will be utilized. The first stage considers reading all of the pictures from the dataset that will be applied to training. In this segment, all of the mathematical phases will be performed on the embedded platform of board for the Raspberry- Pi -3in order to run the FR system on it. The respective block is split into two sections: the period of training(it builds a picture database that will be used in the re-cognition stage using a set of AT&T photos) and the period of recognition(Each and every pre-processing step is applied to the image to be examined, beginning with color to grey conversion, normalization, column vector conversion, and filtering) (Sonia Kuwelkar et. al., 2017).

**An Analysis of The Previous Work**

This section discusses various works that have already been accomplished in the Face Recognition field. Because of their numerous applications, face recognition systems have increased in popularity over the last few decades.

A significant amount of research has been done in this field to create an effective facial recognition syst em.The systems of face recognition must have a high rate of recognition as well as a fast speed of recognition. The goal is to select an algorithm of recognition that will improve accurateness while also accelerating the method of facial recognition.

Both LDA and PCA are methods of linear transformation; however, while LDA is supervised and seeks routes that enhance separation between several classes, PCA is an unsupervised algorithm that ignores class labels and finds directions that enhance variance.

A system of face recognition was proposed by Himavati, Dhanaseely, and Srinivasanthat reduced dimensionality with PCA and classified faces with a neural network. The facial recognition system based on a neural network is inspired biologically and works in the same way that neurons in humans do, transporting messages from one location to another. A perceptron, like a neuron, calculates a weighted total of numerical inputs to decide whether or not a person is recognized. Using a neural network necessitates a significant amount of computational effort. Many algorithms for face recognition systems have been clearly proposed as a result of the literature review. As a result of merging two famous algorithms of face recognition, PCA and LDA, in this paper, a face recognition system is suggested. Both of these approaches require the computation of Eigen values and Eigen vectors. The Eigen Values and Eigen Vectors are computed using the Jacobi method. This technique is unique in that it increases the rate of recognition while decreasing the time of recognition. Any real-time application

 

that needs a facial recognition system may be built using this method and implemented on any embedded platform(Sonia Kuwelkar et. al., 2017).

Various methods based on ICA have been introduced over the last decade. The proposed survey project revolves around face recognition based on ICA. This section discusses the various techniques based on ICA used over the last decade.

ICA-based facial feature extraction methodology uses both global and local feature extraction methods in this case. The global feature is conferred here, which also supports edge data. Within the results, the local alternatives that modular ICA supports are explored and agreed upon. In this paper, the work that is presented may point the way forward for statistical analysis in the future.

ICA was used to recognize human faces. He recognized human faces using the Info-Max algorithm.There is a considerable likelihood that a JADE recognition experiment will result in a noticea ble improvement.In orderto proceed with the performance testing of the methodology. The False Accept Rate (FAR) and False Reject Rate are used to gauge the effectiveness of the methodin relation to the target face under various lighting and/or noise conditions(to get as close to real-world scenarios as possible)(Rajat Naik et. al., 2018).

Table 1 (Rajat Naik et. al., 2018): The table below presents a comparison of various ICA-based face recognition techniques. This comparison examines various methods and their advantages. The authors of the papers are listed in the first subsection. The second sub-section discusses the various techniques used in the papers, and
The final part compares the various approaches and examines the advantages of each.The third sub-section illustrates various methods and their effectiveness.

| S.No. | Author | Approach | Benefit | Year |
|---|---|---|---|---|
| 1. | K.J. Karande et al | Put attention on ICA and its cutting-edge variations, including Fast ICA, also KICA and also Modular ICA. | Use a range of global and local characteristics for face recognition. This enhances the output of the ICA approach. | 2016 |
| 2. | Alyasseri et al. | The scientists made use of a local dataset of 40 students and several face expressions, including natural, smiling, dim, bright, and wearing sunglasses. Real-time facial recognition using ICA will be the main focus. | Work with either runtime pictures or natural photos. Apply ICA to different image circumstances. Displays effective outcomes in a range of low-resolution photos. | 2015 |
| 3. | J.J. Zhang et al. | Focused on ICA with SVM on a variety of common datasets, including ORL Yale and Yale B. | A greater rate of face recognition is shown by ICA+SVM. A nice result is also exhibited using PCA+SVM. | 2014 |
| 4. | Reagan et al. | A novel incremental PCA+ICA algorithm's effects on different outcome parameters, such as the fluctuation in accurate recognition rate, should be discussed. | The average Success Rate or CRR of the IPCA-ICA method is greater than that of ICA. | 2013 |

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| 5. | K.J. Karande et al. | Utilizing both OLOG and ICA, features are extracted. | OLOG using the Fast-ICA algorithm obtains 84% identification accuracy for facial pictures when the number of independent components is 25. | 2012 |
| 6. | Lihong et al. | PCA and ICA in combination is advised. Matrix creation and whiting are performed using PCA, the unmaking matrix is computed using Fast ICA, and the features are calculated using ICA. | The recognition rate for this approach, which combines PCA and ICA, may reach up to 99 percent. | 2011 |
| 7. | N T Naresh Babu et al. | It combines two techniques. The ICA and DWT. | An effective method for matching pictures, the suggested recognition methodology based on DWT-ICA has a high recognition rate. | 2011 |

**Applications of FR**

The technology of face recognition (FR) has various potential appeals in surveillance and law enforcement, smart cards, information security, among others. Because of this reason, over the last 20 years,Both the industrial and academic communities are paying close attention to FR technology (F. Zhang et. al., 2006).

Face recognition (FR) across poses deals with the recognition of facial images in various poses by computer systems. It has received a lot of attention in various FR applications, in particular, those that uses uncooperative or unconcerned disciplines. For example, FR technology is appealing for airport security because it can identify terrorists. Generally, terrorists' facial datasets are first gathered and then recorded in a database counter to which the facial datasets of travelers will be matched. Then there is the face-scanning at the checkpoint for everyone. When a match is detected, cameras are activated to monitor travelers through the live video streaming, after that, authorities will validate the match and instruct whether to resist the person or not(Y. Gao et. al., 2009).

**A. Investigation of Crime and Evaluation of Forensic Evidence**

The algorithms of face recognition are often used for the investigation of crimes. For example, a comparison of a scene of the crime image toan identification photographs' database. In forensics, mainly study of face is manually conducted on image pairs that comprise a suspect image and an image of the crime scene. The FR is used to assess the probative value of evidence that is found in image pairs, which is introduced in an adequate probabilistic aspect in the court.

**B. Investigations into Image Databases**

These comprise numerous applications, like searching for missing people images, police booking, national IDs, passports, etc. These types of applications make use of variations of face like image resolutions etc.

**C. Expression Recognition**

Faces of humans give crucial knowledge, like expressions. Various crucial areas for expression recognition applications have been recognized. These comprise of a collection of demographic

 

information as well as marketing of electronics that is real-time. Actions are in advancement for the identification of facial expressions accurately under uncontrollable conditions.

### D. Commercial Locations

Face recognition technology can be useful in public/commercial places. Under various circumstances, facial detection is helpful to observe doubtful expressions of people. Some of the examples are commercial malls, public places etc.(T. Ali et. al., 2017).

### FR Difficulties

Despite the growth of enormous numbers of face recognition algorithms, various complications still challenge these FR algorithms as listed below:

- A crucial factor in face recognition is poor resolution, faced when the images get caught from a very far distance. Additionally, closing of eye furthermore influences the recognition's accuracy of most face recognition systems, because they rescale and normalize images prior to recognition.
- The details of the implementation frequently figure out the enactment of the system. Like, several times the input images are placed under normalization concerning scale, in-plane rotation, masking etc.
- The face recognition algorithms are chosen as preferred by the application. Like, on facial images of poor resolution methods that are featured based can't be applied, as same as 15 x 15 pixels or below.
- When maximum developed face recognition algorithms are put to work in uncontrollable conditions, their performance rapidly degrades. Till now, neither of the face recognition algorithms could be readily used so as to cope up with aforesaid problem(T. Ali et. al., 2017).

### Conclusion

We discovered that combining LBPH along with Haar cascade yields the best results of any of the algorithms tested in this study. They will not produce the same results with the same precision if we do not use them together. Using PCA, with eigenfaces we get better results than with fisher face. The eigenface algorithm, on the contrary, is advisable for dataset representation, whereas for classification of data as well recognition of pattern, the fisherface algorithm is best.

### References

1. Y. Xu, Z. Li, J. Yang, and D. Zhang, "A Survey of Dictionary LearningAlgorithms for Face Recognition," IEEEAccess, vol. 5. Institute of Electrical and Electronics Engineers Inc., pp. 8502– 8514, 2017. doi:10.1109/ACCESS.2017.2695239.
2. Y. Kortli, M. Jridi, A. al Falou, and M. Atri, "Face recognition systems: A survey," Sensors (Switzerland), vol. 20, no. 2. MDPI AG, Jan. 02, 2020. doi:10.3390/s20020342.
3. X. Tan, S. Chen, Z. H. Zhou, and F. Zhang, "Face recognition from a single image per person: A survey," Pattern Recognition, vol. 39, no. 9, pp. 1725– 1745, Sep. 2006, doi: 10.1016/j.patcog.2006.03.013.
4. S. Farokhi, J. Flusser, and U. Ullah Sheikh, "Near infrared face recognition: A literature survey," Computer Science Review, vol. 21. Elsevier Ireland Ltd, pp. 1–17, Aug. 01, 2016. doi:10.1016/j.cosrev.2016.05.003.
5. X. Zhang and Y. Gao, "Face recognition across pose: A review," Pattern Recognition, vol. 42, no. 11, pp. 2876– 2896, Nov. 2009, doi:10.1016/j.patcog.2009.04.017.
6. P. Sinha, B. Balas, Y. Ostrovsky, and R.Russell, "Face recognition by humans: Nineteen results all computer vision researchers should know about," Proceedings of the IEEE, vol. 94, no. 11, pp. 1948–1961, 2006, doi: 10.1109/JPROC.2006.884093.
7. "Face Recognition for Smart Environments," 2000.

 

8. I. Masi, Y. Wu, T. Hassner, and P. Natarajan, "Deep Face Recognition: A Survey," in Proceedings - 31st Conference on Graphics, Patterns and Images, SIBGRAPI 2018, Jan. 2019, pp.471–478. doi:10.1109/SIBGRAPI.2018.00067.
9. A. F. Abate, M. Nappi, D. Riccio, and G.Sabatino, "2D and 3D face recognition: A survey," Pattern Recognition Letters, vol. 28, no. 14, pp. 1885–1906, Oct.2007, doi: 10.1016/j.patrec.2006.12.018.
10. K. W. Bowyer, K. Chang, and P. Flynn, "A survey of approaches and challenges in 3D and multi-modal 3D + 2D face recognition," Computer Vision and Image Understanding, vol. 101, no. 1, pp. 1–15, 2006, doi:10.1016/j.cviu.2005.05.005.
11. S. Emami and V. P. Suciu, "FacialRecognition using OpenCV FaceBotsView project Facial Recognition using OpenCV," 2012. [Online]. Available: www.jmeds.eu
12. G. Guo and N. Zhang, "A survey on deep learning based face recognition," Computer Vision and Image Understanding, vol. 189, Dec. 2019, doi: 10.1016/j.cviu.2019.102805.
13. UniversitasAtma Jaya Yogyakarta, Institute of Electrical and Electronics Engineers. Indonesia Section. Computer Society Chapter., Institute of Electrical and Electronics Engineers. Indonesia Section., and Institute ofElectrical and Electronics Engineers, 2019 International Conference ofArtificial Intelligence and InformationTechnology (ICAIIT 2019) : 13-15 March 2019, Platinum Adisucipto Yogyakarta Hotel & Conference Center.
14. Institute of Electrical and ElectronicsEngineers. DMI College of Engineering Student Branch, Institute of Electrical and Electronics Engineers. Madras Section., and Institute of Electrical andElectronics Engineers, International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT) - 2016 : 3rd-5th, March 2016.
15. L. Dinalankara, "Face Detection & FaceRecognition Using Open ComputerVision Classifies FACE DETECTION &FACE RECOGNITION USING OPEN COMPUTER VISION CLASSIFIRES," 2017. [Online]. Available:https://www.researchgate.net/publica tion/318900718
16. K. Kadir, M. Khairi Kamaruddin, H.Nasir, S. I. Safie, and Z. Abdul KadirBakti, "A Comparative Study betweenLBP and Haar-like features for FaceDetection Using OpenCV."
17. SCAD Institute of Technology andInstitute of Electrical and Electronics Engineers, ICISS-2019 : proceedings of the International Conference on Intelligent Sustainable Systems (ICISS 2019) : 21-22, February 2019.
18. N. Stekas and D. van den Heuvel, "Face recognition using local binary patterns histograms (LBPH) on an FPGA-based system on chip (SoC)," in Proceedings - 2016 IEEE 30th International Parallel and Distributed Processing Symposium, IPDPS 2016, Jul. 2016, pp. 300–304. doi: 10.1109/IPDPSW.2016.67.
19. D. Pissarenko, "Eigenface-based facial recognition," 2002.
20. RVS Technical Campus, IEEE ElectronDevices Society, and Institute ofElectrical and Electronics Engineers,Proceedings of the SecondInternational Conference on Electronics, Communication and Aerospace Technology (ICECA 2018) : 29-31, May 2018.
21. A. Albiol, D. Monzo, A. Martin, J. Sastre, and A. Albiol, "Face recognition using HOG-EBGM," Pattern Recognition Letters, vol. 29, no. 10, pp. 1537–1543, Jul. 2008, doi:10.1016/j.patrec.2008.03.017.
22. Surya Engineering College and Institute of Electrical and Electronics Engineers, Proceedings of the InternationalConference on Computing Methodologies and Communication : ICCMC 2017 : 18-19, July 2017.
23. X. Tan, S. Chen, Z. H. Zhou, and F. Zhang, "Face recognition from a single image per person: A survey," Pattern Recognition, vol. 39, no. 9, pp. 1725– 1745, Sep. 2006, doi: 10.1016/j.patcog.2006.03.013.
24. X. Zhang and Y. Gao, "Face recognition across pose: A review," PatternRecognition, vol. 42, no. 11, pp. 2876–2896, Nov. 2009, doi: 10.1016/j.patcog.2009.04.017.
25. Z. Mahmood, N. Muhammad, N. Bibi, and T. Ali, "A review on state-of-theart face recognition approaches," Fractals, vol. 25, no. 2. World Scientific Publishing Co. Pte Ltd, Apr. 01, 2017. doi: 10.1142/S0218348X17500256.

 