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A Survey of Face Recognition Systems

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Abstract

With the quick grow of multimedia contents, from among this content, face recognition has got a lot of significant, specifically in latest little years. The face as object formed of various recognition characteristics for detect; so, it is still the most challenge research domain for researchers in area of image processing and computer vision. In this survey article, tried to solve the most demanding facial features like illuminations, aging, pose variation, partial occlusion and facial expression. Therefore, it indispensable factors in the system of facial recognition when performed on facial pictures. This paper study the most advanced facial detection techniques too, approaches: Hidden Markov Models, Principal Component Analysis (PCA), Elastic Cluster Plot Matching, Support Vector Machines (SVM), Gabor Waves, Artificial Neural Networks (ANN), Eigen Face, Independent Component Analysis (ICA) and 3D Morphable Model. Additionally to the above works, mentioned various testing facial databases including JAFEE, FEI, Yale, LFW, AT&T(formerly termed as ORL) and AR (Aleix Martinez and Robert Benavente) etc to analyze the results. Even so, the goal of this survey is to present a comprehensive literature review for the face recognition besides its applications after a deepness discussion, some of the experimental results was introduced in the end.

Keywords Face Recognition, Aging, Illuminations, Pose Variation, Partial Occlusion

1.Introduction

The twenty one century is considered a recently and scientific era in which great strides have been made acceleration people in the finishing of their missions. In supporting to the above statement, at the present time the using of computer technology has being an essential part that cannot parted from the life. The computers are utilizing in pyramids of the applications that ranging from the simple to the complicated problem-solving ways. From between these contributions, the face recognition technological has appeared as a beneficial tool for recognizing features of the faces based on their inherent features. And it was one from the most researched fields in domain of computer vision and pattern recognition. Even so, because of it's widen use in a many applications for example biometrics, surveillance system, police access control, information security and smart cards. But there is several challenges to

the researcher that need be solved. Such as partial occlusion, aging, pose variance, illuminations, and facial expression. Face recognition issue can be classified into two major stages: 1. face verification and 2. face identification. In first stage, specifies a face in a picture. and in second stage, features are extracted from the facial in the picture in order to distinguish. Then they are compared with the pictures in the face database for recognizing the correct face picture. Even so, some present recognition ways for the authentication suffer from a shortage of reliability. For example, wallets, smart cards, tokens and keys use passwords and PINs that are so hard to recall. In addition, these codes and passwords can be easily forget; those magnetic cards also can be lost, stolen or reproduced. As a consequence, this make them illegible. Unlike the biological traits and characteristics of a person, they not possible to be misplaced, loss, or forgotten [1]. The system of biometric recognition can be constructed by different techniques. Even so, the most common ways used are the iris and fingertips. These require the participation of the person in order to accessing the system. Furthermore, the newest systems provide participants with access without their intervention. Among these ways, face recognition are one of most practicable technologies that can easily detect and surveillance a person over the system. The face recognition databases ranging from controllable pictures to non-controllable videos, like using (YouTube Faces) YTF [2] for videos and (Labeled Faces in the Wild) LFW [3] for pictures.

2. Databases

Many databases with faces public nor private for research purposes are available. These databases are differentiated from one another according to various criteria. The most important are on the following:

- The number of photos contained in every database is the most crucial standard.
- The number of photos for every unique class: knowing that each person is characterized by a class c, the number of pictures in a class stand for the number of representative pictures of the person. In fact, the pictures are taken under various conditions (aging, facial expression ...etc.).
- The existence of occlusion (beards, glasses, etc.).
- Gender of the obtained persons.
- The volume of the pictures.
- The existence of static pictures or videos.
- The time among recordings.
- Face alignments and pose.
- The changing in lighting.
- The existence of a unified background.

So, recommended to choice the suitable database while the testing of the algorithm. In fact, some having well defined protocol permitting directly comparison of results. Furthermore, the choose should depends on the issue to be tested: aging, facial expressions, illumination, etcetera. The availability of several different pictures for every person can be critical argument to the correct performance to the algorithm. **Table 1.** show the major 2D faces databases. Those databases progress several differentiations in terms of : gray or RGB picture, number of pictures by person, number of people, differentiations of the picture [occlusions (o), Aging (a), pose (p), facial expression (e) and illumination (i)].

Table 1. The Main 2D Face Databases (The picture differences are represent through (e) facial expression, (p) pose, (a) aging, (i) illumination and (o) occlusion)

Database	RGB Color/grey	Number of Pictures/Persons	No. of Persons	Pictures Size	Variation
Yale [4]	Gray	165	15 (14 men and 1 woman)	320 × 243	i,e
AT&T [5]	Gray	10 (pictures per person)	40	92 × 112	i,a
XM2VTS [6]	RGB	2360	295	576 × 720	p
AR database [7]	RGB	4,000	126 (56 women and 70 men)	576 × 768	o,e,i,a
CVL [8]	RGB	7 (pictures per person)	114 (6 women and 108 men)	640 × 480	e,p
Oulu Physics [9]	RGB	16 for every person (and additional 16 if have glasses)	125	428x569	i
JAFEE [10]	Gray	213	10	256 × 256	e
FEI database[11]	RGB	2800	200	640x480	p,e,i
LFW [3]	RGB	13,233	5749	250 x 250	P,i,e,o,a

3. Structure of Face Recognition System

Three main phases are utilized for develop a strong face recognition system: 1) Face Detection 2) Feature Extraction 3) Face Recognition [12,13]. The face detection phase is utilized for detecting and locating the person face picture got by the system. And the feature extraction phase is used for extract feature vectors to whatever person face detected in first phase. lastly, the face recognition phase comprises features extracted from a person face so in order to compared against all model face databases to determine identity of the person face. The structure of face recognition are illustrated in the **Figure 1.**

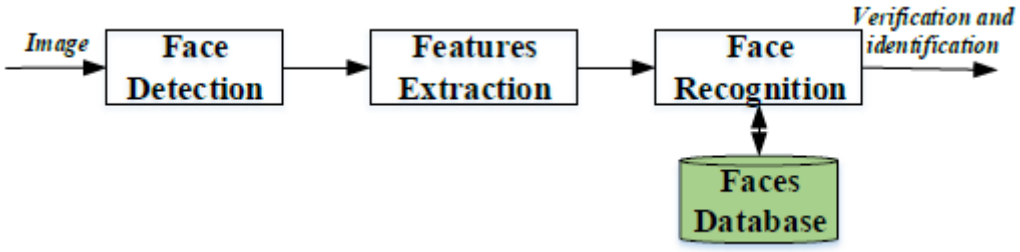

Figure 1. Face Recognition Structure [14]

3.1. Face Detection

A face recognition system first starts with localizing human faces in a specific picture. As illustrative in the **Figure 2.** The purpose from this phase is to determination whether the input picture contains person faces or not. Changes in facial expressions, illumination and ...etc. can block correct facial recognition. To simplify the development of face recognition system and makes it further strong, preprocessing steps are executed. Numerous techniques are used for detect & locate the picture of a person face, for instance the Histogram Oriented Gradient (HOG) [15,16], Viola-Jones Detector [17] and Principal Component Analysis (PCA) [18]. as well , the face detection phase can be used to object detection [19], region of interest detection [20], picture and video classification and etc.

Figure 2. Example of the Face Detection [21]

3.2. Extraction of Features

The major function of this phase is for extract features of facial picture detected at the detection phase. As illustrative in the **Figure 3.** This phase represent a facial with group of vector features named "signature", which describes the eminent features of the picture of the face, like: eyes, mouth and nose with their geometric distribution [22,14]. Every face is characterized via its own size, shape and structure, that allowing to identify it. many techniques include extracting shape of the nose, mouth or eyes for identifying the face by using distance and size [12]. for instance: Local Binary Pattern (LBP) [12], Fourier Transforms [22], Local Phase Quantization (LPQ) [23], Scale-Invariant Feature Transform (SIFT) [13], Linear Discriminant Analysis (LDA) [24], Eigenface [25], and Histogram Oriented Gradient (HOG) [15] are wide used for extract facial features.

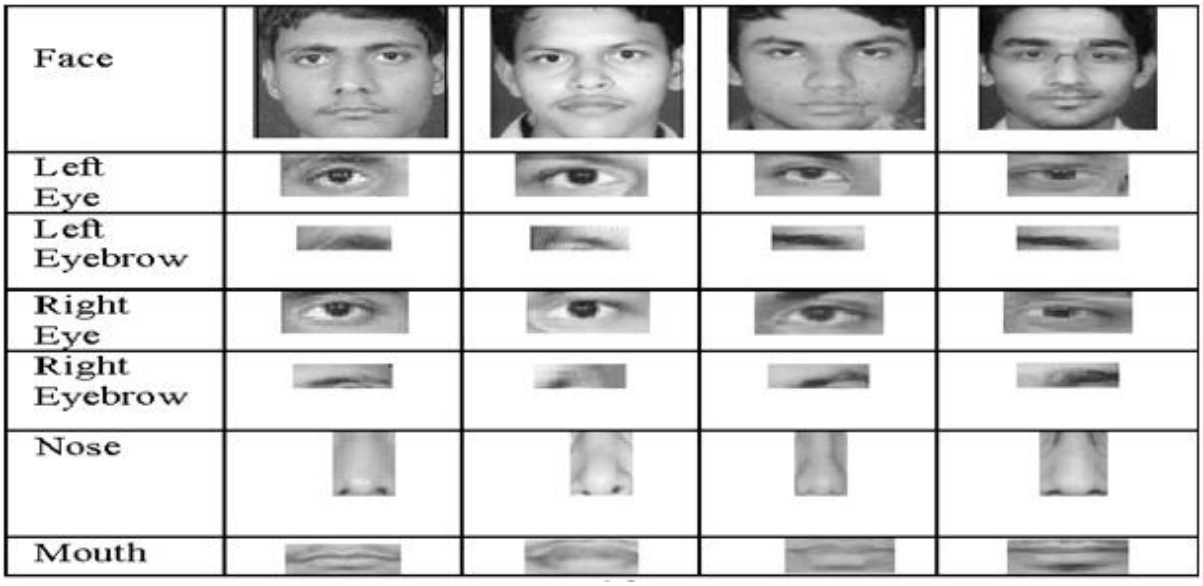

Figure 3. Face Component

3.3. Face Recognition

This phase considers the extracted features from background while the feature extraction phase and compares them to known faces saved in a specified database. Generally there are two steps to the face recognition, the first termed identification and the second is verification. At identification step, the test facial are compared with the faces set, for find the most similarly match. At verification step, the test face are compare with a known facial in the database for make a decision on rejection or acceptance [26]. k-nearest neighbor (K-NN) [27], convolutional neural network (CNN) [28] and Correlation filters (CF) [29] are known for treating effectively this task. The face recognition phase illustrated in the **Figure 4**.

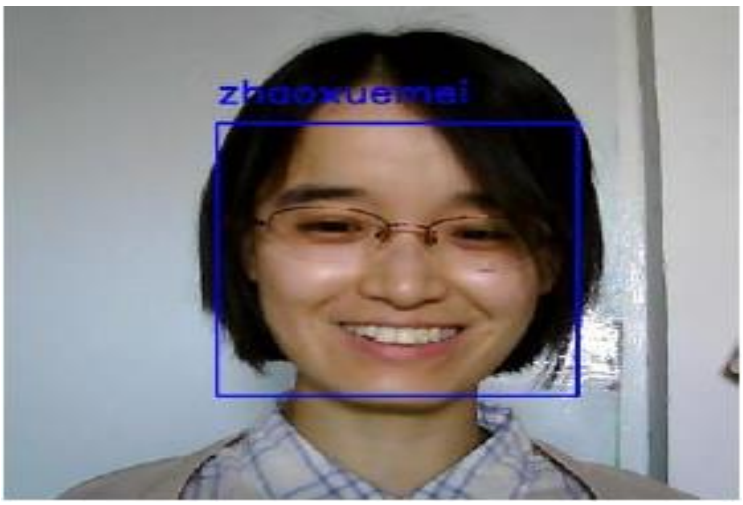

Figure 4. Illustrate the Face Recognition [30]

4. Models of Face Recognition

There are three various methods that are utilized in face recognition applications: 2D, 3D and video. Will review the face recognition issues in these fields in the next departments.

4.1. Face Recognition in 2D

Face recognition have been good studied with 2D still pictures for more than decade [31]. In facial recognition systems based 2D fixed picture, a capture of a user is captured and compared to a database of captures to identify a person. In this method, the user is predicted to cooperating and present a front facial picture with a simple background under uniform lighting conditions to enable high quality capture and segmentation of facial picture. Even so, it is now known that little deffrences in illumination and pose can dramatically decrease the performance of facial recognition systems based on a 2D single-shot image [32]. 2D face recognition is generally classified according into the number of pictures used for identical, as explained in **Table 2.**

Table 2. Face Recognition Scenarios in 2D Domain

Probe	**Gallery**	
	Single still picture	Many still pictures
Single still picture	one-to-one	one-to-many
Many still pictures	many-to-one	many-to-many

And some of the known algorithms for 2D face recognition are depend on Linear Discriminant Analysis (LDA) [33], Correlation-Based Matching [34], the Elastic Graph Model (EGBM) [35] and Principle Component Analysis (PCA) [36].

4.2. Face Recognition in 3D

3D face recognition ways use the geometry of the facial surface [37]. as opposed to 2D face recognition, 3D face recognition is strong against differences in illumination and posture due to the immutability of the 3D shape in relation to these differences. The 3D facial picture captured by the 3D sensor spans approximately 120 ± from right to left. This picture is called 2.5D. A full 3D model covering 360 ± face faces is created by combining multiple (3 to 5) 2.5D scans. Usually the probe is a 2.5D picture, and the database can be a 2.5D picture or a 3D picture. Identification can executed among two range (depth) pictures [37] or among a 2D picture and a 3D face model [38]. **Table 3.** expands **Table 2.** to include 2D and 3D face mod-

els.

Table 3. Face Recognition Scenarios across 2D and 3D Domain

Probe	Gallery	
	2D Pictures	3D Models or 2.5D Pictures
2D Pictures 2.5 Pictures	2D to 2D 3D to 2D	2D to 3D 3D to 3D

There are also many approaches are based on 3D models that has been reconstructed from a set of 2D pictures [39]. The reconstructed 3D model is used to get several 2D projection pictures corresponding to the probe pictures [38]. Alternatively, the reconstructed 3D model can be used to create a front view of the probe picture in any pose and lighting conditions. Recognition done by identical the synthesized probe in ahead pose. In **Figure 5.** shows a 3D model of a face and its correspondent 2D projection pictures in various positions and lighting conditions [21].

Figure 5. A 3D face Model and its 2D Projections [21]

4.3. Face Recognition in Video

Although traditional face recognition systems are depend on still pictures, there is considerable interesting in developing strong face recognition systems that take video as input. Face recognition video has generated interest because of wide prevalence use of monitoring cameras. The capability to automatically identify faces in the real time from the video will facilitate it, between other things, a secret way of identifying people using an existent network of monitoring cameras. However, facial pictures in videos are frequently in off-frontal poses and can be subject to significant changes in lighting, which lead decay the performance of majority commercial face recognition systems. Two characteristic features of video are the provideablity of: i) multi frames for the same topic and ii) time information. Multi frames granteed pose variation that allow the suitable choose of a well quality frame (for instance, an excellent quality face picture in semi front pose) for excellent recognition performance. The temporal info in the video is considered information included in the dynamic movement of the face in the video. However, it is hard to establish if there is any information regarded to identity in the movement of the face - Further work is require to gain benefit the temporal information. Using video capabilities can improve the performance of the face recognition system. **Figure 6.** shows 4 frames in an ideal video that was recorded for face recognition research [21].

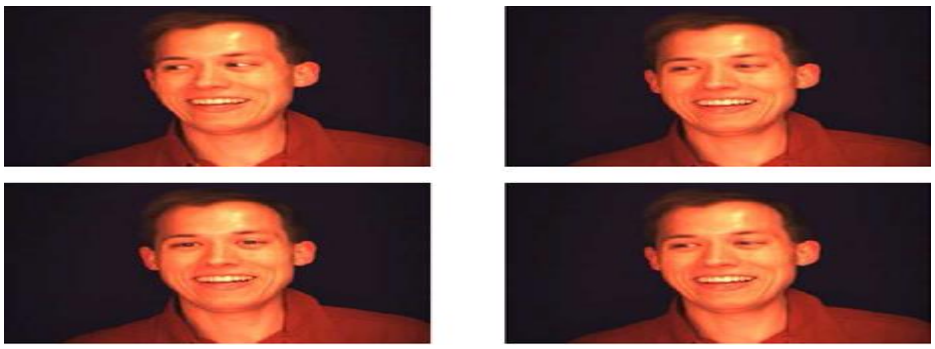

Figure 6. Four Frames from a Video [21]

5. Challenges and Difficulties

In spite of the evolution of numerous facial recognition algorithms, there are still many difficulties. These challenges are still challenging these algorithms, as described below [40]:

5.1. Several databases of facial pictures, such as references. Have been grouped to test faces recognition algorithms. Every database is designed for test determined aspects like occlusion, pose, facial expression and illumination. Prior research work has shown that face recognition has matured under controlled conditions. Even so, facial recognition in an outdoor environment becomes challenging.

5.2. Face recognition is special and difficult state from object recognition. The difficulty of facial recognition stems from the reality that in the front view, the facial pictures look the same, and the differences between it are significant to be analyzed. A research conducted the latest face recognition technologies, on the standard database (like FAT, FERET, and FRVT) have identified detecting illumination, age and pose as the main issues of the facial recognition algorithm.

5.3. The algorithms of face recognition are selected as desired by the application. For instance, feature-based methods not possible be applied to low-resolution (for instance, 15×15 pixels and below) facial pictures. Other issue is: where to use (LDA) and when to use (PCA/ICA) when developing the system.

5.4. Implementation details usually specify the performance of the system. For instance, several times input pictures are normalized with regard to in plane rotation, masking, affine warping and scale for align the shape.

5.5. Low resolution is an significant factor in face recognition when taking pictures from a far distance. In addition, closing the eyes too affects the recognition exactness of most facial recognition systems because they normalize & rescale the pictures before recognition.

5.6. When the face occluded, the recognition rate drops rapidly. Likewise, structural components like mustaches, glasses and beards too significantly impact the recognition rate.

5.7. For good recognition performance, accurate feature location is critical. As the face rotates to a specific angle, the facial features will change, and several face recognition algorithms have difficulty processing them. Age, illumination and pose are the main issues that current facial recognition algorithms plaguing.

6. Factors Affecting of Face Recognition

Identifying human faces from pictures and videos is a very difficult problem. There are many ways to solve this problem, but none can perform it with 100% accuracy because of the many problems that this system faces. These factors fall into 2 categories: internal and external factors [41]. Internal factors include, for example, the physically condition of the person's face are facial expressions, aging, etc. that affect the system, while external factors are factors that cause changes in the appearance of the face, for instance illumination state causing variation.

6.1. Aging

Aging is one of the substantial factors that affect face recognition techniques where it convert into clutter for algorithms. Stability is a basic quality to any biologic measurement to be deal

with it as a biometrics. The face is mixture of skin tissue, bones and face muscles. When muscles contracting, they cause deformation of the facial features. Even so, aging causes very much changes in the face appearance of a person such as illustrative in the **Figure 7.** e.g. face texture (wrinkles, ...etc.) and the face shape over time [42]. Face recognition systems must adequately meet this requirement. Several researches whose primary goal is to solve this problem have been conducted [43]. Due to slow aging process, it is becoming hard to gather data to training the system for cope with the aging factor to recognition purposes [44]. So, age-related researches is gained great popularity.

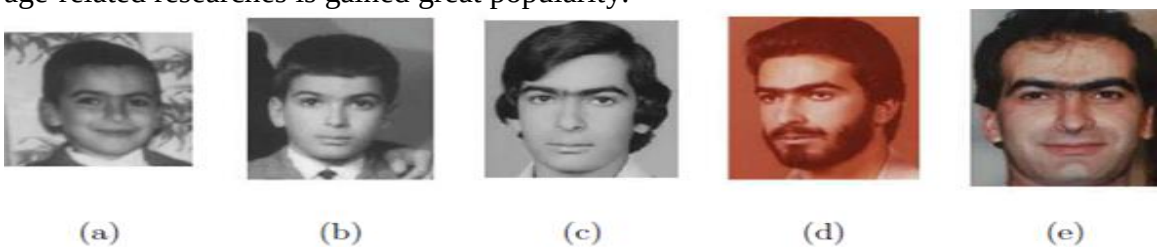

Figure 7. Pictures of the Same Subject at Age (a) 5, (b) 10, (c) 16, (d) 19 and (e) 29 [21]

6.2. Facial Expression

Facial expression is a non-verbal form of communication as it transports messages by use the expressions. Even so, dissimilarity in facial expression create ambiguity for the face recognition systems. Several face recognition systems are evolved that work good with pictures in a controllable environment. Various face expressions show various situations and moods of people and change facial geometry such as illustrative in the **Figure 8.** and with small different in the picture, it is becomes hard for the system to identify the face. Researchers had worked on face recognition with take a consideration of face expressions [45]. There are various approaches that can used for handle with this problem, such as muscle-base approaches, motion-based approaches, model-base approaches [46].

Figure 8. Examples of some Facial Expressions from a Daily Life

6.3. Pose Variation

Another obstacle to the success of a facial recognition system is the variance of pose. People pose are different every time they capture a picture, such as illustrative in the **Figure 9.** There is no similar standard pose. Therefore, this makes it hard to recognize and the distinguish faces in pictures with different poses. Most systems operate under not flexible picturing conditions. In depend on the type of pictures used in the gallery, ways associated with changing the pose can be partitioned into two types: facial recognition by pose and multi view face recognition. Multi view face recognition can be thought of as a front-face recognition annexure in which consider gallery picture of each pose. On other hand, through the pose of facial recognition, consider the face in a situation that the recognition system has not seen before. A good faces recognition approach must have good pose toleration and ability to recognize various poses. Many problems in this regard remain open. In which several researchers are working to address this problem [47]. Even so, there is not yet a system with 100% accuracy. There are

some various approaches and methods that can be used for solve the issue of variable face recognition and pose change, which are partitioned into three categories, involving 2D approaches, general algorithms and 3D models [48].

Figure 9. Examples of some Pose Variations from FERET Database

6.4. Partial Occlusion

Occlusion indicates to artificial or natural obstacles in the picture. The face recognition approaches with partial occlusion classified into various classes, involving Fractal-Based Methods, Feature-based methods and Part-Based Methods [49]. Partial occlusion has affected many picturing areas, like ear identification is occluded because earrings. Occlusion have an affect on the system performance when people mislead it by using scarves, sunglasses, veil, or putting mobile hands or phones in front of their faces such as illustrative in the **Figure 10** and **Figure 11.** Sometimes another factors, such as shadows because of strong illumination, too act as occluded factors. To solve the issue of partially occluded faces. Analytical approaches are used which split the faces into various parts [50]. This issue can be solved by removing some of features that make it difficult to exactness recognize the face in the picture. Frequently, analytical approaches are depend on feature analysis, where best enabled features are discovered, and then they are merged. Other approach that can be taken to this purpose is an almost holistic approach in which the occluded features are removed and the remaining of the face as valuable information is used. Researchers are developing various techniques to deal with this issue [51,52].

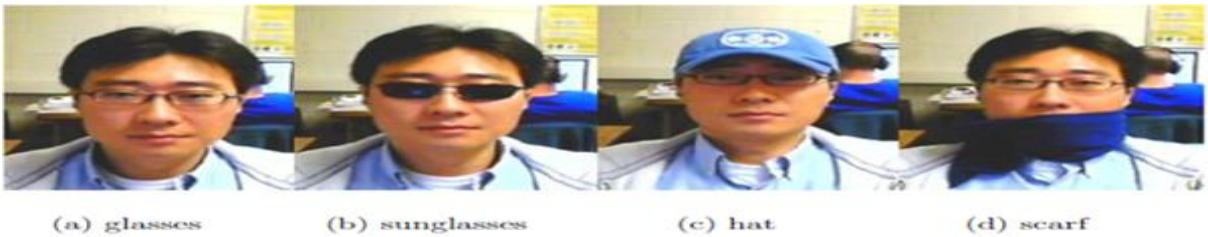

Figure 10. Example of the Partial Occlusion [21]

Figure 11. Faces with Occlusion Effect as Presented in Hand2Face [53]

6.5. Effect of Illumination

Variation in Illumination strongly affect the facial recognition system such as illustrative in

the **Figure 12.** and therefore has become the focus of several researchers. It become hard to recognize one or further person from still pictures or video. It is very easy for extract the desired information from pictures taken under controlled environment in which the background is uniform. Even so, the face in uncontrolled environment need to be recognize from different backgrounds. It include variation because shadows, under exposure and over exposure. Researchers have worked hard to solve this problem. There are three ways to treat with this problem: Face reflection field estimation technique, Gray level, and Gradient. The gray level conversion technique executes in-depth mapping with linear or non-linear function. Extraction approaches of the gradient are used for extract the edges of picture in gray level. Since illumination is a factor that considerably affecting of the faces recognition from videos or pictures, the techniques have been development to ignore the impact resulted by this problem [54].

Figure 12. Example of some Illumination Variation from Yale Database b [55]

7. Advantages of Face Recognition

1. High Success Rate

Today's facial biometric technology has a high success rate, particularly with the appear of 3D facial recognition technology. It is very difficult to cheat the system, so you can rest assured that system you have will successfully track attendance and time with offering better security.

2. Easy Integration

Also easy to integrate your biometric facial systems into your company. Usually will work with the exist software you having.

3. Automatic System

Many companies like the fact that biometric face recognition systems are automated. You not need to worry to having someone there for surveillance the system.

4. Better Security

With a facial biometrics system you'll sweet better security. Not just can you trace employees, but can be added into the system any visitant and traced throughout the area also. will not be given access to anyone that is not in the system.

5. Time Fraud not Exist

One of the great advantages of using face biometrics systems to your association is that don't need to worry for time fraud. It will not be possible to proxy between friends, as everyone needs a face scan to register its attendance. [56]

8. Result

In this section, present a detailed comparison of various experimental results, in the **Table 4.** that showed Difference in Databases, Techniques, Years, Authors, and Results that got it.

Table 4. The Experimental Results

No.	Author/s	Year	Technique	Database	Result
1	Vankayalapati et al. [57]	2009	CNN	ORL	95%
2	K ong, Rui et al. [58]	2011	ICA, SVM	ORL	96%
3	Bellakhdhar et al. [59]	2013	Magnitude Phase of Gabor, PCA, SVM	ORL, FRGCv2	99.90%
4	Jameel, S. [60]	2015	PCA + DCT	ORL	95.122%
5	Fathima et al. [61]	2015	Gabor wavelet and linear discriminant analysis (LDA)	AT&T, MIT-India and Faces94 da-tasets	88–94.02%
6	Ghorbel et al. [62]	2016	Eigenfaces and DoG filter	FERET	84.26%
7	Bhaskar, A. et al [63]	2016	SVM	Yale Faces	97.78%
8	Fu et al. [64]	2017	Guided convolutional neural network, the loss function	CASIAWebface, LFW	91.9–97.1%
9	Khan et al. [65]	2018	PCA	NCR-IIT facial database and real-time video stream	69–86%
10	Banerjee et al. [66]	2018	Supervised learning, Viola–Jones, generic 3D model	PaSC videos and CW images, CMU multi-PIE dataset	88.45–97.28%

10. Applications of Face Recognition

As know efforts are continuously being made for develop the face recognition system to max-imum accuracy, this is due to its relevance in several domains. It uses some of it's applications in:

10.1. Law Enforce

The face recognition systems proven that it is a very efficacious tool for the law enforce bod-ies for finding to missing persons or identify criminals. The investigation manually for hours in the video for person identification is a rather tedious mission for law enforce administra-tors. For instance, It was newly reported [67] that it took Chinese law enforce administrators only 7 minutes for determine BBC newsman "John Sudworth" utilizing its strong CCTV cam-eras network of further more over 170 million camera and the face recognition technique. Fa-cial recognition research fetch a novel generation of smart and efficient investigation abilities to law enforce bodies [68]. Overstaying and unlawful citizenship is another difficult issue for populous communities around world. Advances in facial recognition technology have made it possible to identify and capture the illegal immigrants and foreigners who have exceeded their length of stay. In addition, facial recognition technology is too used for immigration. [69], counter terrorism [70], crime investigation [71, 72], voter identification [73] and banking [74].

10.2. Entertainment

The face recognition has been noticed that is growing popularity in the entertainment field also. The most exciting domains are theme park gaming zones, training, human computer in-teraction, human robot interaction, mobile games and virtual reality [75] etc. Moreover, T. Feltwell et al. presented recently an interest game in which ask the gamers to snap the similar-ities of the audience. It is from motivated of free for play models like the celebrated Pokemon GO game, yet they suggested a variant experience were players can practically hunt and cap-ture the members in realty world [76].

10.3. Surveillance

Surveillance System is one from the most significant and challenge missions for fully automatic and smart monitoring systems, the surveillance are defined as monitoring or close observation, especially for a criminal spy or suspect. This is one of the mostly significant and widely popularity applications. Those systems are generated to meet the security goals of both the outdoor and indoor general audience like: geographic boundaries, banks, airport halls, monitoring public regions etc. Because of the huge data size have been obtained by camera networks, so detection algorithms of brute force spy are non adequate for smartly recognize terrorists and suspects in sensitive regions. Latest research in facial recognition provide a platform for smart video monitoring systems including software and hardware aspects, like machine learning algorithms, signal processing, pattern recognition and automatic interfaces for achieve extremely optimistic results [77]. In addition, the ability of machine techniques for recognition have been shown to be further efficiency than humans in applications of the real world. For make the beneficial of the abilities of machines and humans, the solutions of face recognition in monitoring systems can be efficaciously utilized as tool for supporting human employees in performing recognition tasks and complex monitoring. In spite of, the latest ways for the monitoring systems has been achieved acceptable results, there are remain much challenges for the effective surveillance like: limited training data, Occlusion and blur subject pictures [78,71].

10.4. Access Controlling

With growing the vogue of the face recognition systems, they had been adopted by many auto access controlling mechanisms to the human-machine interact. As too been replaced with another authentication controlling ways like iris verification, password protection, fingerprints, etc. Moreover, CCTV cameras and smart phones widespread, and the use of face authentication has become possible for several real world applications. The hardware based validation systems are quick expanding for control the facial based authorization for the single login into the network multi services. Thus, facial based automatic access for automatic teller machine, access to the cipher text and online money transfers are also becoming popular in various social practices [79].

10.5. Face Authentication in Mobile

The Authentication of the face is become further popularity on the mobiles, permitting mobile applications for validate user's identity in order to give access sensitive mobile phone services like e-banking. Various aspects of face recognition, involving deployment constraints and presentation attacks, must investigated, especially in mobile environments [80,81].

10.6. Another Common Applications

Kwon and Lee [82] recently, presented a inclusive group of face recognition technologies in the software applications. Likewise, Salici and Ciampini [83] introduce facial recognition applications for the forensic investigation section. Identification experiences in 130 real-life status are proven were successful and confirmed through forensic experts. Other modern application is presented by Calo et al. [84] to control privacy in the view, update and destruction of digital information.

10.7 Face Recognition in Smart Cities

According for (2018) Market Researching Report [85], the biometrics market are expected to growth from $ 13.89 billion in (2018) to $ 41.80 billion in (2023), where face recognition have significant growth potential through that interval. The facial recognition market will have tremendous potential in emergent application domains regarded to the identification of persons in the smart cities, including smart homes, smart education and notably electronic administration, from between many others [85]. Along with technical challenges, the utilize

of publicly available facial recognition systems may create ethical dilemmas and challenges associated with question of how the snapped data, as especial class of privacy data, perhaps utilized and manipulated. Those concerns are increasingly recognized via data protection regulations like the (EU General Data Protection Regulation (GDPR)) [86], which aims to protect people from third parties processing their information without their approvement. Thus, there is an urgent need for protect biometric data through the adoption of new laws regulating the use of facial recognition techniques [87].

11. Conclusion

For many years, the research of face recognition stay a striving field for researchers. It has attracted widespread attention because of its many applications in several practical world domains, such as computer graphics, pattern recognition, security and computer vision. In this survey, we first time presented face recognition as biometrical technology. Next, we introduced the face recognition models categorized to three part; we introduced a faces databases use by the researchers in this domain for test their facial recognition approaches and stages, and lastly a table (**Table 4.**) that summarize the experimental results. This paper has introduced a comprehensive survey over the eminent researches of face recognition in different backgrounds. The goal of those literature review for help youth researchers in the domain of facial recognition via compiling the important methods, techniques and models, and to stimulate there to further research.

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