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Facial Recognition: Issues, Techniques and Applications

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Abstract - A facial recognition system is an approach for automatically identifying or verifying a person from a still digital image or a video frame of a video source. The basic fundamental principle in the science of facial biometrics is that the dimensions, proportions and physical attributes of a person's face are unique. Face recognition has recently received significant attention, especially during the past several years. It has become more obvious due to the availability of feasible technologies and a requirement in wide range of law and commercial implementation areas. An accurate automatic personal identification is critical in a wide range of application domains such as image processing, pattern recognition, neural networks, computer vision, computer graphics, and psychology with specific cases in national ID card, electronic commerce, and access to restricted areas like banks, embassies, military sites, airports and law enforcement premises. The advantage of face recognition is that it does not require physical contact with an image capture device and does not either require any advanced hardware. Facial recognition is thus considered as a serious alternative in the development of biometric or multi-biometric systems. Biometric facial recognition systems measure and analyze the overall structure, shape and proportions of the face to create a unique template for comparison with the database of facial images; used for verification and identification. The image captured is compared with the template previously recorded. Even after attaining a certain level of maturity, their success is limited by practical conditions imposed by real applications like in an outdoor environment with changes in illumination and other scenarios. This paper provides a survey of still based face recognition research offering some insights into the studies of machine recognition of faces, potentially applicable to the design of face recognition systems.

Keywords: Biometric, Facial Biometrics, Facial Recognition, Image processing, Pattern Recognition.

I. INTRODUCTION

Face recognition has received significant attention, during the past several years. Data, availability of realistic technologies and wide application areas ranging from law to commercial implementation, have further emphasized the need for face recognition. It has become a critical aspect in various domains. Psychology, neuroscience, neural networks, image processing, pattern recognition, computer vision, computer graphics, are a few areas with extensive attention. Human beings always had the innate ability to be familiar with and distinguish between faces, yet computers only of late have shown the same ability. In the mid 1950s, scientists worked on computer machine to identify human faces. Since, facial recognition has come a long way. Facial recognition technique is primarily based on the ability to recognize a face and measure its features with numerous, distinguishable landmarks, peaks and valleys, the nodal points. Facial recognition systems take a facial image; the algorithms measure nodal points creating a numerical code representing the face in the database. Each human face has approximately 80 nodal points or characteristics such as the distance between the eyes, the length and width of the nose, the angle of the jaw, depth of the eye socket or the shape of the cheekbones.

Fig.1 Human Face Nodal Points

It is a biometric technology used as a method of identification for years. The least obtrusive and objectionable method of biometric identification is based on the images of a human face. Biometrics is the study of distinguishable physical, biological or behavioral characteristics used for the identification of humans and animals. Human brain uses to recognize and distinguish one person from another based on Physical characteristics– fingerprints, hand geometry, iris or retina patterns, facial features, etc. and Behavioral traits – signature, voice, speech patterns, etc. Recognition occurs when an individual's image is matched with the group of stored images. The brain does this relatively quick and efficiently, where

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as for computers recognize a living image matching the stored image is time consuming and costly. These systems extract features from face images and perform face matching using these features**.** Good biometric software then produces a number of potential matches, rating each based on a numeric score of how similar the match is. When multiple images are used, the accuracy of biometric readings increases greatly, a fact which has provoked the assembly of massive databases, particularly on key figures such as terrorists.

A. All biometric technology systems operate using the following four-stage procedures:-

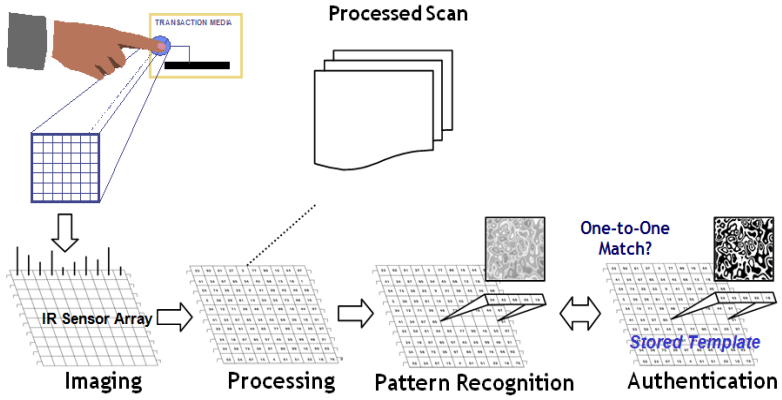

Fig.2 Generic Face Recognition

1) *Capture*: a physical or behavioral sample is captured during enrollment.
2) *Extraction:* unique data is extracted from the sample and a template is created
3) *Comparison:* the template is compared to new sample
4) *Match/Non-Match:* system then decides if the features extracted match or not.

The earliest work on face recognition can be traced back to 1950s in psychology [1] and in engineering literature [2]. Work on facial expression of emotions was reported by Darwin [3], Ekman [4] and on facial profile-based biometrics by Galton [5]. Research on automatic machine recognition of faces was given in the 1970s [6] and after the seminal work of Kanade ([7]-[10]) have performed local feature analysis. Many of the hypotheses and theories put forward by researchers in these disciplines have been based on small sets of data images. Among appearance-based holistic approaches, eigenfaces ([11],[12]) and Fisher faces ([13]-[15]) have performed experiments with large databases, considerably effective. Feature-based graph matching approaches [16] have also been rather successful. In 1995, a review paper [17] gave a thorough survey of FRT and another survey by [18] appeared in 1992. At that time, video-based face recognition was still in a nascent stage.

II. ISSUES RELEVANT TO FACE RECOGNITION

Human recognition processes exploit a broad spectrum of stimuli. Contextual knowledge is applied, in recognizing faces in relation to where they are made-up to be located. In many applications the only images with single or multiple views of 2D intensity data are available, to obtain visual inputs for computer face recognition algorithms. Various studies in psychology and neuroscience have direct implication to engineers involved in designing algorithms or systems for machine recognition of faces. Findings in psychology [19],[20] about the relative significance of diverse facial features have been eminent in the engineering literature [21]. On the other hand, machine systems provide tools for conducting studies in psychology and neuroscience [22],[23]. A detailed review of pertinent studies is beyond the scope of this paper. We only summarize answers that are potentially applicable to the design of face recognition systems.

A. Significance of facial features:

[19],[20] Hair, mouth, nose, face outline, eyes are resolute to be important for perceiving and identification faces [20]. Several studies have shown nose plays an insignificant role as these studies have been done using frontal images with few profiles extracted from side views, a distinctive nose shape could be more important than the eyes or mouth [19].

B. Effect of lighting change:

[19],[24],[25],[26]: It is observed that photographic negatives of faces are difficult to recognize. Relatively little work has explored this difficulty. In [26], experiments were conducted to explore whether difficulties with negative images and direction of lighting, rendering a top-lit image of a face apparently lit from below. It was confirmed in [26] that bottom lighting does indeed make it harder to identity familiar faces. In [25], the importance of top lighting for face recognition was established using a different task: matching surface images of faces.

C. Facial expressions:

[19]: Based on neurophysiological studies, analysis of facial expressions is accomplished in parallel to face recognition. Some patients, with difficulties in identifying familiar faces, nevertheless seem to recognize expressions due to emotions organic brain syndrome patients suffer from poor expression analysis but perform face recognition quite well.

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III. FACE RECOGNITION ALGORITHMS CAN BE DIVIDED INTO TWO MAIN APPROACHES

Geometric, which looks at distinguishing features or photometric and Statistical approach that distill an image into values and comparing the values with templates to eliminate variances. The geometric face recognition algorithms identify faces extracting features from a subject's face. Algorithm analyzes the relative position, size, shape of the features like eyes, nose, cheekbones, and jaw matching these features with other images. The alternate statistical approach use algorithms to normalize a gallery of face images and then compress the face data, only saving the useful data in the image for face detection. The image is then compared with the face data based on template matching techniques.

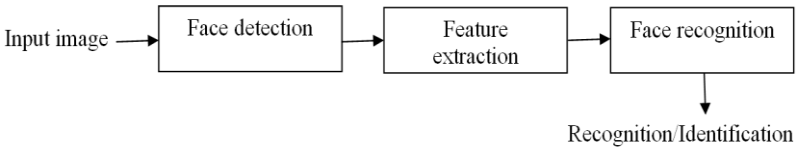

Fig.3 Generic Phases for Recognition

At enrolment, several pictures are taken of the user's face, with slightly different angles and facial expressions, to allow for more accurate matching. For verification and identification, the user either stands in front of the camera for a few seconds, or is tagged from a group or a picture. The features are extracted and measured. These are then represented in the format used for matching/comparison. The program creates a unique template for comparison with the database of facial images. To prevent a photo of the face or a mask from being used, face biometric systems will require the user to smile, blink, or nod their head. Facial Thermograph can be used to detect the heat patterns of blood vessels emitted from the skin using infrared camera. Even identical twins have different thermograms.

IV. TECHNIQUES IN RECORDING FACES

A. 2-Dimensional

The 2D image captured needed to be of a face that was looking directly at the camera; But if images are not taken in a controlled environment, even the smallest change in light or orientation reduces the effectiveness of the system, and couldn't be matched to any face in the database, leading to a high rate of failure.

B. 3-Dimentional

This technique uses 3-D sensors to capture facial information. This information is then used to identify distinctive features on the surface of a face, such as the contour of the eye sockets, nose, and chin. This is not affected by changes in lighting like other techniques. It can also identify a face from a range of viewing angles, including a profile view. But even a perfect 3D matching techniques could be sensitive to expressions.

C. Skin texture analysis

Uses the visual details of the skin, as captured in standard digital or scanned images. This technique turns the unique lines, patterns, and spots apparent in a person's skin into a mathematical space thus improving the performance in recognizing faces by 20 to 25 percent.

D. Software and Commercial products

Google's PICASA digital image organizer or Picasaweb.com has a built in face recognition system. It can associate faces with persons. Apple IPHOTO, photo organizer includes a system using which people can tag recognized people on photos. Sony's Picture Motion Browser (PMB) analyses photo, associates photos with identical faces so that they can be tagged accordingly, and differentiates between photos with one person, many persons and nobody.

Table 1 Commercial Products

Commercial Product	Website
FaceIt from Visionics	http://www.FaceIt.com
Viisage Technology	http://www.viisage.com
FaceVACS from Plettac	http://www.plettac-electronics.com
SpotIt for face composite	http://spotit.itc.it/SpotIt.html
ImageWare Sofware	http://www.iwsinc.com/
Cognitec Systems	http://www.cognitec-systems.de
Visionsphere Technologies	http://www.visionspheretech.com/menu.htm
Biometric Systems	http://www.biometrica.com/

V. APPLICATIONS AREAS OF FACIAL RECOGNITION TECHNOLOGY

Physical Access Control to provide access to building and restricted areas like banks, embassies, military sites, airports and law enforcement areas. Airports in United States and other nations are incorporating biometric face recognition systems, as there is high potential for terrorist targeting. Banks have begun test programs outfitting their auto-teller machines with biometric face recognition programs, to offer instant cashing of cheques. Time Attendance Reporting

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System to replace traditional paper based or ID card/PIN no. based time attendance system. Face Recognition Solutions may replace visitor management system consisting conventional pen-paper bases visitor entry system.

Table 2 Application Areas

Application Areas	Specific applications
Entertainment	Virtual reality, training programs, robot training and interaction, human-computer-association
Smart cards	*National ID card, electronic commerce, licenses , passports, voter cards, aadhar cards*
Information security	Parental control, personal device login, Application security, database security, file encryption Internet access, medical records, Secure trading terminals.
Surveillance and Law enforcement	*Access to restricted areas like banks, embassies, military sites, airports and law enforcement premises.* CCTV control and surveillance. Portal control, Shoplifting, suspect tracking and investigation

VI. DISCUSSIONS AND CONCLUSIONS

Among the different biometric techniques, facial recognition may not be the most reliable and efficient. However, one key advantage is that it does not require aid (or consent) from the test subject. Properly designed systems installed in airports, multiplexes, and other public places can identify individuals among the crowd. Other biometrics like fingerprints, iris scans, and speech recognition cannot perform this kind of mass identification. However, questions have been raised on the effectiveness of facial recognition software in cases of railway and airport security.

Limitations of face recognition is not perfect under certain conditions. Ralph Gross, a researcher at the Carnegie Mellon Robotics Institute, describes "Face recognition has been getting pretty good at full frontal faces and 20 degrees off, but as soon as you go towards profile, there've been problems." Face recognition does not work well include poor lighting, sunglasses, long hair, or other objects partially covering the subject's face, and low resolution images also is less effective if facial expressions like a big smile vary.

The increased need of privacy and security in our daily life has given birth to this new area of science. It is tempting to think of biometrics as being sci-fi futuristic technology that we shall all be using some time in the near future. Face Recognition is becoming more prominent in the non-criminal realm, Offers convenience as it is a more restrictive threat model than I-cards. A face does not have as many uniquely measurable features as fingerprints and eye irises, so facial recognition reliability is slightly lower than these other biometric recognition methods. However, it is still suitable for many applications, especially when taking into account its convenience for user. Facial recognition can also be used together with fingerprint recognition or another biometric method for developing more security-critical applications.

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