ANALYSIS OF FACIAL MARKS TO DISTINGUISH BETWEEN IDENTICAL TWINS USING NOVEL METHOD

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Abstract- Reliable and accurate verification of people is extremely important in a number of business transactions as well as access to privileged information. The biometrics-based methods assume that the physical characteristics of an individual (as captured by a sensor) used for verification are sufficiently unique to distinguish one person from another. But the increase in twin births has created a requirement for biometric systems to accurately determine the identity of a person who has an identical twin. Identical twins have the closest genetics-based relationship and, therefore, the maximum similarity between fingerprints is expected to be found among identical twins. They can't be discriminated based on DNA. As one of the most successful applications of image analysis and understanding, face recognition has recently received significant attention, especially during the past several years. Identical twin face recognition is a difficult task due to the existence of a high degree of correlation in overall facial appearance. In this paper, we study the usability of facial marks as biometric signatures to distinguish between identical twins. We propose a multi scale automatic facial mark detector based on a gradient-based operator known as the fast radial symmetry transform. The transform detects bright or dark regions with high radial symmetry at different scales. Next, the detections are tracked across scales to determine the prominence of facial marks. Extensive experiments are performed both on manually annotated and on automatically detected facial marks to evaluate the usefulness of facial marks as biometric signatures. The results of our analysis signify the usefulness of the distribution of facial marks as a biometric signature.

Index Terms- Biometrics, face, Identical twins, facial marks, face recognition

1. INTRODUCTION

The increase in twin births has created a requirement for biometric systems to accurately determine the identity of a person who has an identical twin. The ability to distinguish between identical twins based on different biometric modalities such as face, iris, fingerprint, etc., is a challenging and interesting problem in the biometric area. Fingerprint analysis and retinal or iris scans, these methods rely on the co-operation of the participants, whereas a personal identification system based on analysis of frontal or profile images of the face is often effective without the participant's cooperation or knowledge. There are two types of twins: monozygotic (or identical) and dizygotic (or non-identical). Monozygotic twins are a result of a single fertilized egg that splits into two cells, each one giving origin to one individual. Dizygotic twins are a result of two different fertilized eggs. Monozygotic twins have the same deoxyribonucleic acid (DNA) and, therefore, they cannot be distinguished using DNA. Thus, it is necessary to use other forms of identification for monozygotic twins. They cannot be discriminated based on DNA. Using face recognition to differentiate between identical twins (monozygotic twins) is very difficult because of the high degree of similarity in their overall facial appearance. In this paper we focus on distinguishing between monozygotic twins based on localized facial features known as facial marks.

Traditionally, biometrics research has focused primarily on developing robust characterizations and systems to deal with challenges posed by variations in acquisition conditions (such as pose, illumination condition, distance from sensor, etc.) and the presence of noise in the acquired data. Recognition using biometric traits is now a well-accepted and proven method. A biometric characteristic is a detectable biological or behavioural characteristic of an individual that is distinguishable and repeatable. Some examples include fingerprints, face, palm prints, iris, retina, and voice. A biometric system relies on the distinctiveness of the biometric characteristics to perform the recognition. While many biometric techniques are extremely accurate, some variations in sensing data, noise, etc. can cause the system performance to drop significantly. We could say it is more difficult to discriminate identical twins than unrelated persons because of their genetic similarity.

Although identical twins cannot be distinguished from each other using DNA, some of the biometric modalities, such as fingerprints, iris, and palm prints, can still be used to distinguish them. Some experiments show that face and voice can be used to distinguish identical twins. Due to the difficulty in obtaining a large biometric database of identical twins, most experiments are performed on small databases, making the conclusions less reliable. A fingerprint is the impression of the friction skin on a finger. The individual characteristics of friction ridge skin are determined during fetal development. Their formation is similar to the formation of blood vessels or capillaries during the growth of the fetus in the

uterus. The fingerprint formation starts at approximately 6 or 7 weeks of gestational age and it is due to the flow of amniotic fluids in a micro-environment [4]. A minor change in this flow and in the position of the fetus in the uterus cause the minute skin structures around palm or finger tips to differentiate. Friction ridge skin can be distinguished from the skin of the rest of the body due to a variety of factors, such as the presence of raised ridges, increased sensory abilities, absence of hair and sebaceous glands, and a thicker and more complex epidermis. Friction ridges are related to grasping and gripping, which explains their presence in our hands and feet. A fingerprint pattern has some details inherent to each individual, like ridge endings, the point where a ridge ends abruptly, or a ridge bifurcation or trifurcation, where the ridges are divided into different branches.

These details are called minutiae points and they are supposedly different in every fingerprint, even in prints of identical twins, because, as mentioned before, a very small difference in micro-environment is sufficient to change the process of cell formation, causing minutiae points to be different. As a result, fingerprint is considered very reliable in terms of biometric identification because of its distinctiveness. Another reason for this reliability is that fingerprints do not change significantly over time, an essential characteristic of a biometric modality since a biometric system is typically meant to be used to identify a person over a long period of time. A friction ridge pattern consists of three levels of detail, which are used for fingerprint matching: ridge flow and pattern (level 1 features), ridge path and minutiae (level 2 features), and dimensional, edge shape and pore details within a specific ridge (level 3 features). Ridge flow pattern falls into three general categories: whorls, in which the ridge flows form a complete circuit; loops, in which the ridge flow enters from one side of the fingerprint, curves and returns in the same direction from which it came; and arches, in which the ridge flow enters from one side and exits the opposite side. In the second level features, ridges vary in length, and can be dots, which are very short ridges containing just one pore, or they can cross the entire area of friction skin without being broken. An example of the third level feature is the sweat pores that are regularly spaced along the ridges and whose specific locations and shape can be used as distinctive features for identification. The iris is an annular shaped part of the eye between the pupil and the sclera that regulates the amount of light entering the eye through the pupil.

Fig. 1 shows a pair of identical twins from the dataset. Although they are similar in appearance, they can be distinguished using facial marks. High-resolution images enable us to capture these finer details on the face. Facial marks are defined as visible changes in the skin and they differ in texture, shape and colour from the surrounding skin. Facial marks appear at random positions of the face. By extracting different facial mark features we aim to differentiate between identical twins. We have defined fourteen types of facial marks including moles, freckles, freckle groups, darkened skin, lightened skin, etc., for the analysis.

Fig. 1 Example Twin

II. RELATED WORK

Traditionally, biometrics research has focused primarily on developing robust characterizations and systems to deal with challenges posed by variations in acquisition conditions (like pose, illumination condition, distance from sensor, etc.) and presence of noise in the acquired data. Only recently have researchers started to look at the challenges involved in dealing with the task of distinguishing between identical twins. Here we provide pointers to a few of the relevant investigations. Kong et al. observed that palm prints from identical twins have correlated features (though they were able to distinguish between them based on other non-genetic information). The same observation was made by Jain et al. for fingerprints also. They observed that though fingerprints appear to be more correlated for identical twins, fingerprint matching systems can be used to distinguish between them. Genetically identical irises were compared by Daugman and Downing and were found to be as uncorrelated as the patterns of irises from unrelated persons.

Lin et al. represented the face at multiple layers in terms of global appearance, facial features, skin texture and irregularities that contribute towards identification. Global appearance and facial features are modeled using a multilevel PCA (Principal component analysis) followed by regularized LDA (Linear discriminant analysis). A Scale Invariant Feature Transform (SIFT) is employed to detect and describe details of irregular skin region, which is combined with elastic graph matching for recognition. Improved performance was achieved by fusing facial features at multiple levels. Pierrard et al. presented a framework to localize prominent facial skin irregularities, like moles and birthmarks. They use a multiscale template matching algorithm for face recognition. A discriminative factor is computed for each point by using skin segmentation and local saliency measure and is used to filter points. Recently, Zhang et al. designed a facial skin mark matcher based on a region growing algorithm. Each facial mark is described in terms of position, color intensity and size. The results of the facial skin mark matcher are fused with the results of a PCA based matcher to evaluate the performance of the system. A drawback of the method is that they need to have prior knowledge about the location of facial marks in order to apply the region growing algorithm. Park et al. proposed to use facial marks as soft biometrics. They initially map each face image contour obtained from an Active Appearance Model (AAM) into a mean shape using barycentric texture mapping. The mean shape images are then filtered using a Laplacian of Gaussian filter. This acts as a blob detector. Once the facial marks are detected, matching is performed based on Euclidean distance with a set threshold. The number of matches represents the similarity score between images. However, they do not use facial marks by themselves to evaluate performance. They fuse the scores from the facial mark matcher and a commercial face recognition software to evaluate the performance. They observed marginal improvement in performance by fusing the two scores. We have not compared the proposed method with any other previously published methods mainly because previous approaches fuse different face features with the features obtained from facial marks. The work proposed in this paper uses only facial marks as biometric signatures to distinguish between individuals.

Kodate et al. experimented with 10 sets of identical twins using a 2D face recognition system. Recently, Sun et al. presented a study of distinctiveness of biometric characteristics in identical twins using fingerprint, face and iris biometrics. They observed that though iris and fingerprints show little to no degradation in performance when dealing with identical twins, face matchers find it hard to distinguish between identical twins. All these studies were either conducted on very small twin biometric datasets or evaluated using existing in-house or commercial matchers. We build on these efforts and present facial marks based approach to characterize faces to address this challenging task. Facial marks were recently used as soft biometric for face recognition by Jain and Park in which they fuse a commercial face matcher with facial marks and observe small improvement in matching performance on non-twin datasets.

III. TYPES OF FACIAL MARKS

A facial mark is defined as a region of skin or superficial growth that does not resemble the skin in the surrounding area. Facial marks represent finer details on the face. They contain information useful to discriminate between identical twins. Availability of high resolution images enables us to view facial marks in greater detail for analysis. We have identified and defined the following facial marks shown in Figure 2.
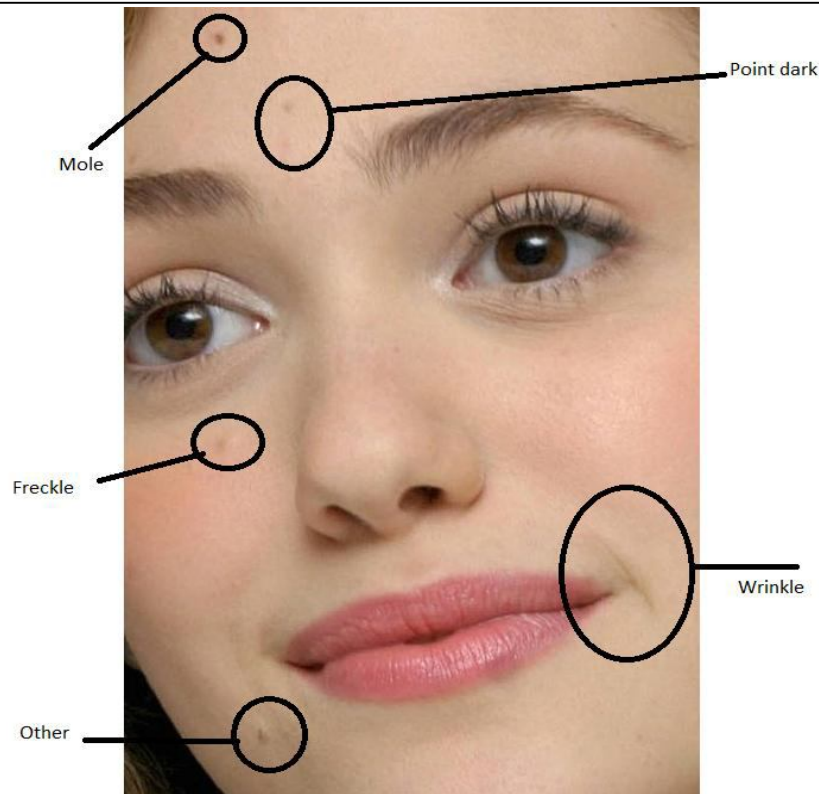
Mole | Freckle and Freckle Group | Lightened Patch | Darkened Patch
Raised Skin | Scar (Round) | Pockmark | Acne

Fig. 2, Examples of facial marks Scar, mole, and freckles etc.

1) Mole: A small flat spot less than 1 cm in diameter. The color of a mole is not the same as the nearby skin. It appears in a variety of shapes and is normally black in color
.

2) Freckle: A small flat spot less than 1 cm in diameter and appears in a variety of shapes. It is usually brown in color.

3) Freckle group: A cluster of freckles.

4) Lightened patch: A flat spot that is more than 1 cm in diameter and appears in different shapes. It is lighter in color than its surroundings.

5) Darkened patch: A flat spot that is more than 1 cm in diameter and appears in different shapes. These spots are arker in colour than their surroundings.

6) Birthmark: A persistent visible mark on the skin that is evident at birth or shortly thereafter. Birthmarks are generally ink, red, or brown in colour.

7) Splotchiness: An irregularly shaped spot, stain, or coloured or discoloured area.

8) Raised skin: A solid, raised mark less than 1 cm across. It has a rough texture and appears red, pink, or brown in colour.

9) Keloid scars: These scars are the result of an overly aggressive healing process. They extend beyond the original injury.

10) Contracture scars: If your skin has been burned, you may have a contracture scar. These scars tighten skin, which can impair your ability to move. Contracture scars may also go deeper, affecting muscles and nerves.

11) Hypertrophic scars: These are raised, red scars that are similar to keloids but do not go beyond the boundary of the injury. Treatments include injections of steroids to reduce inflammation or silicone sheets, which flatten the scar.

12) Acne scars: If you've had severe acne, you probably have the scars to prove it. There are many types of acne scars, ranging from deep pits to scars that are angular or wavelike in appearance. Treatment options depend on the types of acne scars you have.

13) Pockmark: A hollow area or small indentation.

14) Pimple: A raised lesion that is temporary in nature.

IV. ALGORITHM

Image Data: Face images were captured under different scenarios and conditions like controlled and Uncontrolled lighting, presence and absence of eyeglasses, different facial expressions like smile or neutral, different poses with yaw ranging from -90 to 90 degrees, where 0 degrees is a frontal view. The

dataset used for the proposed experiments consists of only frontal (yaw=0) face images with no glasses, no facial hair and a neutral expression. These images were captured under controlled lighting.

Gaussian Pyramid Construction: The Gaussian pyramid consists of a set of low-pass filtered and subsampled images. The original image is defi ned at the base level. The successive levels of the pyramid are obtained by filtering the image in the previous level and down-sampling it by a factor 2. Gaussian pyramid is defined by

2) $G_0(x,y) = I(x,y)$ for $l = 0$

$$G_l(x,y) = \sum_{m=-2}^{2} \sum_{n=-2}^{2} w(m,n)G_{l-1}(2x+m, 2y+n),$$

(where $G_0(x,y)$ is the base image of size $N \times N$ and $G_l(x,y)$ represents the images in the subsequent levels, l is the level number and $w(m,n)$ is a Gaussian filter of size 5×5. The number of levels in a Gaussian pyramid is defined by $l = \log N$. In this study we define $l=5$. Facial marks are detected at each level and then tracked across levels to signify their prominence. Detection of Primary Facial Features: The primary facial features like eyes, eyebrows, lips and nostrils are localized using an Active Shape Model (ASM). Individual masks are created based on the output of the ASM to mask the primary features.

Fast Radial Symmetry Detector: A color progression-based interest operator (the fast radial symmetry transform) is applied to the masked image. The transform detects regions of high radial symmetry. Applying a threshold to the output of the fast radial symmetry transform result in detecting bright or dark regions of high radial symmetry, which corresponds to potential facial marks. Bipartite graph matching: The process for matching facial marks detected by the multi-scale automatic facial mark detector is similar. In the case of automatically detected facial marks, each facial mark is characterized only by its geometric location on the corresponding face image. Therefore, automatically detected facial marks are treated as point features and can be viewed as they all belong to the same category. The similarity in the distribution of facial marks is used to determine the similarity between two face images. The similarity is computed by formulating a bipartite graph matching problem. The above steps constitute the total process of twin differentiation as shown in the figure 3.
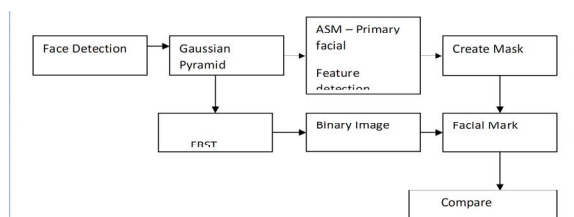

Fig. 3 Block diagram of Twin Differentiation

V. SIMULATION RESULTS

In this section the simulation results are presented. In figure 4, the practical execution of figure 3 is given. First of all, from a scene faces are extracted by using face detection. Then it is passed through the said Gaussian pyramid. Then feature extraction by using ASM Primary facial feature detection was performed. Then the mask is created which specific to each input image. Also, to the output of Gassian pyramid FRST is applied and stored the results separately. After getting binary version of output of FRST, it is given to Facial marks detection along with the output from the mask. Depending on the facial marks the given persons are classified into three categories; first as twins, second as different persons, and third as identical or same person. The first case is shown in figure 5, second case in figure 6, and third in figure 7.
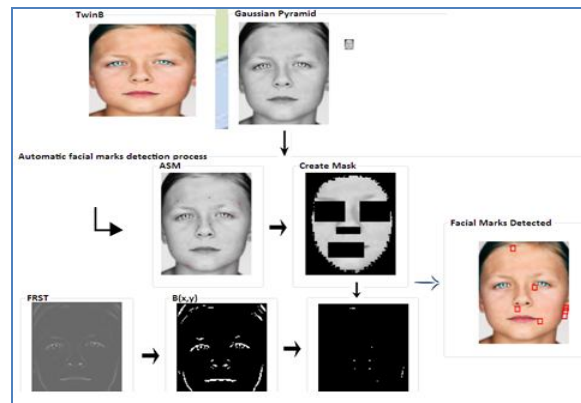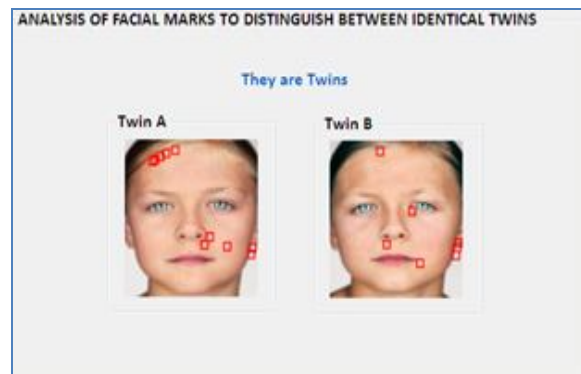

Fig. 4 Screen shot of Execution process

Fig. 5 Results when twins are given as input

Fig. 6 Results when different persons are given as input
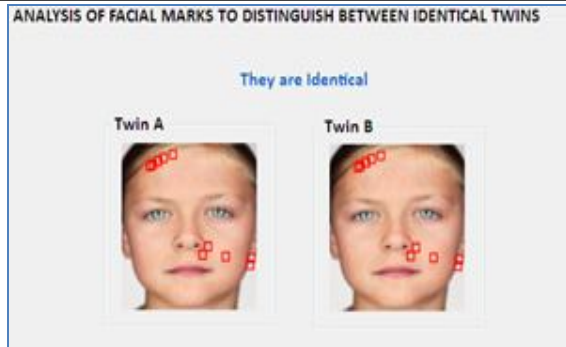
Fig. 7 Results when identical (Same) persons are given as input

VI. CONCLUSIONS

In this paper the facial marks are utilized to distinguish between twins. The technique presented in this paper clearly identifies different faces, twins and same face. A multi-scale automatic facial mark detection system for distinguishing between identical twins solely based on the geometric distribution of facial marks was proposed. The experimental results show that the performance of the technique presented in the paper is very good to distinguish between the twins. If the method is modified by considering large number of data samples and use genetic algorithm or neural network algorithms, the performance can be improved.

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