Identity Verification of Newborn Using Biometrics

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Abstract

A proper identity verification system for newborns is a requisite in the current scenario. The various crimes against newborns' like illegal adoptions (intentionally, accidentally), missing, swapping and child trafficking are on a rise. The proposed system uses biometrics to prevent such acts by using the footprint trait of the newborn. The authenticity is further enhanced by using multimodal biometrics i.e. the mother fingerprint for verifying the identity of the newborn. Hence, newborn footprint and mother fingerprint are used for identification and verification respectively. The performed test shows a better performance over the unimodal system.

Index Terms—*Biometrics, Fingerprint, Footprint, Newborn*

I. INTRODUCTION

The increasing need for security in present day society has generated considerable interest in the use of biometrics. Biometrics, which refers to identifying an individual based on his or her physiological or behavioral characteristics, has the capability to reliably distinguish between an authorized person and an imposter. A biometric system can be operated in two modes: verification mode and identification mode [1]. A biometric system operating in the verification mode either accepts or rejects a user's claimed identity while a biometric system operating in the identification mode establishes the identity of the user without any claimed identity information.

II. NEWBORN RECOGNITION

A. Traditional Methods

The currently followed method of footprint acquisition in hospitals is by using ink applied on the foot of the newborn which is copied on a paper along with the fingerprint of the mother. This is stored in a file which forms the medical database. This method of image acquisition is offline. Although capturing offline newborn's footprint has been exploited in many countries, there exists a big debate on the effectiveness of offline footprint recognition caused by the image quality of offline footprint. Another general practice is to tie a number band around the hands/legs of the newborn as a measure of identity. This number band is same as the one which is also tied to the mother of the infant. At the time of any violence like child kidnapping or abduction, mixing of babies, multiple claims for an infant in any hospitals, birthing centers causes confusion and emotional breakdown of parents. Also, it is a more sensitive issue to be dealt with. This raises a question on the effectiveness of the offline method done using ink and paper and the method of tying number bands (ID bands). This eventually leads to the DNA test at times or to a solution less situation. Hence, biometrics can be used to solve such identity issues.

B. Other Proposed Methods

The use of palmprint as a biometric trait using a high resolution scanner for image acquisition was developed in [2]. Since it is often difficult to let a newborn open his/her hand and also the images must be carefully acquired to ensure proper resolution and quality, this biometric trait cannot be used effectively. Up to now, face recognition with high accuracy is still a difficult task even for adults due to illumination, pose, expression, and other varieties. Particularly, the face of newborn may have a drastic change within several days after birth and also it is a solution for short period of time [3]. The use of ear recognition for newborn authentication as in [4] poses illumination covariates. Meanwhile, the use of the iris as an identification feature is also a difficult method for newborns, especially the premature, because they hardly open their eyes; .therefore, they do not have the ability of looking into a scanning device, and touching their eyelids to collect an image could hurt them. Besides, the iris pattern only stabilizes after the child's second year [5].

Although, fingerprint recognition has been widely and successfully used, it is not feasible for newborns. The main reason is that newborn's fingers are very small. As a result, newborn's fingerprint cannot be clearly captured [5]. The

DNA examination is proven to be efficient in the univocal identification of individuals, it comes at high cost and demands sophisticated laboratory procedures, therefore cannot be used in real-time applications [5].

Compared to other techniques, footprint recognition is very attractive for newborn personal authentication, since it is a noninvasive method, of easy applicability, high availability , very low cost, wide acceptance and has been used for more than 100 years [5]. But the offline footprinting has drawbacks as in [6], so an online system is proposed.

C. Our Method

In the online system, the ink and paper method is replaced by a digital source and computers are used for processing and storage. The digital source could be either a digital camera or a suitable high resolution scanner. The use of electronic processing results in higher speed, computationally efficient, reliability, accuracy, more robust, easy storage and retrieval. There is no high resolution scanner(>1000ppi) available, so this method conducts a preliminary study using a Digital Single Lens Reflective (DSLR) camera for capturing the footprint of the infant and extracting the texture feature from the image in contrast to the method proposed in [6].

Also, the identified newborn is further verified by the fingerprint of the mother using effective minutiae matching algorithm. The block diagram of the proposed system is shown in figure 1.

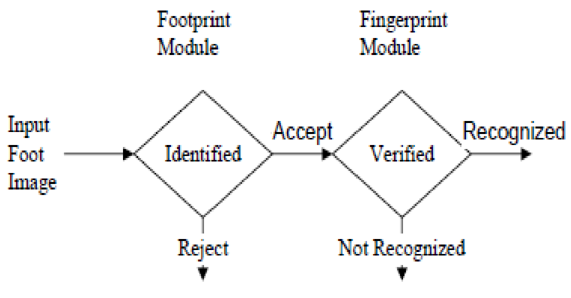

Fig 1. Block diagram of proposed system

In case of any identity crisis, verification is done following the identification stage by using the two modalities mentioned.

III. FOOTPRINT IDENTIFICATION

A. Image Acquisition

The newborn's footprint images using a digital SLR (DSLR) camera, whose type is Canon EOS 7D. Since there is no available newborn footprint database, the images must be captured in real time. The image capturing work was done in the Primary Health Center (PHC), Medavakkam, which is one of the Government run hospital in India. After getting the legal permission from the health services officials, the images were captured. When capturing images, two persons are needed. One person is the author of the paper whose task is to pacify and hold the foot of the newborn and the other person is a well qualified professional photographer to take pictures of the newborn foot. A black cloth was wrapped around the ankle to facilitate image segmentation. It can be seen that the quality of the online image is much better than the offline image as shown in figure 2. All the images were collected in one session during the first 2 days following birth. After we explained some knowledge about the importance and significance about Newborn's biometrics to newborn's parents, they consented that we can capture footprint images once.

In image acquisition stage, a crucial problem is to select an opportune time to capture images. If a newborn is hungry, crying or suffering from any minor illness, he/she will ceaselessly move his/her hands, feet, and whole body. In this time, it is difficult to hold and capture footprint images with desirable quality. On the contrary, if a newborn is calm or sleeping, the task of image capturing will become easy. In this paper, all images were captured when newborns were calm or sleeping.

Fig 2: Footprint. (a) Offline image (b) Online image

B. Image Preprocessing

The color image is converted to gray scale for further processing. The preprocessing steps as described in [7] are used to implement the system.

1) Particle Filter*:* The significant structures in an image is separated from the rest of the image, the unwanted background are termed particles which may be of various size and shapes.

2) Morphology: The concepts of erosion and dilation are used in morphology.

3) ROI Extraction: A sub-image with the fixed size on the basis of coordinate system, which is located at the certain part of the footprint for feature extraction, is extracted.

C. Feature Extraction

The image is now almost free from background and so that the stable features in the image now needs to be extracted for processing and storing as a template in database or for testing.

In general the newborns' footprint image at low resolution contains rich features such as texture, line, and direction etc. Particularly, the pattern of footprint is similar to the one of palmprint. In this regard, many methods proposed for palmprint recognition can also be used for footprint recognition[7].Among all kinds of methods, Gabor filters is one of effective and efficient methods, which has been successfully applied to palmprint [8, 9]. In this system it is exploited for newborn footprint identification.

Generally, there exist some principal lines, wrinkles in a footprint image. But these lines do not contribute adequately to high accuracy because of the similarity of these principal lines between different subjects. Wrinkles play an important role in footprint identification but accurately extracting them is difficult. This motivates to apply texture analysis to footprint recognition.

A circular 2-D Gabor filter in the spatial domain has the following general equation form,

$$G(x, y, \theta, u, \sigma) = \frac{1}{2\pi\sigma^2} \exp\left\{-\frac{x^2 + y^2}{2\sigma^2}\right\} \times \exp\{2\pi i(ux\cos\theta + uy\sin\theta)\}$$

where $i=\sqrt{-1}$; u is the frequency of the sinusoidal wave; θ controls the orientation of the function and σ is the standard deviation of the Gaussian envelope. These filters can model the receptive fields of a simple cell in the primary visual cortex. In the experiments u, σ is set as 0.0916 and 5.6179 respectively whereas θ is varied between 0 to 1 radian as in [7]. The feature extracted image is stored as a pattern vector as shown in figure 3.

Fig 3. Pattern vector

D. Footprint Matching

Matching is used to determine whether the footprints are from the same subjects. The pattern matching algorithm as in [7] is used. Similar footprint patterns from the given footprint database are grouped for further identification. The extracted pattern(test image) is compared against the pre-registered pattern(training image) in the database to obtain a matching score as explained in [7].

E. Experimental Results

A newborn's footprint database is established. In total, the database contains 240 images from 40 newborns' captured at the Primary Health Center, Medavakkam. Six images were collected from the right foot of the newborn. All the images were collected within two days after birth. In each class, the first footprint image is used for training and the remaining footprint images are for testing. Therefore, the numbers of images for training and testing are 40 and 200, respectively. The experiments were conducted on a personal computer with an Intel Pentium B960 processor (2.20 GHz) and 4.0G RAM configured with Microsoft XP and LabVIEW 11.0 software.

When identification is done, if test image "A" matches with the image belonging to a same class i, then the corresponding matching score generated for that particular class is highest whereas the other matching scores are lesser than the highest value and also less than the predefined system threshold value. Hence, the top match is alone retrieved for further verification as in [10]. In a database with 200 testing images, there are totally 130 images that are correctly matched and the rest are incorrectly matched. Table 1 shows an example of the identification matching score results.T1 represents test image 1 and Tr1 represents the training images. The table shows an example of the scores for 7 training images. The first score which is highest corresponds to the same class of the the test and training image, example Baby 1. The other scores are comparatively lesser due to both incorrect matchings and non-match.

TABLE I

EXPERIMENTAL RESULTS OF IDENTIFICATION MATCHING SCORES

	Tr1	Tr2	Tr3	Tr4	Tr5	Tr6	Tr7
T1	0.83	0.32	0.04	0.27	0.6	0.058	0.18

IV. FINGERPRINT VERIFICATION

The identified newborn is now verified with the corresponding fingerprint of the mother for which the following procedures are used to obtain the fingerprint details.

Fingerprints are graphical flow-like ridges present on human fingers. The pattern of the ridges and valleys on the human fingertips forms the fingerprint images. Analyzing this pattern at different levels reveals different types of features that are, global feature and local feature. Global features shape a special pattern of ridge and valleys, called singularities or Singular Point (SP) and the important points are the core and the delta. The core defined as the most point on the inner most ridges and a delta defined as the centre point where three different directions flows meet. Local features so-called minutiae are an important feature for fingerprint matching. Fingerprint patterns are full of ridges and valleys. The information of the ridge structures can be treated as two levels. At the coarse level, the number and the relative positions of singular points, including cores and deltas, are concerned for classification. At the fine level, the minutiae, a group of ridge endings and bifurcations, are used as the features for matching. The uniqueness of a fingerprint is exclusively determined by the local ridge characteristics and their relationships as in [11]. Fingerprint matching generally depends on the comparison of local ridge characteristics and their relationships. A total of 150 different local ridge characteristics, called minute details, have been identified [11]. These local ridge characteristics are not evenly distributed. Most of them depend heavily on the impression conditions and quality of fingerprints and are rarely observed in fingerprints. The two most prominent ridge characteristics, called minutiae, are *ridge ending* and *ridge bifurcation*. A ridge ending is defined as the point where a ridge ends abruptly. A ridge bifurcation is defined as the point where a ridge forks or diverges into branch ridges. A fingerprint typically contains about 40 to 100 minutiae. Examples of minutiae are shown in Fig. 4.

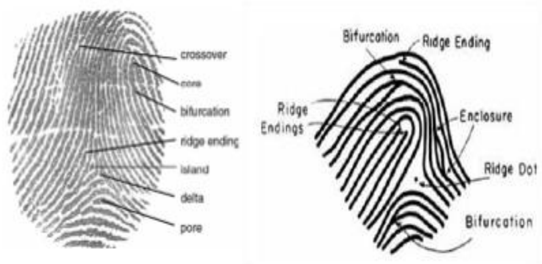

Fig 4. Fingerprint showing minutiae details

Fingerprint verification consists of two main stages: minutiae extraction and minutiae matching. The minutiae extraction algorithm as in [12] is used with certain modifications and it has the following three steps.

1) *Orientation field* (*ridge flow*) *estimation,* in which the orientation field of input fingerprints images is estimated and the region of interest is located,

2) *Ridge extraction,* in which ridges are extracted and thinned.

3) *Minutiae detection and Postprocessing,* in which minutiae are extracted from the thinned ridge maps and refined. For each detected minutia, the following parameters are recorded:

- x-coordinate,
- y-coordinate,
- Orientation, which is defined as the local ridge orientation of the associated ridge.

The overall process can be defined into three main operations ;(i) Preprocessing and Segmentation, (ii) Thinning and Feature extraction and (iii) Postprocessing. The figure 5 shows the functions involved after converting the color image to the gray scale image.

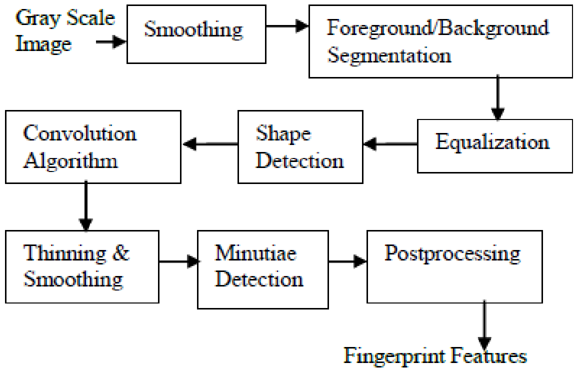

Fig 5. Stages in feature extraction algorithm

A. Preprocessing and Segmentation

The image is smoothed using a low pass filter.

1) Foreground/Background Segmentation: A fingerprint image usually consists of a region of interest (ridges and valleys of fngerprint impressions) along with a printed rectangular bounding box, smudgy patches of ink and blurred areas of the pattern and background. We need to segment the fingerprint area (foreground) to avoid extraction of features in noisy and background areas of the fingerprint by setting a proper threshold.

2) Shape Detection: The segmented image is equalized for ridge detection. The shape detection tool in the software is used to estimate the orientation of the ridges. The edges in an image and the contours are found to define the region of interest (ROI). This is followed by a convolution algorithm using a linear filter. The size of the convolution matrix is 7x7. A binary image is now obtained with the ridges having a pixel value of "1" and the other areas have a pixel value of "0". This segmented image is known as ridge map. Figure 6 shows the equalized and shape detected image.

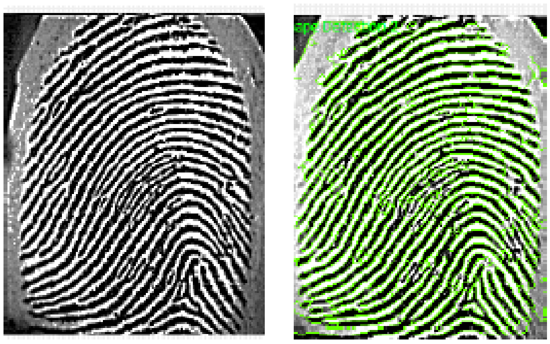

Fig 6: a. Equalization b. Shape detection

B. Minutiae Extraction

The binary ridge image needs further processing before the minutiae features can be extracted. The first step is to thin the ridges so that they are single pixel wide as in [12]. The thinning operator in the software is used which alters the shape of objects by eliminating parts of the object that match the pattern specified in the structuring element of size 3x3. Locating minutia points in the thinned image is relatively easy. A count of the number of “on” neighbors at a point of interest in a 3x3 window is sufficient for this purpose. A ridge end point has only one neighbor in the window and a ridge bifurcation has at least three neighbors. All the ridge end points and ridge bifurcation points detected with this method are not always true features, but the method does seem to identify most of the true feature points. A postprocessing stage filters out the undesired feature points based on their structural characteristics.

C. Postprocessing

The preprocessing stage does not eliminate all possible defects in the input gray scale fingerprint image. For example, ridge breaks due to insufficient amount of ink and ridge cross-connections due to overinking are not totally eliminated. In fact, the preprocessing stage itself occasionally introduces some artifacts which later lead to spurious features. The postprocessing stage eliminates spurious feature points based on the structural and spatial relationships of the minutiae as shown in figure 7. For instance, two minutiae in a real fingerprint cannot occur within a very short distance of each other. Hence, spurious minutiae get deleted with this method as in [12].

Fig 7. Post processed image

D. Minutiae Matching

For each detected minutia, the following parameters are recorded:

 x-coordinate,

 y-coordinate,

 Orientation, which is defined as the local ridge orientation of the associated ridge.

The minutiae matching determines whether two minutiae patterns are from the same finger or not. A similarity metric between two minutiae patterns is defined and a thresholding on the similarity value is performed. By representing minutiae patterns as two-dimensional “elastic” point patterns, the minutiae matching may be accomplished by an “elastic” point pattern matching as long as it can automatically establish minutiae correspondences (in the presence of translation, rotation, and deformations) and detect spurious minutiae and missing minutiae. The same method described in [13] is used where an alignment stage and pattern matching is used with an adaptive bounding box representation as in figure 8. The matching scores are generated after performing the verification tests.

Fig 8. Image with minutiae

V. EXPERIMENTAL RESULTS

The fingerprint verification was tested on various databases like UPEK, Shivang Patel and FVC 2002.The UPEK database consists of 16 subjects and each with 8 impressions. Similarly, the Shivang Patel database gives the fingerprint of 21 subjects with 8 impressions per subject. The FVC 2002- Set DB1-B fingerprint database is used where three fingerprints were chosen randomly. Each subject gives 8 impressions of the finger. Thus, a total of 40 subjects fingerprint were collected and are numbered accordingly to the above mentioned database order. In all the subjects, the first image is selected for training and the other images are used for testing.

The newborn footprint identification was tested on 240 images (40x6) which is next verified with the mother fingerprint. Hence, each infant is virtually assigned to the corresponding mother fingerprint. The sample database with the newborn footprint and the mother fingerprint is shown in figure 9. The retrieval and verification method is employed to identify the baby with his/her mother. Verification is a one to one matching where a test image is compared only against the trained image or the stored template. The identified baby (top match) is now verified with the corresponding template of the mother fingerprint (one to one) as described in [10]. Based on the comparison a matching score is obtained and by setting a threshold, the score determines the decision to either accept or reject the claim for the baby. As a measure, the Receiver Operating Curve (ROC) is plotted between the False Acceptance Ratio (FAR) and Genuine Acceptance Ratio (GAR) as shown in figure 10.

Fig 9. Sample database

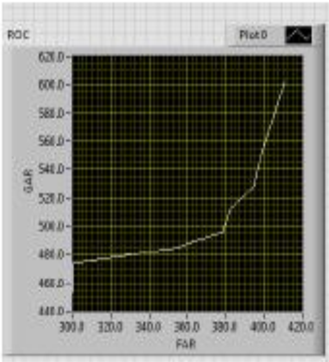

Fig 10. ROC curve

VI. CONCLUSION AND FUTURE WORK

In this paper, an online footprint recognition method is proposed for newborn personal authentication. Those infants whom are identified by their footprint may be accepted falsely or rejected unknowingly. A final decision regarding the authenticity of the newborn cannot be decided by the unimodal system alone. Hence, they must be further verified by a multimodal system i.e. fingerprint of the mother. Once the identification is done, the next process of verification is begun using the mother fingerprint. The recognition accuracy has constraints due to the problems faced while acquiring the image i.e. certain background which cannot be removed fully and the number of images captured.

Thus, foot biometric data can be a very promising tool for identification of newborn. The accuracy of the proposed system can be further enhanced by considering large database, by having a better image acquisition protocol. Also, fusion techniques can be implemented to improve the accuracy and performance. A correct fusion technique can be used to give the decision over the identity of the newborn since it integrates the multimodal system effectively. This method is a low cost solution to the newborn violence rather than the expensive DNA procedures.

ACKNOWLEDGMENT

The authors would like to thank the Deputy Directorate of Health Services, Saidapet division and the Primary Health center, Medavakkam for permitting us to acquire the newborn foot images and the source of the fingerprint databases used.

REFERENCES

[1] Anil .K .Jain, Ross A, Prabhakar S (2004) An introduction to biometric recognition. IEEE Trans Circuits Syst Video Technology Special Issue Image Video based Biometrics 14(1):4–20

[2] Anil K Jain, *et al*, "*Biometric Recognition of Newborns: Identification using Palmprints*", International Joint Conference on Biometrics, October 11-13,Washington DC USA, 2011

[3] Aruni Singh, Shrikant Tiwari, , Sanjay Kumar Singh,"Intelligent method for face recognition of Infant", International Journal of Computer applications, vol. 52, issue 4, pp. 36-50

[4] Shrikant Tiwari, Aruni Singh and Sanjay K Singh.: *Newborn's ear recognition: Can it be done?*,International Conference on Image Information Processing (ICIIP), 3-5 Nov. JUIT India, 2011.

[5] D. Weingaertner, O. R. P. Bellon, L. Silva, and M. N. L. Cat. Newborn's biometric identification: can it be done? International Conference on Computer Vision Theory and Application (VISAPP), pages 200–205, 2008.

[6] Hai-Yang Cai, *et al* "Newborn footprint recognition using orientation feature", Neural Computing & Applications: 1-9,dec ICIC 2010.

[7] S.Balameenakshi. S.Sumathi," Biometric Recognition of Newborns: Identification using Footprints", Proceedings of 2013 IEEE International Conference on Information and Communication Technologies (ICT 2013), 737-742, Tamilnadu, India

[8] Li.W , Wai Kin Kong, David Zhang " Palmprint feature extraction using 2-D Gabor filters", Pattern Recognition, vol. 36, pp. 2339-2317, 2003.

[9] Sumathi.S, Rani Hemamalini. R, "Person Identification Using Palm Print Features with an Efficient Method of DWT",

Global Trends in Information Systems and Software Applications, Communications in Computer and Information Science, Volume 270, 2012, pp 337-346.

[10] Piotr Gutkowski, "Algorithm for retrieval and verification of personal identity using bimodal biometrics", Information Fusion, Volume 5, Issue 1, March 2004, Pages 65–71

[11] L. Hong, A.K.Jain, S. Pankanti, and R. Bolle, "An identity authentication system using fingerprints," *Proc. IEEE*, vol. 85, no. 9, pp.1365–1388, Sep. 1997.

[12] N. Ratha, S. Chen, and A. Jain, "Adaptive flow orientation based feature extraction in fingerprint images," *Pattern Recognition*, vol. 28, pp. 1657– 1672, Nov. 1995

[13] A. Jain, L. Hong and R. Bolle, "On-Line Fingerprint Verification", IEEE Trans. Pattern Analysis and Machine Intelligence, Vol. 19, No.4, pp. 302-3 14, Apr. 1997.