Multimodal Database of Newborns for Biometric Recognition

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Abstract

Missing, swapping, mixing, and illegal adoption of newborns is a global challenge and research done to solve this issue is minimal and least reported in the literature. To the best of our knowledge there is no multimodal database of newborns is available in public domain to test the algorithms for their identification. An attempt has been made to prepare a multimodal database of newborns to help the researchers to test their different algorithms for the recognition accuracy. The database includes physiological characteristics like face, ear, headprint and soft biometrics data like gender, height, weight and blood group of 280 newborns. With all these identity characteristics this database may be useful for authenticating the newborns using unimodal and multimodal biometric systems development for newborn.

Keywords: *Newborn, face, ear, headprint, multimodal database*

1. Introduction

How can the mother be sure that her new born will not be mixed up in hospital? The question is inevitable and none should be answered with greater care, sympathy and understanding than this of the incoming maternity patient. The care with which it is answered, and the technique of the identification procedure explained, hangs the peace of mind of the parents until such time as the newborn shows unmistakable evidences of its parentage. The security of maternity ward is a prime concern not only to medical fraternity but also to the parents worldwide. The problem of missing children is a very serious issue throughout the world and seeing the importance of this issue, May 25 is observed as National Missing Children's Day since it was first proclaimed by President Ronald Reagan in 1983. When confronted with baby swapping or abduction, many parents fear that there is nothing they can do to prevent this tragedy. In developing countries, this problem is more challenging because of overcrowding and scarcity of medical facilities in maternity ward. Every year around 1, 00,000 to 5, 00,000 newborns in United States are exchanged (swapped) by mistake, or one out of every eight babies born in American hospitals sent home with the wrong parents [1]. According to study [2], out of 34 newborns that are admitted to a neonatal intensive care unit there are 50% chances of incorrect newborns identification only in a single day.

In real applications, the biometrics traits that are commonly used in different authentication systems are the face, fingerprint, hand geometry, palm print, signature, iris, voice, *etc.* [3]. But most of these practical biometric systems are developed for adults only. Therefore, the challenge is to design a biometric system for newborns to solve the problem of their missing and swapping, which has been less addressed in the literature as per our knowledge.

The use of identification document (ID) like bracelet and radio frequency identification (RFID) tag by hospital authorities has not solved the problem of newborn swapping or mixing completely. The biometric traits like Deoxyribonucleic Acid (DNA) typing and Human Leukocyte Antigen (HLA) typing are cumbersome techniques for identifying the newborns because these takes more time and higher cost involvement [3]. The most popular biometrics for adult identification, *i.e.*, fingerprints also fails because fingerprint taken within 17 months after birth of a baby are not useful for identification [4]. Due to illegibility problem, footprint of an newborn cannot be a potential mark for their identification in the majority of cases [5, 6, 7, 8]. The use of iris biometrics for newborns authentication is challenging, especially in the cases of premature birth. This is due to the fact that the newborns are unable to open their eyes properly and looking into the scanning devices and touching their eyelids while collecting their iris image may harm their eyes. Further, iris patterns are only stable after two years of birth [3] and therefore it is not recommended for newborns' recognition. Fields et al., [9] have studied and manually analyzed the samples of ear modality of newborns on a database of 206 subjects. They have concluded that ears can be used to distinguish among newborns. All the literatures that are focusing the problem of authenticating newborns surveyed by the authors, none of them have evaluated their performance by the automated means.

2. Need for new Database

It is surprising that very little research regarding new born biometric identification is published, while that of adults receives much funding for research [22]. It has to be emphasized that the Multimodal Database of new born provides new challenging scenarios for newborn not considered in existing biometric databases.The assertion is that the biometric features of newborns can be utilized for a short span of time (between 0-45 days) in order to solve the problem of swapping, mixing, abduction and illegal adoption. The performance (reliability) of recognition can be further increased if more than one biometric modalities are used.

One of the main reasons of limited research for newborn identification is the non availability of reference database in public domain. This paper presents a novel multimodal database of newborns which can be used in solving the problem of missing, swapping, mixing, and illegal adoption of newborns. The database is not only useful in testing of the existing techniques but also for the development of new techniques that may offer an increase in the recognition accuracy. In brief, the author's intention is to provide a benchmark database of newborns that addresses the problem of authentication and other medical applications.

2.1 Data Acquisition Setup

Following equipments are used in preparing the multimodal database: (1) Digital camera of 10 megapixel and video camera of 14 megapixels to capture the images of face, ear and headprint. (2) Infantometer to measure the height of newborns, and (3) Digital weighing machine to measure the weights as shown in Figure 1(a) and Figure 1(b).

Figure 1. Data acquisition device: (a) Infantometer; (b) weighting machine

3. Database Description

The newborns database consists of static digital images of face, ear and headprint including soft biometrics data like gender, height, weight and blood group. The data base acquisition of newborns took one year to complete and thus it has minor variations in lightning conditions due to changes in weather conditions. The database of each subject is prepared in two different sessions. In the first session data is collected within four hours of birth of a child and the data of second session depends on the type of birth. For example, if there is a case of normal birth then data is collected after 20 hours otherwise in scissoring cases data is collected after 70 hours of the birth. In this data collection, the time for data acquisition is set according to the period that a newborn stays in the hospital after his/her birth. The database statistics of different characteristics and their acquisition session is shown in Table 1. These images are captured without imposing any constraint on the targeted subjects or their surroundings.

Table 1. Number of Subjects 210

Session	Face	Ear	Headprint
First (Within 4 hours after birth)	Subject x Images 210 x 5	Subject x Images 210 x 5 x 2	Subject x Images 210 x 5
Second (Normal Birth, after 20 hours)	Subject x Images 120 x 5	Subject x Images 120 x 5 x 2	Subject x Images 120 x 5
Second (Scissoring, after 72 hours)	Subject x Images 85 x 5	Subject x Images 85 x 5 x 2	Subject x Images 85 x 5

Newborns are presumed to exert no voluntary control over their expressive behavior (*e.g.*, they do not adhere to cultural display rules), due to this they are highly non-cooperative users of biometrics and to capture their frontal face image is big challenge. Therefore, the images shown in Figure 2 display the variation in their pose, illumination and expression which can be used to test the algorithms for recognition of newborns with pose, illumination and expression variations.

3.1 Face

The important covariates of face recognition are illumination, image quality, expression, pose, aging, and disguise. In case of new born, the challenges of aging and disguise are not manifested. The face database contains variations in images collected in different pose, illumination, expression and variations in quality due to motion blurriness. Facial images are grouped according to variations mentioned above to solve the problem of face recognition in newborn as shown in Figure 2(a), Figure 2(b), Figure 2(c) and the statistics of face database is shown with help of Venn-diagram shown in Figure 3.

Figure 2. (a). Sample neutral face Images of Newborn from the Database

Figure 2. (b). Sample crying face Images of Newborn from the Database

Figure 2. (c). Sample sleeping face Images of Newborn from the Database

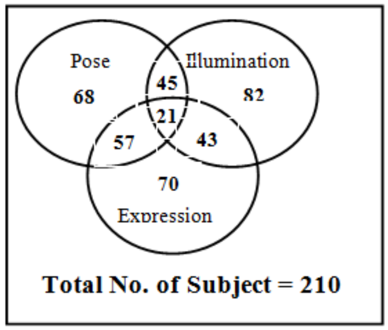

Figure 3. Venn-diagram statistics of face database with pose, Illumination and Expression

3.1.1 Expression

A facial expression results from motions or positions of the muscles of the face, and overall expression of the face is a composite of signs from many sources, such as the bony structure, shapes and positions of features, and color and texture of the skin. Variations in expression can cause deformation in local facial structure which changes the facial appearance and local geometry of the face. Figure shows example of variations in facial features which can reduce the recognition accuracy. The facial images of sleeping baby and crying baby are other variations in the database that are shown in Figure 2. In case of sleeping babies, since their eyes are closed so it is difficult to locate the exact position of eyes which is essential for most of the facial recognition techniques (FRT). While in crying babies case the position of prominent facial features like eyes, mouth, nose and other part of the face varies.

3.1.2 Illumination

Images with proper illumination captured under controlled environment are ideal for face recognition. However, face images of newborn with illumination variations (Figure 2) may reduce the performance of recognition algorithms because illumination variations may alter the appearance and the features may be hidden.

3.1.3 Pose

Frontal face images of newborn contain enough information to be used for face recognition. However, in a semi-profile face image, as shown in Figure some features are not visible and matching a frontal face image with a profile face image may produce incorrect results.

3.1.4 Quality

Quality of a face image depends on various features such as motion blur, sensor noise, environmental noise, image resolution, and gray scale/colour depth. Any degradation in the quality of face images, as shown in Figure can lead to reduced recognition performance. Thus the database consists of all the covariates mentioned above to test the various face recognition algorithms by the research community.

3.2 Ear

Ears have gained attention in biometrics due to robustness of the ear shape [11, 12, 13, 14, 15]. The ear shape does not change due to emotion and remain constant over most of person’s life [11], but can change from other causes. A subject may pierce their ears, wear different jewellery, wear their hair differently or even wear clothing that occludes part of their ear. The ear database of newborn consists of pose, illumination and occlusion covariates. Occlusion is due to some tradition that soon after birth parents put black earrings or black threads in the ear. Five frontal photograph of each ear, *i.e.*, left and right ear are acquired in two sessions of 210 subjects with slight variations in pose, illumination and occlusion. Ear images are grouped according to variations mentioned above to solve the problem of ear recognition in newborn is shown in Figure 4(a), Figure 4(b), Figure 4(c) and Figure 4(d). and the statistics of ear database is shown with help of Venn-diagram shown in Figure 5.

Lighting determines how easily the feature can be seen. It also affects the way the feature is perceived, as lighting will cause shadows to fall differently depending on the direction and intensity of the light source. Pose will provide variance, as well. Images where the subject is looking up or down will have same ear features available as a subject looking straight ahead, but these cannot be compared directly against each other without being brought to a standardized pose.

Figure 4(a). Illumination variation ear images of newborn from the database

Figure 4(b). Occlusion variation ear images of newborn from the database

Figure 4(c). Pose variation ear images of newborn from the database

Figure 4(d). Blurred ear images of newborn from the database

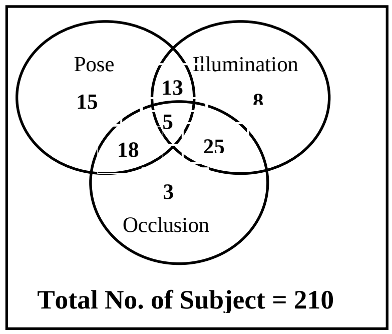

Figure 5. Venn-diagram statistics of ear database with pose, Illumination and Occlusion

3.3 Headprint

Headprint hair forms an important part in the perceptual identity understanding by humans. The visual appearance of hair cannot be used as a long term biometric due to non rigid nature of hair, but for short interval of time this data can be useful in recognition of newborns. Dark and light hair differ in their physical interaction with light in addition to their reflectance properties: light hair can transmit incident light internally but dark hair cannot [17] this is used to enhance face recognition [16]. The work done by Aradhye, *et al.*, [23] Successfully defined a set of features for pixel-based and line-based characterizations of the imaged appearance of human hair. For pixel-based characterization, a rotation-invariant statistical feature is used to determine texture and color. For line-based characterization, many different types of attributes including shape, line texture and orientation, and color are developed.

Figure 6. Sample headprint images of newborn from the database

3.4 Soft biometrics

Soft Biometrics characteristics like gender, ethnicity, age, height, weight and eye color are not unique and reliable, they provide some information about the individual and these are referred as soft biometric trait and these trait compliment the primary biometric trait [18, 19]. Soft biometric traits help in filtering large databases by limiting the number of entries to be searched in for each query. In case of newborns we have collected gender, height, weight, blood group. The format of soft biometric data is shown in the Table 2. Furthermore, soft biometrics is unobtrusive, there is no risk of identity theft, the perception of the big-brother effect is small, the equipment needed is low-cost, and the methods are easy to understand.

Table 2. Database Statistics of Soft Biometrics

Gender Distribution	**Male**				**Female**			
	70				140			
Blood Group	A+	A-	B+	B-	AB+	AB-	O+	O-
	32	21	30	20	25	18	58	6
Height	40 cm to 45 cm			46 cm to 50 cm		more than 51 cm		
	50			130		30		
Weight	1500 gm to 2500 gm			2501gm to 4000 gm		more than 4001gm		
	50			130		30		

Note: - The numerical values within the parenthesis indicate the number of newborns.

Table 3. Sample database of soft biometrics

Subject	**Gender**	**Height (cm)**	**Weight (gm)**	**Blood Group**
1	Male	43	1700	O+
2	Female	47	3800	B+
3	Male	48	3900	AB-
4	Female	46	3700	O+
5	Female	48	3900	AB+
6	Female	47	3800	AB+
7	Male	52	4100	O+
8	Female	41	1600	B-
9	Female	48	3900	O+
10	Male	49	4000	AB+

3.5 Database of Twins

There are two types of twins, monozygotic (identical twins) and dizygotic (different twins). Dizygotic twins result from different fertilized eggs. Consequently, they have different Deoxyribo Nucleic Acid (DNA). Monozygotic twins, also called identical twins are the result of a single fertilized egg splitting into two individual cells and finally developing into two persons. Thus, identical twins have the same DNA. The frequency of identical twins is about 0.4% across different populations [2]. Some people believe that this is the limit of face recognition systems [17].

This database contains seven pairs of twins that include images of face, ear and headprint with soft biometrics data that includes gender, height, weight and blood group. The samples images of face, ear and head print of three pairs of twins are shown in Figure 7. Nevertheless, not all biometrics have sufficient information to classify identical twins having the same genetic expression.

Figure 7. Sample twins images of newborn from the database

4. Problems Encountered During the Preparation of Database

The biggest problem in preparing the database of newborn is the consent of parents and the cooperation of medical staff to prepare the database. The active participation of parents and the medical staff provides an additional advantage for the successful preparation of the newborn database. It is really difficult to convince the parents for data acquisition as some parents were unwilling and concerned about the privacy issue.

New born are highly non cooperative users of biometrics and most of the time they are sleeping or crying. Therefore, to capture their image, *e.g.*, face, ear, head print, *etc.*, is rarely difficult because as soon as they are targeted for data acquisition they get disturbed and start crying as shown in Figure 2. Soon after their birth some parents apply oil on the whole body of newborn and this affects the texture quality of the image.

During biometric data acquisition a crucial problem faced by the biometric researchers is to decide an opportune time of the data acquisition. If a newborn is uncomfortable due to hunger or medical illness then he/she will cry and ceaselessly move his/her head, feet or whole body. Even if they are sleeping, then the task of their data acquisition becomes challenging further the facial images is of little use if their eyes are closed. In order to prepare the favorable environment to capture the biometric data of a single newborn it takes about 40 to 45 minutes of time.

5. Discussion

Mixing and kidnapping of new born probably garner such a strong negative response because they are things that parents fear the most-things that seem difficult or impossible to control or stop. When confronted with these problems, many parents fear that there is nothing they can do to prevent this tragedy. There is a strong justification for the use of biometrics for identification of newborns to mitigate the problem of mixing, switching, abduction and illegal adoption. Some of the biometric traits collected in the prepared database are justified for only short period of time.

The prepared database provide a mechanism to develop secure algorithms to solve the problem of the newborns from mixing, switching, abduction and illegal adoption while at the same time it also facilitates to the authorities in tracking of the missing child based on their biometric features. This would lessen the fear of parents that their babies might not be swapped and they are the legitimate parents of their own baby.

6. Conclusion

Part of the face database has been tested and published in BTAS-2010 conference and the results obtained are very promising [10]. The objective of public biometric database is to allow the creation of common and repeatable benchmark algorithms, so that new developments can be done with existing ones. However, biometric database collection is a time and resources consuming process, especially in the case of newborns (non cooperative users) multimodal database. This multimodal database is a collaboration work between the Department of Computer Engineering IT-BHU and Institute of Medical Science, BHU. Further work is being carried out in developing a recognition algorithm using a multiple feature approach.

Acknowledgement

Authors would like to thank Prof. B. M. Singh and Dr. Niraj Srivastava (Department of Kaumar Bharitya, Faculty of Aurveda, Institute of Medical Science, BHU) for their help and cooperation in preparing the database. We are also thankful to Dr. M. Vatsa and Dr. R. Singh (IIIT, New Delhi) for their nice suggestion.

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