Chapter 1 .Introduction

1.1 Motivation

Face Recognition (FR) is a field of biometrics that deals with the authentication and identification of an individual by extracting the individual’s facial features.

FR in new born child has emerged as a necessity due to swapping, mixing and abduction of these children. In India a problem involving the act of parents escaping and leaving their newborn child alone just after their birth is very common .These problems are now emerging as global one among various part of the nation. Humans can recognize thousands of faces and identify familiar faces despite large changes in the visual stimulus due to viewing conditions, expression, aging, sex, and distractions such as glasses, or changes in hair style [1]. When it comes to reorganisation of identities among newborns the recognition is enduring because of similar features among babies. This similarity among basic facial features turns into a reason for the successful abduction or swapping of the new born.

According to the National Centre for Missing and Exploited Children, 288 cases of newborn/infant abduction have been reported in the United States from year 1983-2013 .In medical science, different methods have been explored to identify newborns. Deoxyribonucleic Acid (DNA) typing and Human Leukocyte Antigen (HLA) typing are very efficient and accurate methods for verifying the identity of babies [2]. DNA testing has provided the biggest revolution in the identification of individuals. Still, the technology has limitations. Most genetic tests take 24-72 hours but the time taken for DNA to go from hospitals for identification and this can span as long as 14 days. Therefore DNA tests and HLA are time bound procedures, although effective but by the time that the results are back, the suspects often have been eluded [3].Newborn identification varies from hospital to hospital, but one of the most prevalent methods is the use of corresponding Identity Card (ID) bracelets between mothers and their babies. Some of the bracelets contain Radio Frequency Identification (RFID) technology to facilitate identification. Despite of the advancement in the ID technology the

Infant-mother mix-ups happens more than 23,000 times each year [4]. Footprint acquisition is another method employed using a high resolution sensor (above 1500dpi), but data acquisition procedure was difficult and little time taking.

Latest solution for the identification of a new born baby is the use of a new biometric technique called Baby Footprint Identification [5]; this is a very recent and advanced technique. The pros and cons of this technique are listed in Table no 1.1. Sample images of the software that captures the footprints are given in figure no 1.1

S.No.	Advantages	Disadvantages
1	Image acquisition is fast, so reduces time for capturing footprint image.	Use of inadequate materials (ink, paper, cylinder);
2.	More reliable than other types of newborns footprints identification. Example : taking a picture of footprint	Untrained personal for footprint acquisition can lead to poor data
3.	If high resolution scanner used to scan ,greater resolution would yield better results	Baby's skin covered with an oily substance that makes data acquisition difficult.
4.	Fast and accurate identification.	Reduced thickness of the newborn epidermis, easily deforming the ridges upon contact and filling the valleys between ridges with ink and reduced size of new born ridges i.e. five time smaller than adults.

Table 1.1 Advantages and Disadvantages of Footprint Identification among Newborns

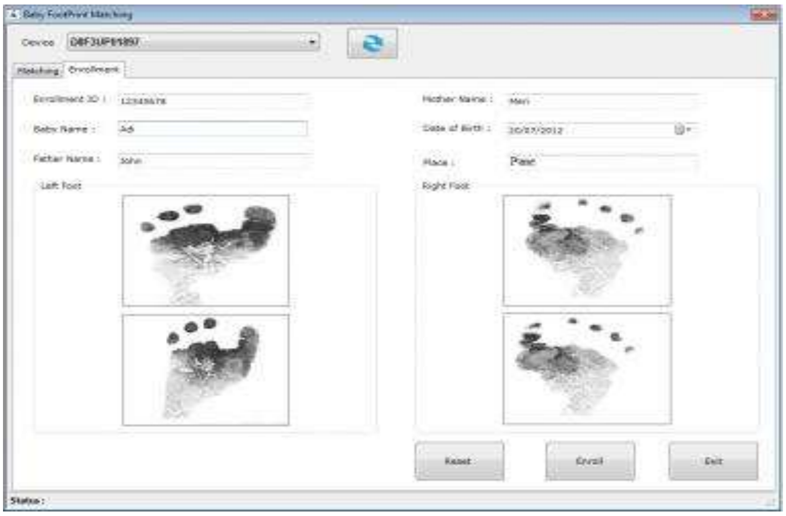

Fig1.1 Foot Print Enrolment sample of a newborn [5]

The consideration of growing demand for a highly advanced facial recognition system is essential. There is a requirement of facial recognition system that is able to recognition a newborn baby and his parents. It would be worthy to further enhance the robustness and adaptively of the existing recognition system for this purpose.

1.2 Biometrics: Core of Face Recognition

The roots of facial recognition lies in the field of biometrics, therefore the knowledge of biometrics and its basic characteristics is paramount. The term “Biometric” is composed of two Greek words bios meaning life and metrics meaning measurements thus, biometrics is the science and technology of measuring and analyzing biological data, in computer sense it means the automatic identification or verification of the identity of a person based on physical characteristics and/or behavioural.

Biometric recognition is one of the most eminent techniques in day today security issues. The basic advantage of biometric recognition is its uniqueness and robustness.

Biometrics is a very interesting technology, because it can be embedded into any application system that require security or access control, therefore it effectively eliminate risks connected with less advanced technologies of similar types.

Although the most common biometrics are fingerprints and iris, but several other human features have been studied in past few years such as signature, voice, face finger/palm geometry,. Figure 1.2 shows the distribution of the most popular biometrics in the few years from a commercial viewpoint.

Like all the other technologies biometrics too have drawbacks. Iris recognition is extremely accurate, but being expensive it is not acceptable among people .Fingerprints are quite reliable and non-intrusive, but unsuitable for non-collaborative individuals. FR on the converse seems to be a good middleware between reliability and social acceptance in addition it balances security and privacy very well.

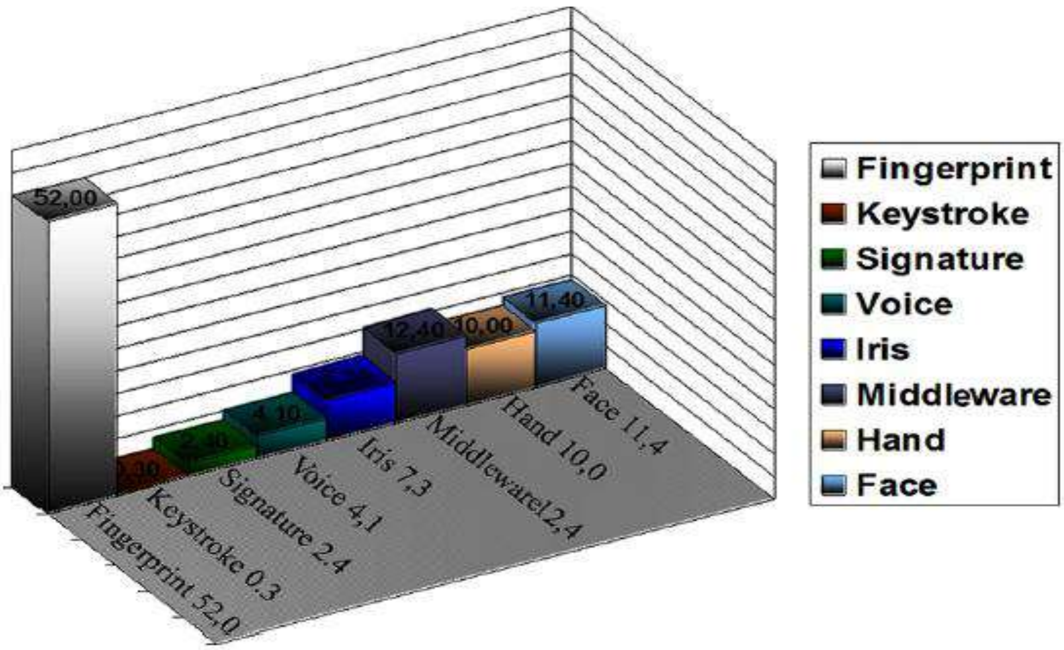

Fig 1.2 The spreading of most popular Biometrics [6,7]

1.2.1 Biometrics Characteristics

The conceptual structure of biometric system is based over its characteristics; the illustrations of these characteristics are present in figure.1.3. Biometric system can be developed when it satisfies the following characteristic requirements:

- ***Universality***: Each and every person worldwide should have a biometric characteristic on the basis of which he/she can be represented, for example every person bears a thumb impression which is unique character.
- ***Distinctiveness***: Any two persons should be sufficiently distinct in terms of a biometric characteristic measure. Taking the above example any two persons will have different thumb impression which distinctively measurable.
- ***Collect-ability***: Biometric characteristic can be measured quantitatively with ease. For example collection a sample of face is typically easy using a camera, where as it is difficult to take a retina sample of a person, but it is possible.

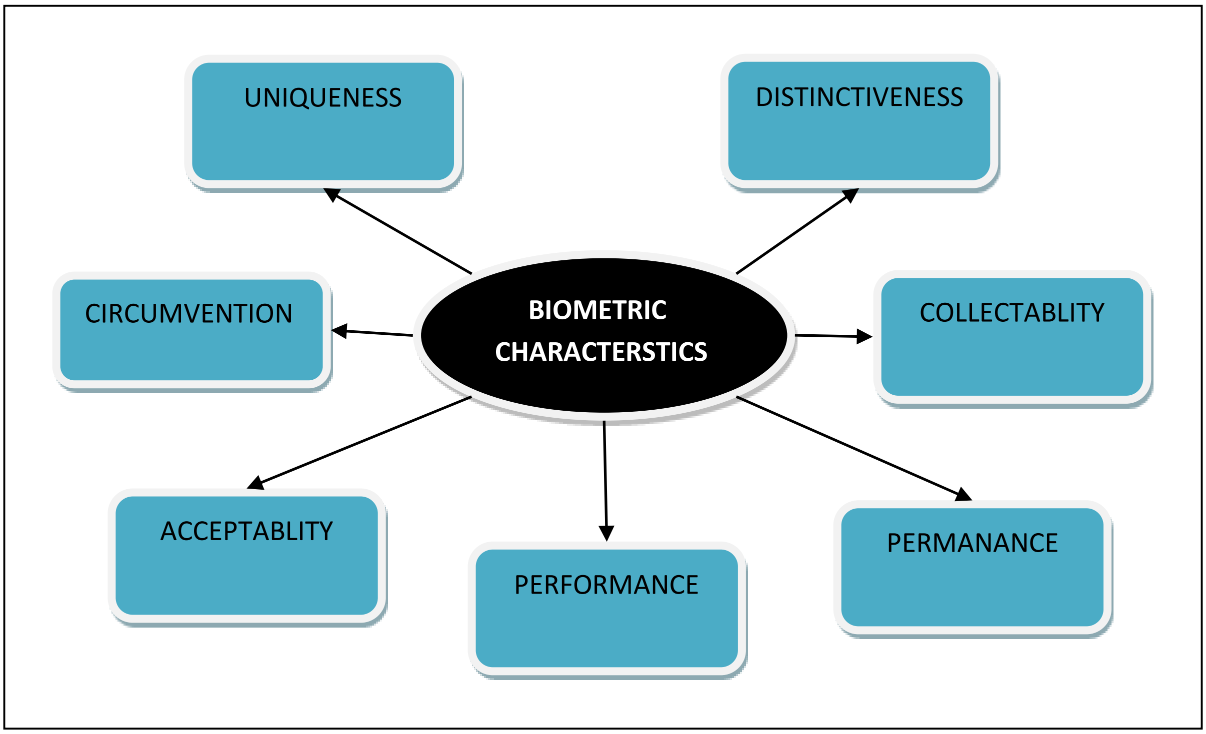

Fig1.3Characteristics of Biometrics

- ***Permanence***: Characteristic should be sufficiently invariant (with respect to the matching criterion) over a certain period of time. Taking an example of FR as a person grows in age his or her face changes over a time.
- ***Performance***: This characteristic refers to the achievable recognition accuracy and speed, the resources required to achieve the desired recognition accuracy and speed, as well as the operational and environmental factors that affect the accuracy and speed.
- ***Acceptability***: This characteristic indicates the extent to which people are willing to accept the use of any particular biometric identifier (characteristic) in their daily lives. For instance, Aadhar cards in India are now being accepted criteria for biometric authentication
- ***Circumvention***: It reflects how easily the system can be fooled using fraudulent methods or could be avoided. For example in voice recognition any person's voice can be recorded and the biometric system can easily be fooled.

1.2.2 Biometrics: Block Structure

A Biometric system comprises series of steps that are implemented to authenticate and validate an individual. The procedure of this system can represented as in figure 1.4. The process specifies the actions that are actually performed when a trait of a person is either verified or enrolled (first time user).

A Biometric system encompasses the following step by step building blocks:

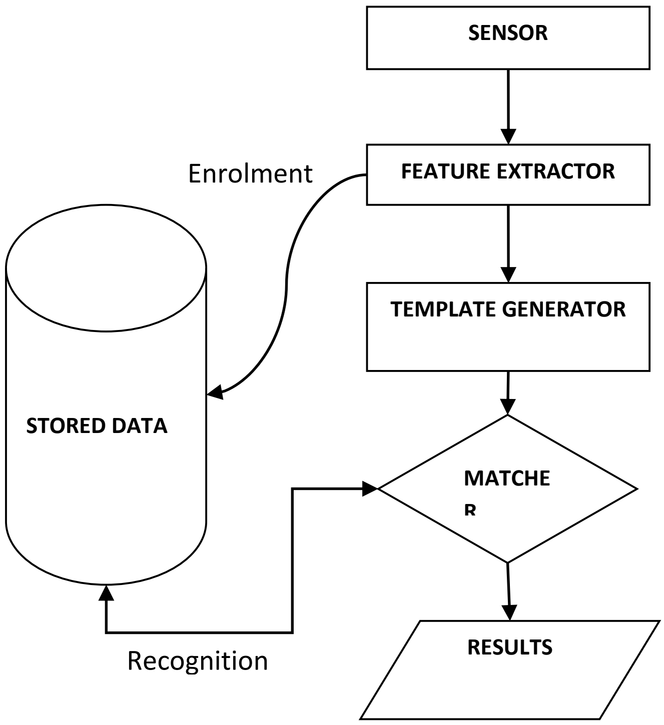

Fig1.4 Procedure of Biometric System

1. **Sensor**: It is the block that acquires all the necessary data that will be used in the system. For instance, a camera lens that collects image for facial recognition.
2. **Feature Extractor**: The extraction of the desired feature is generated and forwarded for template creation. Various algorithms are implemented at this block for the extraction of the desired feature. For example nose shapes are extracted from a face for analysis.
3. **Template Generator**: A template is a synthesis of the characteristics in of a feature extracted in the optimal size to allow for adequate identifiably .The template of the feature is generated and stored for the enrolment or recognition.
4. **Storage**: During enrolment is being performed, the template is stored somewhere within a database. When recognition is being performed, the obtained template is passed to a matcher that compares it with other exiting templates.
5. **Matcher**: The recognition process is performed at this block, and then conclusions are derived. A varied range of recognition algorithms are incorporated at this matching block, as this is the major section that draws the consequence of procedure. Results are then forwarded as a data after the matching process is done.

1.3 Fundamentals of Face Recognition System.

Principal basis of FR system is the physical characteristics of the face and is then the adjoining, in actual, human concept called **"**personal recognition**"**. Usually, enrolment takes a only some seconds that is essential for capturing of frames from still images. Though, images can be captured from a video source but this research scopes around still images. Some systems can sort a user from multiple angles achieving a 3D model of the face. The user's agreement for the feature based biometrics is generally high as it is a natural and non- invasive nature of the acquisition method. Moreover, FR type of biometric technique has a benefit of low invasiveness (no physical contact) and to provide the likelihood of attaining a remote subject to recognize. The first step involves of an automatic system that examine the information enclosed in faces, such as verifying identity, is the Face Detection (FD). Usually the FR system follows of two major steps: a) Face Detection and b) Face Recognition these steps are discussed the later sections.

1.3.1 Face Detection:

The basis of face recognition is concerning about face detection. This is a fact that detection seems quite peculiar to numerous researchers these days. However, an individual must be proficient to unfailingly find a face and its features before face recognition is possible. Segmentation problem in practical systems is basically the one in which most of the attempts go into working out this job. In actuality, it is only a petty last few step in the major recognition based on features extracted.

There are two types of face detection procedure:

1) Face detection in images

Most FD systems make an effort to extract a particular feature of the whole face, thereby removing most of the inadequate part and other areas as in an individual's head hair are nonessential for the FR task . For static images, FD is often done by running a 'window' across the image.[8] Using, FD algorithms the FD system judges whether or not a face is present inside the window. With static images there is enormous search space of potential locations of a face in an image. Faces may be either smaller or larger else it may be present somewhere in the image from the lower right to upper left.

Most FD systems use an illustration based learning approach to determine whether or not presence of face is there in the window at that given time [9,10]. Using supervised learning with 'face' and 'non-face' examples, a classifier or a neural network is trained, thereby facilitating to classify an image (window in face detection system) as a 'face' or 'non-face'. It is relatively effortless to find face examples, but unfortunately for an individual finding a representative example of images which presents non-face is tedious. Therefore, FD systems implementing example based learning require thousands of 'face' and 'non-face' images for efficient training.

There is an additional practice for determining whether there is a face inside window is using Template Matching[14]. The difference between a fixed target pattern (face) and the window is calculated and thresholds are obtained. If the window contains a pattern which is nearly matching to the target pattern (face) then the window is containing a face is concluded. An execution of template matching called Correlation Templates. It uses a whole compilation of fixed sized templates to find facial features in an image. Using a number of templates of diverse (fixed) sizes, faces of separate scales (sizes) are distinguished.

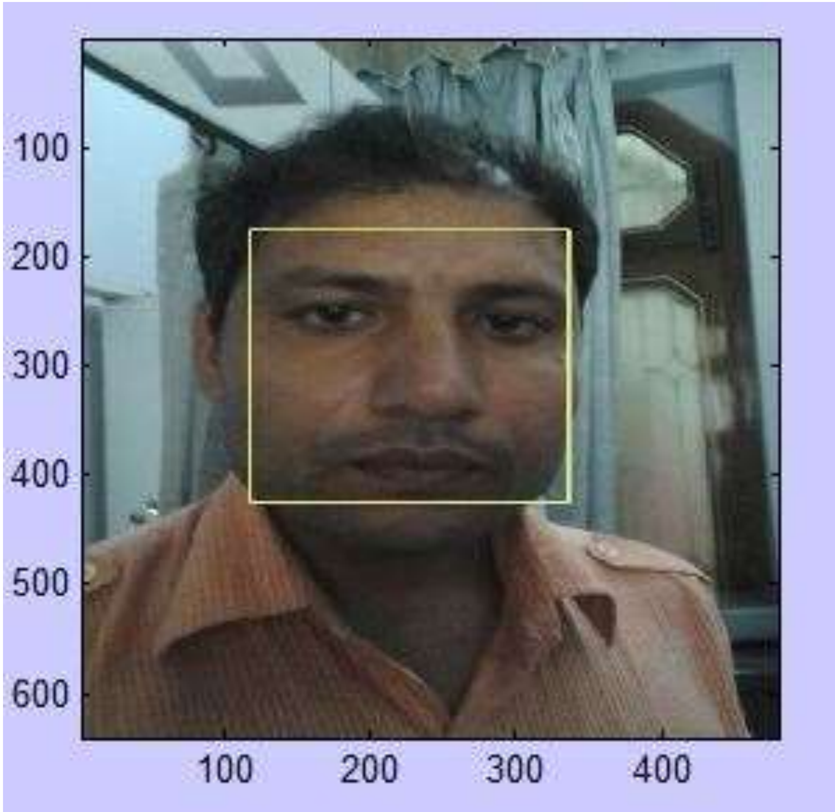

Fig1.5 Window based Face detection

2) Real-time face detection.

Real-time FD includes detection of a face from a sequence of frames from a video-capturing device. Real-time FD is, in reality is an effortless procedure than detecting a face in a still image whereas the hardware requirements for this type of a system are far tougher, from a computer vision perspective. The reason of real-time FD being an effortless process is that, in contrast most of our neighbouring environment, people are always (or mostly) moving.

In real-time FD, the system is offered with a sequence of frames for detecting a face, by implementing spatio-temporal filtering (finding the difference between subsequent frames), the area of the frame that has changed can be identified and the individual detected [11,12].

1.3.2 Key Challenges in Face Detection:

The aim of Face Detection (FD) system is to locate and remark an image presented as an input to sensor system. The detection process goals to determine whether or not there are any faces in the given image. This appears to be a very trivial task while discussing in case of humans but on the other hand it is one of the most challenging task for computing machines and it has been a part of top researches from past many decades. Some factors that lead a FR system to be challenging task while detection are:

- **Face orientation**: A face can appear to be different over many poses. For example the face provided in a frontal or a profile (i.e. sideways) position appears different comparing the same face by rotating it in plane (say inclined at an angle of 45'), so Therefore, a face appears in many different shapes in an image.
- **Face size**: The face of a Human varies in many sizes. Not only do the persons have wide range of facial size, the distance of a face from camera lens can emerge to make variable size of a face. For instance, a closer camera capture larger facial image and a smaller sized image are captured when camera is kept at some distance.
- **Different facial expression**: The appearance of any person while crying will be totally different while laughing. Therefore, the facial expressions are directly related to the appearance of any face.
- **Different facial feature**: Some people may bear moustache or a beard, wear glasses or having any scar .Such features are known as facial features. There are innumerable illustrations of facial features and they all vary in shape, size and colour.
- **Occlusion:** Faces in images may be fully or partially occluded. As in case if a person standing in front of another or any item that is placed in front of the face. Therefore only a part of face is visible.
- **Lighting condition**: Appearance of a face is totally different when distinct lighting conditions are used. For instance when lightening is used sideways, a part of the face is very clear and bright while the other part is very dark and shadowy.

1.3.3 Face Recognition Phases

In general, facial recognition can be decomposed into four phases[13]:

- **Pre-processing:** This means ensuring that the image which is applied to the recognition process meets certain required standards: for such that the face is located in the centre of the image and provided part of the same; that the background satisfies certain constraints, and so on. Usually this phase is done by sampling equipment designed to image through mechanisms that tend to prevent the user from providing distorted images: an example may be the sensors necessary to capture the image when the subject is an acceptable distance.
- **Phase segmentation or localization:** is the exact location of the face or certain parts of it. This phase arises from the need to characterize, through some characteristic features, The face of a subject.
- **Feature Extraction Phase**: maybe it is the core of the whole face recognition process. A feature it's a characteristic useful for distinguish a face from another. It can be extracted from the image through different kind of processes. Usually, higher is amount of extracted features, the higher is the capacity of discrimination between similar faces. Some interesting features are, for example, the eyes or hairs color, the nose or the mouth shape. Those features are usually referred as locals because they refer to a particular and restricted area of the image.
- **Recognition Phase:** once the image is associated with an array of values, the recognition problem reduces itself to a widely studied problem in the past literature: the main part of those is then mainly related to the features extraction. The recognition problem can be divided into three phases: deciding over which features the recognition will be done; automatic extracting the chosen parameters from the face digitalized image; classifying the faces over the acquired parameters

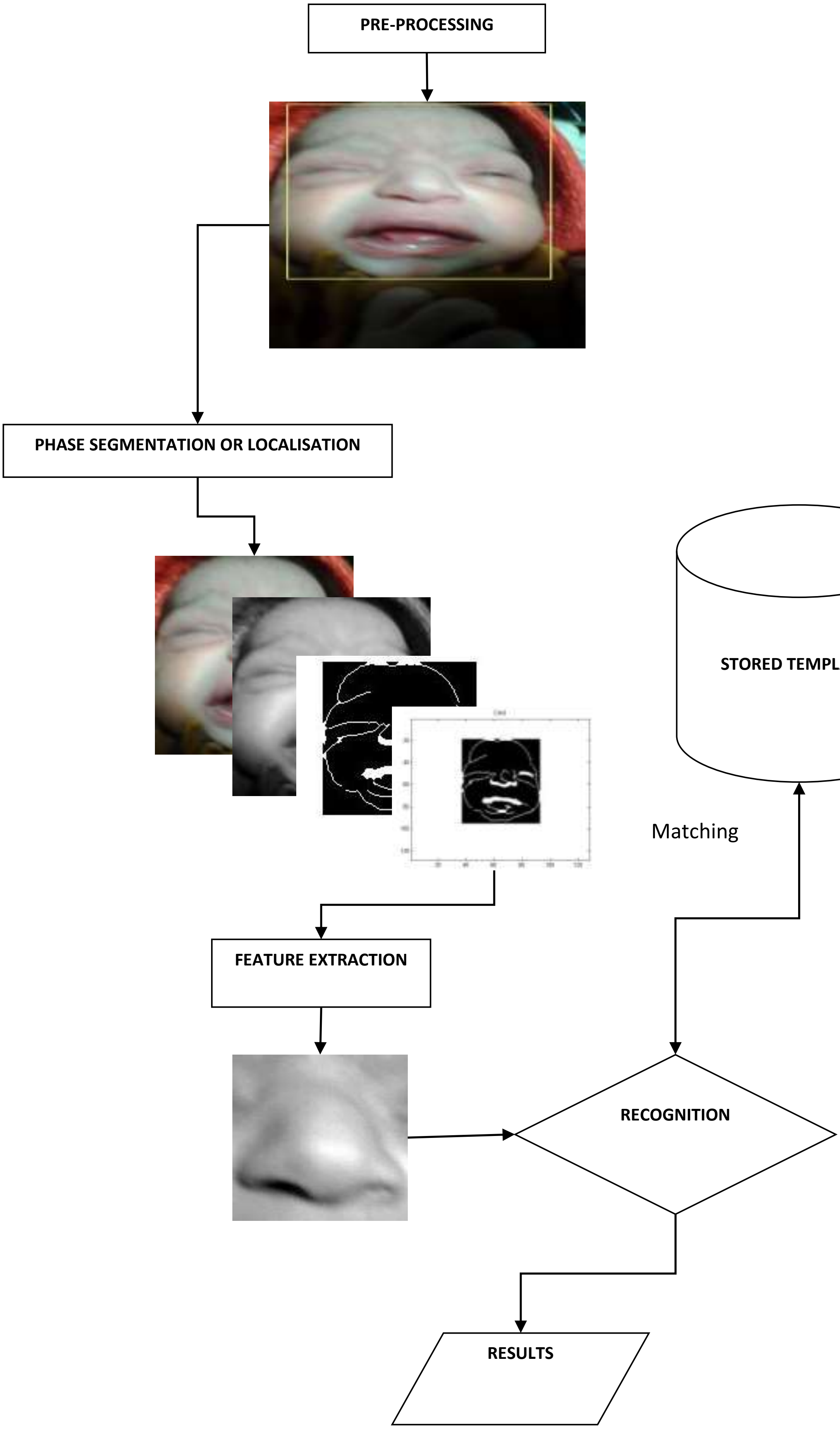

Figure 1.6 Face Recognition Phases

1.4 Face Recognition Applications

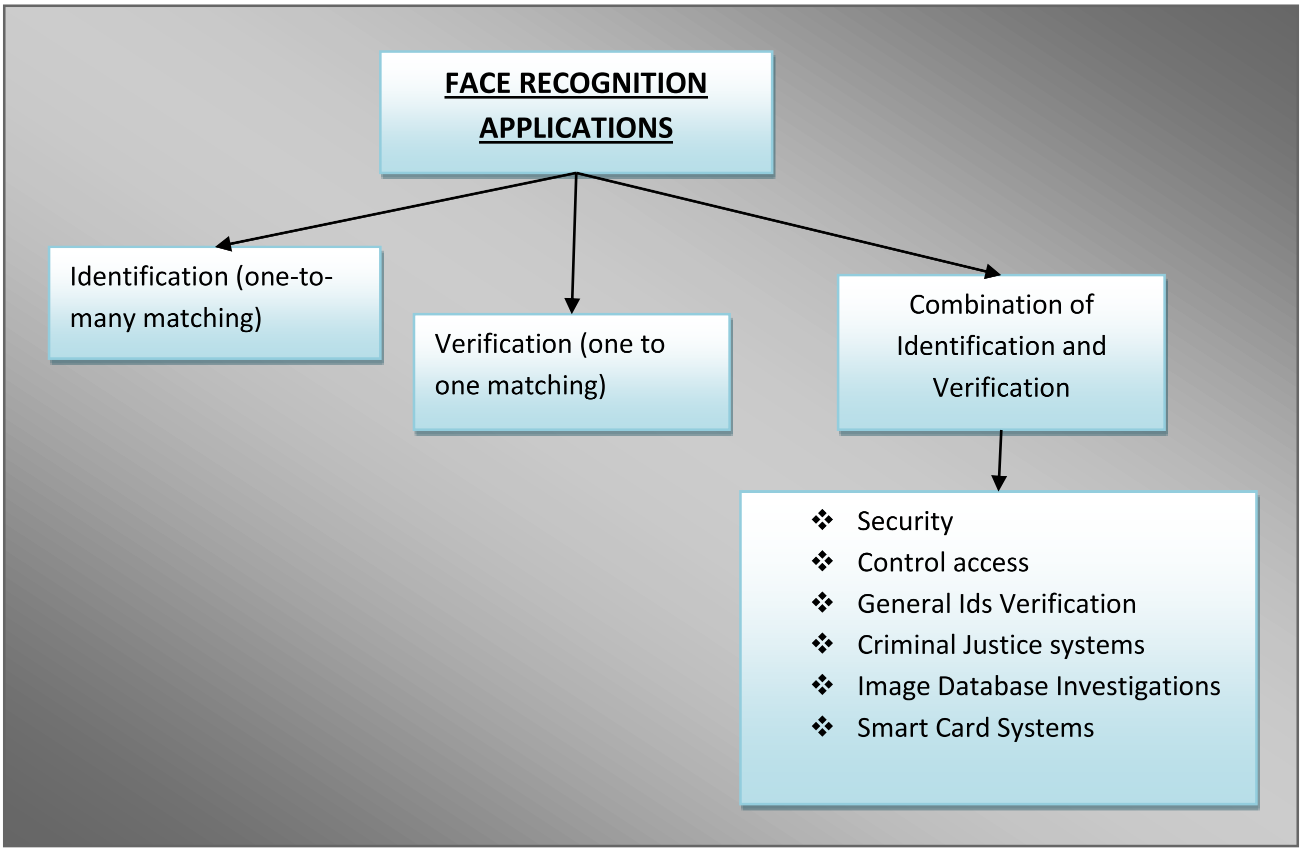

Fig. 1.7 Applications of Face Recognition

There are many applications of FR (shown in figure 1.7) which are focussed long two main principal tasks:

1. Verification (one-to-one matching): When presented with a face image of an unknown individual along with a claim of identity, ascertaining whether the individual is who he/she claims to be [15].

2. Identification (one-to-many matching): Given an image of an unknown individual, determining that person's identity by comparing (possibly after encoding) that image with a database of (possibly encoded) images of known individuals [15].

There are abundant application areas in which FR can be embedded for these two purposes, a few of which are summarized below.

a) **Security**: access control to buildings, airports/seaports, ATM machines and border checkpoints [16]; computer/ network security [17]; email authentication on multimedia workstations:

b) **General identity verification**: National Ids, banking systems, electronic commerce, passports, drivers' licenses, identifying newborns, employee Ids, electoral registration

c) **Criminal justice systems**: Forensic analysis, maintaining a database at the ATM's for tracking of criminals, police database maintenance.
d) **Image database investigations**: Searching image databases of missing children, benefit recipients, police bookings, immigrants and licensed drivers.
e) **Smart Card applications**: In lieu of maintaining a database of facial images, the face-print can be stored in a smart card, bar code or magnetic stripe, authentication of which is performed by matching the live image and the stored template [18].

1.5 Research Overview

In this section, the detailed information about the thesis is being presented. Initializing, by identifying the importance of the research in social life including the motivations (already mentioned in section 1.1), objectives to be attained, followed methodology, and the contributions right through this work and in the end demonstration of the content in the research.

1.5.1 Objectives

The presented research surveys the strengths, capabilities, and weaknesses of a new proposed technique based on Hidden Markov Model (HMM) and Singular Value Decomposition (SVD) Coefficients techniques for facial recognition of newborn baby and identification of his parents by comparing the two faces.

The elementary objective for this research is twofold. First, it surveys a practice for detecting and generating a database of newborn's face precisely from still images considering the different susceptible environment that can be present in the image. Second, it routes the detected face as a previous step for helping in be familiar with the parent's face using robust recognition techniques.

1.5.2 Methodology

The tool incorporated for the research is MatlabR2010a. The basic technique implemented for the program is based on HMM and SVD coefficients. The well-designed Graphic User Interface (GUI) enabled programming system is developed using the Matlab that has mechanism divided into two major actions:

- **Database Generation:** For any system development the major and the most essential requirement lies into the data on which the system actually works on. For a FR system development for identification and recognition relating newborn database containing various images of the parents as well the newborn are maintained. The images holding several angles and illumination scenarios are stored so that all the possible detection and recognition can take place. The HMM training sets are implemented to store the new added images into database. The detailed analysis of the database generation has been discussed in the later chapter of this research.

- **Comparison and Result Generation:** This phase of comparison and results generation is the one where the concept of "Face Recognition" actually works on. The Hidden Markov Models are implemented to calculate the probabilities for various facial patterns, and these patterns are stored for further recognition process. The SVD coefficients are applied to the input images presented for recognition. There are few possibilities that arise when an image input is provided and they are:
  1. The input image (baby's image) belongs to the database, and will be compared with the desired image (parents 'image).
  2. The input image does not belong to the database and is needed to be trained first.
  3. The input image belong to database and is matching with the desired image
  4. The input image is not present in database and does not contain any face image.

Since there are a lot of possibilities that arise when any input image is selected, thus the detailed knowledge of the algorithms and all the functions is mandatory. Detailed explanation of this phase has been discussed in the later chapter of this research.

1.5.3 Our Contribution:

The thesis surveys the obstacle that appears in the facial recognition and comparison of a newborn's image with his biological parents. These obstacles vary from one to another but, no doubt they will affect any FR system. Though many researches are performed in the field of FR from past years but this field is still mystifying. Hence, it is essential for developers to incorporate system for recognising face of a newborn and then identifying their parents. The chief contributions of this research are highlighted here under:

- This research, provide approach that can overstep a wide range of recognition challenges that appears in FR systems to provide proficient results.
- The FD in the system is a Hybrid approach as the basic approach in searching for important training set for the face.
- This work is distinct from other researches because, it uses Hybrid approach for detecting different face which is together forms mixture of approaches that lead to detect the face efficiently and propose a robust face recognition (newborn's) and comparison with different parents.
- This research uses existing techniques such as HMM and SVD Coefficients to strength the proposed system in dealing with different illumination problems.

1.6 Thesis Outline :

This thesis initiates by providing a background and the related work in the FR field in Chapter 2, it provides a brief review about the FR approaches related works done in this field previously and their results. In Chapter 3, thesis proceeds with an introduction to familiarize with the research objectives, contribution, and methodology. It presents of a brief survey of known techniques of HMM SVD. Chapter 3 also contains thorough and formal description of this thesis work. Afterwards, Chapter 4 evaluates the results of the system developed and discussion relating the issue raised for the recognition of an infant; it elaborates test results of the proposed system in FR using developed face databases. The Chapter 5, explains future scope and the motivation behind the need of developing a robust FR system for the new born baby in lucid manner, it also describes the benefits of developing the proposed research. Chapter 6 concludes the thesis with a list of relevant reference implemented for the research and these references can be further used for the detailed survey of the mentioned technique.

CHAPTER 2 LITERATURE REVIEW

2.1 OVERVIEW

This chapter presents a significant evaluation of the previous research published in the literature concerning to FR among newborns as well as the general FR approaches. There are many research performed for the face recognition of adults using HMM and SVD approaches but using the same technique there are very few surveys over the face recognition of the newborn babies. For the recognition of the newborn babies, most recent researches have been performed in the year 2013 only. These researches highlights the generation of database and use of soft biometrics for the generated database. Interestingly, the area of research for the newborn's FR mainly confines to Indian researchers, though the problem establishes the global concerns but the solution is highlighted within a particular region

The outline of this chapter operates into three major sections. In the section 2.2 and section 2.3 the all approach implemented for identification of newborn other than FR is being discussed, section 2.3 mentions the evaluation of the research based on the recognition of newborns using different approaches. Section 2.4 mentions the discussion relating the previous work performed for the FR using HMM and SVD techniques.

2.2. Genetic Methods for Identification of Newborns

"**Genetics** is a discipline of biology, is the science of genes, heredity, and variation in living organisms" [19] [20]. The HLA and DNA techniques are one of the essential identification modes for the closely related persons. Heredity concept is the passing of traits from parents to their child, and these concepts are used for indentifying a baby to his real parents. Both of the methods are discussed in the further sections.

2.2.1 Human Leukocyte Antigen (HLA) Technique

Human leukocyte antigen (HLA) is a protein or marker found on most cells in of body especially in all the vertebrates and is used to match newborn with that of a suspected parents. The origin of HLA is found in the genetics involving inheritance concept.

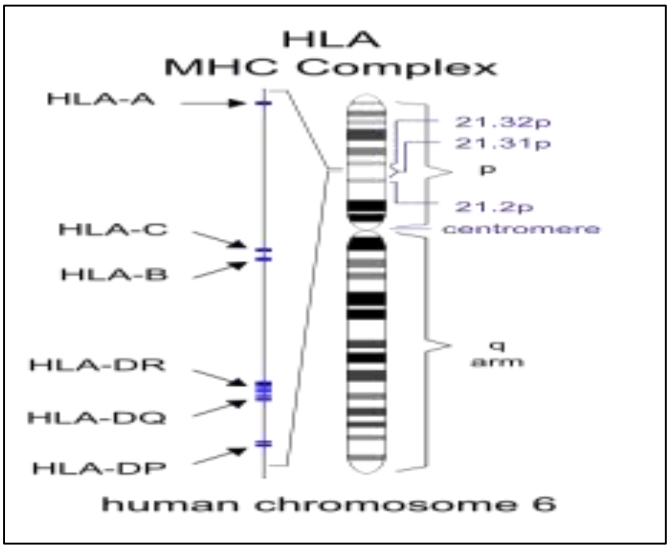

Fig.2.1 Typical Diagram of HLA [21]

An illustration of HLA is shown in fig. 2.1 and it explains various types of HLAs and the centromere present on the sixth chromosome of a human. Mainly, HLA techniques are used for the donation of bone marrow or a cord blood transplants. In the case of transplants, the best result occurs when an acceptor's HLA and the donor's HLA closely match. The research area for HLA typing is very vast as it more used in the stem cell (special type of cell present inside bone marrow of a human) research. A typical diagram of bone marrow and the extracted stem is shown in fig 2.2. Haematopoietic stem cells are specialised cells that have the capability to adapt into new type of others cells; hence these cells are used for donation. As the scope of this research is restricted to recognition among newborns therefore further details of stem cell transplant is not essential.

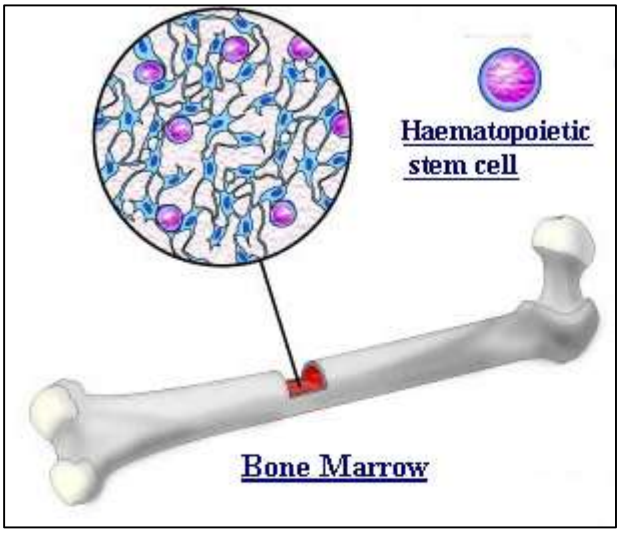

Fig.2.2 An illustration of Bone Marrow and Stem cell

The role of HLA for the recognition purpose is that half of the HLA proteins are inherited from mother and other half from father. Even the siblings have 25%, or 1 in 4, chance of matching type of HLA. It is very opportune that family members' HLA can be used for matching the newborn. Under very rare conditions, family members and other siblings may differ the HLA architecture of the baby.

HLA Matching

There are various HLA markers every one bearing a unique name. The names are either combinations of letters or letters and numbers. Researchers or scientists re-examine at least eight HLA markers for these min needs: [22] two A markers, two B markers, two C markers, and two DRB1 markers. Some doctors look for an extra marker, called DQ, to examine [22].

Illustration of the HLA process is shown in fig 2.3 and these illustrations can be explain here as:

Example A Shows that the parent's markers match with the baby's. When HLA markers A, B, C, and DRB1 [22] from the parent and the baby match, it is known as 8 of 8 matches. When A, B, C, DRB1, and [22] DQ markers all match, it's known as 10 of 10 match.

Example B Shows that one of the parents's A markers do not match with one of the baby's A markers. Therefore, this is a 7 of 8 match or, if the DQ marker matches, a 9 of 10 match [22].

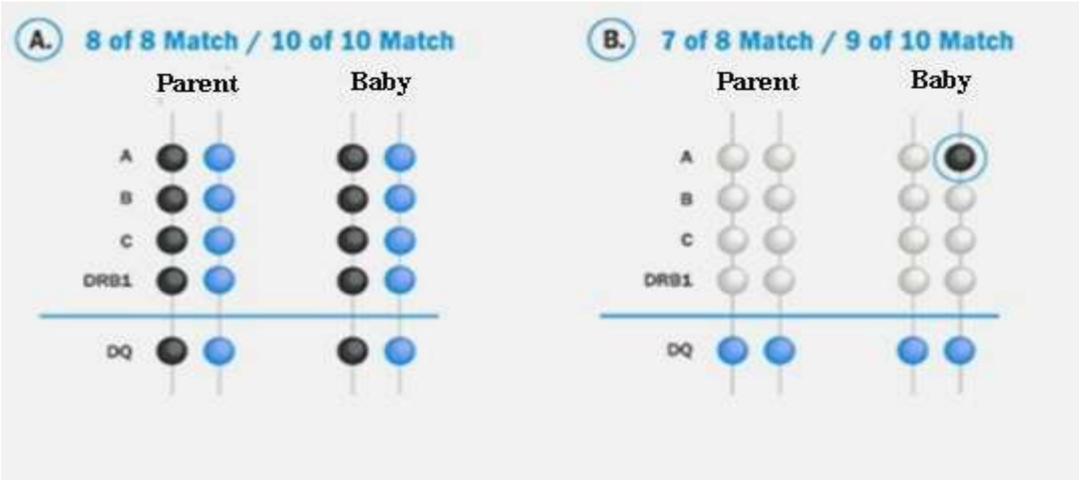

Fig2.3 Examples of HLA Matching

The HLA matching is more effective for bone marrow transplants [22]. The major function of HLA lies into HLA markers matching for the implantation of bone marrow from a donor and transplantation of it into a receiver or patient. But the HLA matching for the detection cannot be 100% right in its final results. Moreover, the HLA matching is not much cost effective approach when it comes to match HLA's of the family relations [22]. Thus, this method is not much used to identify parents of a newborn baby.

2.2.2 Deoxyribonucleic Acid (DNA) Matching

One of the major applications of DNA lies in "Parental Testing". **Parental testing** is the "use of genetic fingerprinting to determine whether two individuals have a biological parent–child relationship" [23] .Genetic Fingerprinting is the use of DNA samples for identification of an individual by his respective DNA profile.

The information in DNA is stored as a code made up of four [23] chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). Human DNA consists of about 2 billion bases, and more than 99 % of those bases are the same in all people. The sequence of these bases describes the information available for maintaining and building an organism, similar to the way in which letters of the alphabet [23] appear in a certain order to form words and sentences.

The definition of DNA can be defined as "**Deoxyribonucleic acid (DNA)"** is a [23] molecule that converts the genetic instructions used in the improvement and functioning of all known living organisms [23] and many viruses". Fig 2.4 shows a well labelled configuration of DNA.

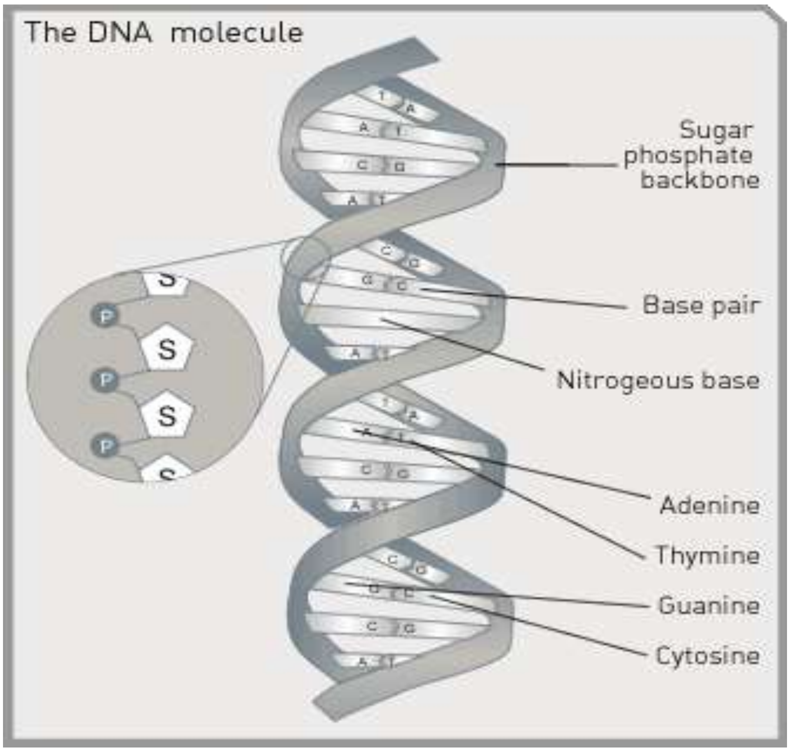

Fig2.4 Structure of DNA

DNA bases set up with one other, A with T and C with G [23], to form units called base pairs. Every base is also enclosed to a phosphate molecule and a sugar molecule. Together, a base, phosphate and sugar are defined as a nucleotide. Nucleotides are managed in two long components that form a spiral defined as a double helix. The architecture of the double helix is slightly like a ladder, with the base [23] pairs forming the ladder's rungs and the phosphate and sugar molecules making the vertical sidepieces of the ladder.

A principal property of DNA is that it can duplicate, or make copies of itself. Every strand of DNA in the double spiral can serve as a pattern for duplicating the arrangement of bases. This is crucial when cells divide due to every new cell needs to have a particular copy of the DNA exist in the old cell.

Role of DNA Profiling in Parental Testing

The process begins with a sample of an individual's DNA (typically called a "reference sample"). The most desirable method of collecting a reference sample is the use of a buccal swab, as this reduces the possibility of contamination. Samples obtained from blood relatives (biological relative) can provide an indication of an individual's profile, as could human remains which had been previously profiled.

The DNA of an individual is the alike in each somatic (non reproductive) cell. Sexual reproduction conveys the DNA of both parents together casually to create a unique combination of genetic [23] material in a new cell, so the genetic material of an individual is originated from the genetic material of both parents in equal quantity. This genetic material is also known as the nuclear genome of an individual.

Comparing or matching the DNA sequence of the individual to that of other individual can show whether one of them was [23] derived from the other. However, DNA paternity tests are not currently 100% accurate. Specific sequences are usually looked at to see whether they were copied verbatim from one of the individual's genome to the other. If that was the case, then the genetic material of one individual could have been derived from that of the other (i.e., one is the parent of the other). Besides the nuclear DNA in the nucleus, the mitochondria in the cells also have their own genetic material termed the mitochondrial DNA. Mitochondrial DNA comes only from the mother, without any shuffling.

Proving a relationship based on comparison of the mitochondrial genome is much easier than that based on the nuclear genome. However, testing the mitochondrial genome can prove only if two individuals are related by common descent through maternal lines only from a common ancestor and is, thus, of limited value (for instance, it could not be used to test for paternity).

In testing the paternity of a male child, comparison of the Y chromosome can be used since it is passed directly from father to son.

In the US, AABB has regulations for DNA paternity and family relationship testing, however, AABB-accreditation is not necessary. DNA test results are legally admissible if the collection

PROFILES IN DNA

CASE REPORT

Identifying the Parents of Two Abandoned Infants

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CRIMINAL INVESTIGATION

On July 23, 2006, a resident of a small community of French expatriates in Seoul, Korea, made a gruesome discovery when he opened his freezer after returning from a vacation with his wife and sons in France. He found the frozen bodies of two babies, umbilical cords still attached, stuffed into separate plastic bags. He reported his discovery to the Bangbae Police, who immediately began an investigation.

The frozen state of the two babies made the age and complexion difficult to verify. The umbilical cords and presence of meconium indicated they were newborns. There were no signs of external wounds. Faint blood stains were discovered in the washroom and living room and on the veranda, and the towel and vinyl bag that covered the corpses matched others found at the residence. The Bangbae Police concluded that the infants were probably born at the residence. Autopsy results indicated that the infants were less than 1 week old and probably of Caucasian or mixed blood descent. The infants' lungs were filled with air, indicating that they died after birth. The uneven cut of the umbilical cords suggested that the infants were not born at a hospital.

The police interviewed the resident and learned that all doors and windows of his villa were equipped with security alarms, and only the Philipino housemaid and one of the resident's friends had card keys to enter the house. There were no signs of trespassing, and security records showed that the friend was the only person to check in with the card key while he was away. However, the police did not consider the resident a suspect because he had made the initial report to the police, he cooperated fully in the investigation and had high social status in Seoul. The police began to pursue a lead about a young Caucasian girl who was seen wandering around the villa door to determine her relationship with the resident's friend.

Here we answer questions of maternity and paternity of two abandoned infants.

DNA ANALYSIS

DNA from the infants was submitted to the National Institute of Scientific Investigation (NISI) for STR analysis to shed light on the infants' parentage. Police also collected saliva and hair samples from the resident and blood samples from his two sons. STR analysis showed that the two infants were not identical twins. A paternity test using Y-STR markers showed that all 17 markers of the infants perfectly matched those of the resident, who was assumed to be the father of both babies.

The police now focused on identifying the babies' mother. A maternity test based on mitochondria DNA revealed that the babies shared the same mother. The housemaid's DNA was tested, and she was found to be unrelated to the infants. Unfortunately, the resident's wife was still in France, and her DNA was unavailable for testing, so the Bangbae Police collected DNA from toothbrushes, a comb and an ear pick at the home. DNA analysis yielded six DNA profiles, three male and three female. One of the female DNA profiles was excluded as that of the mother. The other two identical female profiles were consistent with the mother, and since the DNA was found on the wife's items within the house, the Bangbae Police

Fig2.5 Case Study

and the processing follows a chain of custody. Fig 2.5 and 2.6 illustrates a case study based on DNA

PROFILES IN DNA

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believed that she was the mother of the two dead infants. However, without verification, the mother couldn't be identified conclusively.

Two of the male DNA profiles were those of the resident and confirmed his paternity of the two infants. Autosomal and Y-STR analysis of the third male DNA indicated that the DNA was from one of his sons. mtDNA tests confirmed the fraternity between the third DNA and the two dead infants.

Meanwhile, the resident had obtained permission to return to his vacation in France. When officials at the Embassy of the Republic of Korea in France asked for the couple's early return to Korea, he denied paternity and any knowledge of the deaths but agreed to return to Korea on August 28, as soon as his vacation was over.

That changed when the resident was confronted with new DNA evidence. Investigators learned that his wife had a hysterectomy in 2003 and paraffin-embedded tissue from that surgery was available. Analysts at NISI extracted DNA from the tissue and determined that 11 STR markers matched exactly the DNA profile from the wife's household items. Bangbae Police officially announced that the DNA results were consistent with maternity of the two dead infants, and she became a prime suspect. The resident tried to cast doubt on the DNA results by saying "We are not the babies' parents and cannot trust the Korean DNA results. We will not return to Korea but will remain in France."

DISPELLING DOUBT

As the French investigation became more active, this case received more attention in the media, and French people, as well as some Korean people, doubted the DNA test results. At NISI, we were confident of our results. This case was processed as any other case would be, using the expert DNA witness system, which specifies clear objectivity and transparent recording of all steps.

To ensure reproducible and accurate results within a short time NISI uses the cross-checked system, in which results undergo extra verification and reliability testing. Materials are divided into two samples to generate separate profiling data using two different detection systems: the Applied Biosystems Identifiler® Kit and Promega PowerPlex® 16 System. Using this method NISI obtains data from 17 STR markers, including 13 STR markers (TH01, TPOX, CSF1PO, D3S1358, vWA, FGA, D5S818, D13S317, D7S820, D16S539, D8S1179, D21S11 and D18S51) and Amelogenin. The Korea Laboratory Accreditation Scheme approved these methods for STR marker and mtDNA testing in August 2004 and for Y-STR testing in 2005.

The resident tried to cast doubt on the Korean DNA results, but the results of DNA testing performed in France were no different.

In September, the couple agreed to submit to DNA tests performed in France, and these results were no different from those generated at NISI. The resident and his wife were the infants' parents.

A CONFESSION

The wife confessed her crime after Korean and French Police published that she was the mother of the two infants. She had choked the fraternal twins to death as soon as she delivered them in her bathroom in November 2003, then placed them in the freezer. She also confessed to killing a baby in France before she came to Korea. She insisted that she committed the crimes and her husband had no knowledge of her pregnancy or the delivery and murder of the babies because he was frequently away on business trips.

UNANSWERED QUESTIONS

DNA analysis answered the questions of paternity and maternity, but there are still many unanswered questions. When and where were the babies born and abandoned? Were the babies really twins? Why did she abandon them in her freezer for such a long time? Did the husband know about the pregnancy or murders?

The exact date and location of the murders have not been verified. The wife claims the babies were twins, but they could be siblings if the first child was born between August 2002 and February 2003 and the second child was born in November 2003.

She insisted her husband was innocent, but it is unclear how he didn't know about her pregnancy. If the dead infants were siblings, the wife must have been pregnant in August 2002 when they moved to Korea, then again in 2003. If the babies were twins, her abdomen would be clearly visible during pregnancy as the two babies weighed 3.24 kg and 3.63 kg. However, there is a record of the wife leaving the house for 3–4 months on two occasions, so it is possible that her husband really did not know.

For now the police believe that the wife had an unwanted pregnancy and committed the crime alone. We are now waiting for the final investigation results from France.

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Fig 2.6 Case Study

Though DNA testing is very accurate and precise methods of testing the biological parent of baby but, the major drawback of this method is the cost inefficiency and the long time periods in the emergence of the results. Thus, this method is not much acceptable by the people.

2.3 Other Biometric Approaches for Identification of Newborns

There are also some other approaches to identify newborns like palmprints technology, footprint technology, RFID and ear identification etc. These technologies or approaches are discussed in the next.

Morgan and Pauls (1939) presented an approach for gathering palmprints of newborn babies, and said that they resulted good enough images to be used for detection, though no objective analysis of the [26] resulting images were provided, nor did they perform a matching test to support the statement.

To provide timely, exact information to families about newborn babies in neonatal care and reduce the chance of mother-baby mix-ups, Intel led a pilot project to automate the neonatal records system at [28] WonJu Christian Hospital in WonJu, Korea. Intel, working with LG CNS and ECO Inc., developed a DHS (Digital Healthcare System) for the hospital that uses the mobile devices based on [28] Intel® Mobile Media Technology, wireless networks and radio frequency identification (RFID) approach. The system provides newborns record automation and capture, mobile [28] point-of-care (POC) abilities, information sharing for families, and an RFID baby- mother match-up system.

2.3.1 Palm-prints Technique

Anil K. Jain [25] proposed a technique based on high-resolution palm print images, for newborn identification. He used a sensor (Cross Match LSCAN 1000P), to perform preliminary studies with the goal of developing an automatic system for newborn identification. Despite the major drawback of providing only 1000ppi pictures rather than the required 1500ppi, the Cross Match Sensor (CMS) is not ergonomically appropriate for newborns either, making it complicated to attain palmer pictures. However, he found that a division of the acquired images is definitely appropriate for detection.

He collected 1,231 palm prints images (4964 _ 5120 pixels, 256 gray levels, 1000ppi) from 250 newborns at the University Hospital (Universidad Federal do Paraná) to generate a database (NB ID). All pictures were acquired between 1 to 48 hrs after birth. He set up to five picture acquirement sessions each baby. In each session, he has collected three palm print images from the right palm. In order to automatically assess the quality of the images in the database, he use the method proposed in to classify the images into five levels: (1) good, (2) normal, (3) dry, (4) wet and (5) spoiled (Fig. 2.7).

The quality estimation results proved that only 6% of palm print images had enough quality to fulfil the needs for automatic matching and identification. The basic reasons for down rate of images classified as normal or good are the low sensor resolution (1000ppi), and complications in holding the palmer surface of newborn at the accurate pressure and position (to elude ridge deformation). He also categorized the images manually into these five quality levels and the manual categorization also showed that just 4.3% of palm prints images found as good.
He added that only images classified as “good” are helpful to make sure the identity of the infant after testing a many images for identification purposes before she/he leaves the hospital.

The very maiden step is to correctly set up the newborns' palm print to erase the oily stuff and create a fresh and clean surface, in order to develop a appropriate image acquirement protocol to acquire good images. To this last, the images were composed after using various cleaning methods (e.g., only water and soap, only alcohol (alcoholic graduation with Hydrated Ethanol of 70%) or both). In addition, he performed experiments concerning pressure (e.g., low or high) and disclosure time (e.g., one sec. of acquisition or approximately four secs using image pre-processing methods during the acquisition) in an attempt to obtain good quality images.

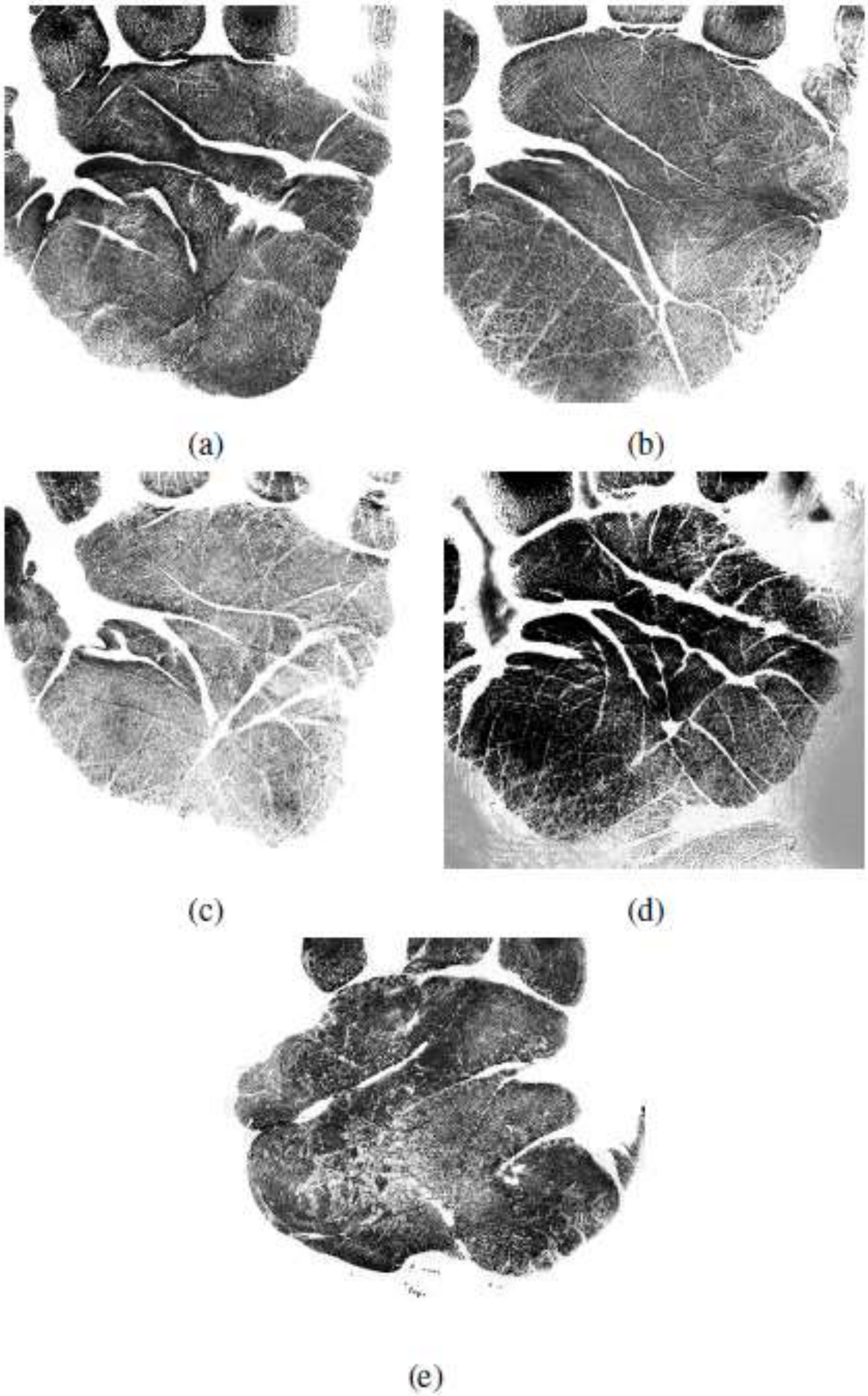


Fig. 2.7 Quality based image classification in Palm-prints: (a) good, (b) normal, (c) dry, (d) wet, (e) spoiled

2.3.2 Foot-prints Technique

Newborns footprints acquisition at birth is used for recognition in various countries since the initiation [26] of the 20th century (Shepard et al., 1966; Cat, 2003; Vaesken, 2006). Generally the footprints are taken with ink spread on the base of foot with a container and then printed on medical record of the newborns along with the mothers fingerprint. That way, it is supposed that any identity uncertainty about his/her mother or the baby can confirmed. Unfortunately, due to illegibility issues, the purpose of the footprints for recognition is not probably in the most of cases. According to [26] various studies (Cat, 2003; Shepard et al., 1966; Pel´a et al., 1975; Lomuto and Duverges, 1995; Thompson et al., 1981), the main reasons for illegible footprints are:

• Baby's skin enclosed with an oily material;
• Untrained personal for footprint acquisition;
• Use of in adequate materials (ink, cylinder, paper);
• The newborn epidermis's reduced thickness, simply deforming the ridges upon contact and filling the [26] valleys between ridges with ink;
• Reduced size of the newborns ridges, which are three to five times smaller than on adults.

It is only said by an author, Montgomery (Montgomery, 1926) that he could obtain newborns' footprints with clearly visible ridges, using a method (not described) developed (but not published) [26] by Prof. J.H. Mathews, of the Wisconsin University. 191 newborns footprints were collected, at 1 to 7 days after birth, and most of them had clearly visible ridges, allowing him to categorize the footprints using a proposed system on the same article.

In the mid of the 20th century, there were not new publications on methods for creating good newborn dactiloscopic prints. Most articles only estimate foot printing with paper and ink, in conflict about their usefulness for recognition purposes.

Wierschem (Wierschem, 1965) described a technique in which footprints gathered by Chicago's hospitals (USA) were analysed [26], including that 98% could not be used for recognition. A new investigation of the collected footprints was performed after providing trainment and the accurate tools to the medical team, showing that 99% allowed the newborn's detection.

But this recognition was not based on dactiloscopic ridges (shown in fig 2.8). It used the flexion creases of the foot, which vary during the maiden months of life.
Shepard et.al. (Shepard et al., 1966) collected footprints of 41 newborns, one at birth and other 4 to 6 weeks later, sending the resulting 102 impressions to the California State Justice Department of Criminal Investigation and Identification (USA) for analysis [26]. Resulting in about 20% identifiable footprints, there fingerprint experts analysed the sample data and were only capable to identify 10 newborn babies. However it was felt that the majority of these 20 perfectly matched prints would not stand up under official inspection in the courts.

In order to verify their quality and the usefulness of collecting them Pel´a et.al. (Pel´a et al., 1975) prepared a great scale examination of footprints. They analysed 1,907 footprints collected during one year in a Brazilian maternity ward, and concluded that none provided details that possibly used for recognition purposes, although The trained personals collected them.

20 newborns' 100 footprints were collected by Thompson et.al. (Thompson et al., 1981) and confirmed that only 12% where technically satisfactory, and only 1 footprint (1%) had all useful elements needed for a legal detection. They also acquired the footprints of 25 premature babies weighting less than 1600g at birth. Many prints were obtained from each baby: at birth and then

after 4 to 8 weeks, and the finest pair of prints were preferred for a matching effort. The final conclusion was that none of them were reliable for recognition purposes.

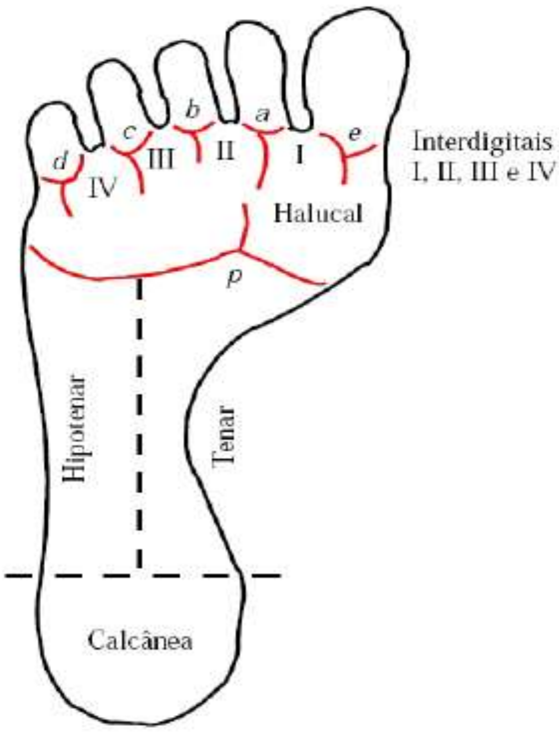


Fig. 2.8 Main dermatoglyph regions in footprints
Adapted from (CUMMINS; MIDLO, 1943)

Thus, most authors concluded that it is safe to say that foot printing as recently done is not useful for detection purposes, and that the footprints' acquisition should be dumped because it only creates unnecessary costs and work. All these authors also say that even with well-trained staff, good materials and suitable methods, it is not possible to obtain fine footprints. A current email debate between biometric researchers also proved that Electronic Discussion Group of Biometric Consortium, it is considered to be not possible to get any dactiloscopic imitations from newborns, because of imperfect ridge formation, their skin being enclosed by an oily material and their extremely brittle ridges.

Besides foot printing, other recognition techniques are also used, such as: signals with ink or chemical solutions, bracelets, and the removal of genetic substance to allow the DNA inspection. The issue is that the bracelets or inks give out only for the phase of permanence of the newborn baby in the hospital ward, and even during this phase these identifications can be altered or altered. On the other side, the DNA inspection is proven to be proficient in the univocal recognition of individuals, but it costs high and cannot be used in the real time applications, exacting complicated laboratory procedures. .

Given the boundaries of these and other identification approaches, the thought of using dermatoglyphic prints continues to be very striking, since it is a non enveloping method, of simple applicability, high accessibility, and broad acceptance and has efficiently been used for more than 100 yrs.

Baby Foot Print Samples :

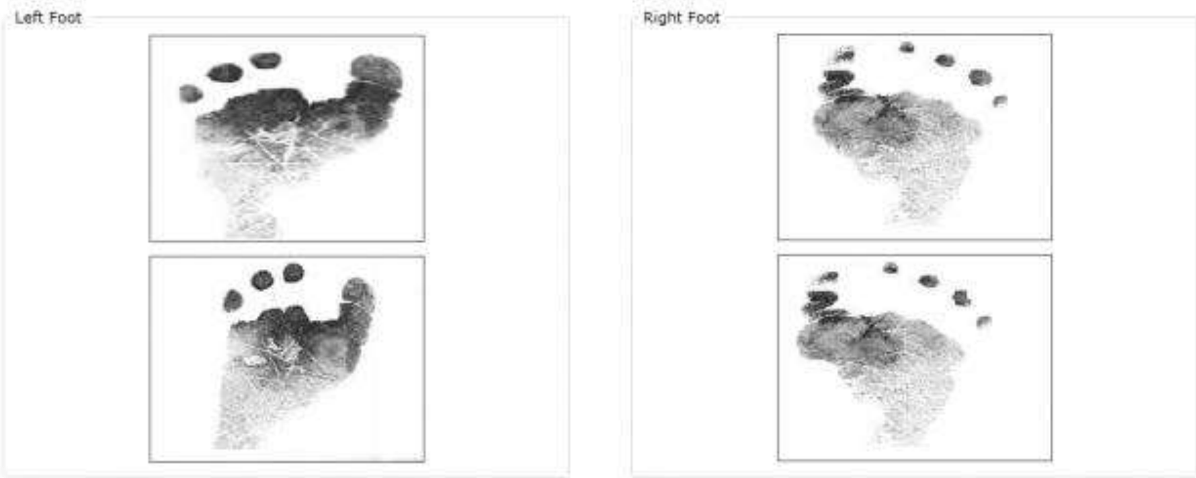


Fig.2.9 Foot print samples of a newborn baby

Baby Foot Print Verification Application:

ENROLLMENT: At the time of baby birth,[5] register that baby in the local DB (database) with the essential details and foot prints.
BasicDetails:
Enrollment ID: - A unique ID for baby.
Baby's Name: – Name of the baby.
Father's Name: – baby's father name.
Mother's Name: - baby's mother name
DOB: - baby's DOB.
Place: - baby's born [5] place details.
Biometric Data : Capture two images of [5] each foot .(right foot 2 and Left foot 2).

Fig.2.10 Baby's left and right foot image

To save the data , click on "Enroll" button.

Matching : For Matching two distinct images of newborn baby footprint taken . We can take the images directly from the DB or by same time scan.

Click on "Match" button, to verify baby footprints. [5]

Below here is an example. Where a newborn baby [5] with name “qwe3r” is confirmed against his/her footprint. One sample is taken from database and other is occupied using live scan.

By matching two right or left footprints then we get the following image showing ‘positive’ it means the footprints belong to same baby.

Fig.2.11 Result image after matching right footprints

But after matching (fig 2.11)wrong footprints to one another the application gives following image result . In this ‘Negative’ shows that the footprints do not belong to the same baby.

Fig2.12. Result image after matching wrong footprints

2.3.3 RFID Technique

An RFID(Radio Frequency Identification) system is essentially composed by two components; reader and tag. In the easiest sampling mode, when the reader “wakes up” the tag (forward ink), responds by transmitting its own unique ID code (reverse ink). , The reader must energize the tag itself if the tag is passive, i.e. is not given with a battery power. The transmission between the tag and the reader can hence be only initiated by the reader.

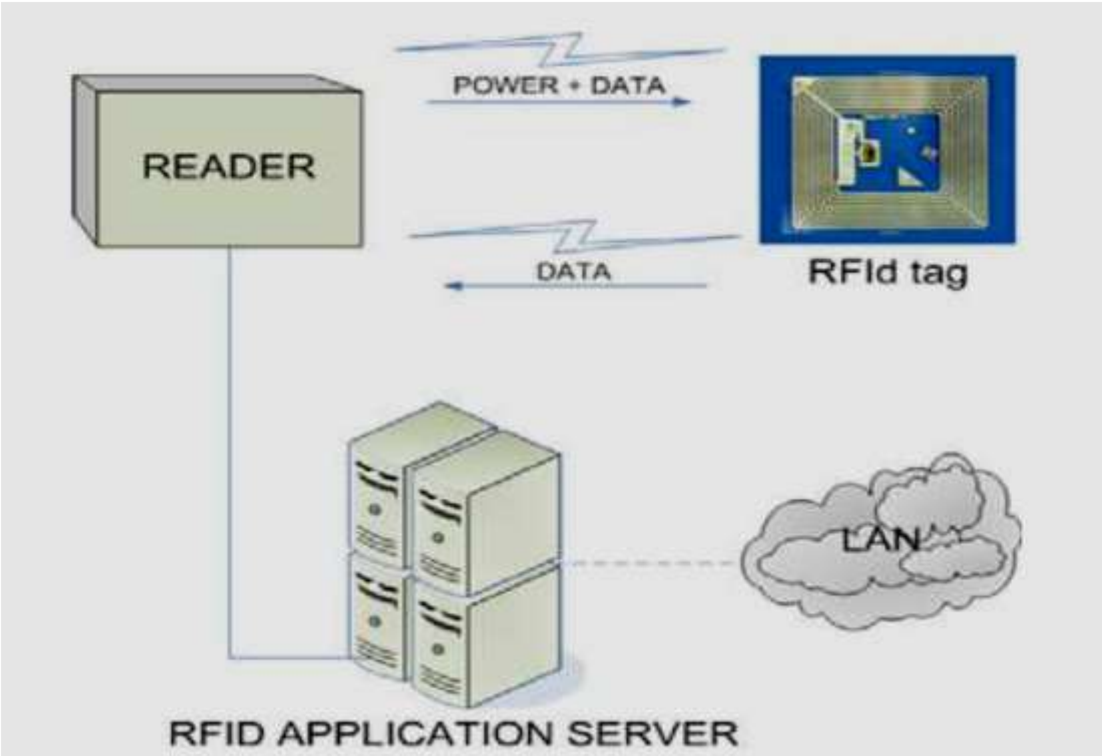


Fig2.13: A simple RFID system

Well- acknowledged cases in the healthcare production describe the unfortunate set-up in which a newborn baby is given to the incorrect mother, either at the discharge, or at the hospital. The mistake can last a few minutes, a few hours, and sometimes little longer. Even mixing newborn baby and mother for a lone breast-feeding session is upsetting and complex, and creates the possibility of proceedings. Figure 2.14 shows the illustration The following particulars apply to mother- newborn baby mix-ups in the United States alone, and show the requirement for a mother-baby ID system:

• The **average length of stay** (ALOS) for mother and newborn baby is 24 hours for normal births or 72 hours for [28] caesarean sections and complicated deliveries .

• It is calculated that there are about 4.3 million live births in the U.S. each year; 4.0 million in hospitals with less care services.

• A healthy mother and baby should spend 24 hours in the hospital; caesarean sections or complicated deliveries require a longer stay, typically 48-72 hours.

• During the starting hospital stays, newborns are transferred to and from mother about 22 million times every year.

• There are about 25,000 mistaken infant-mother transfers each year.

• The huge majority are exposed before discharge, usually through pure fortune.

• 65 mother-baby mix-ups happen every day—a rate of 2.8 mix-ups per hour.

Hospitals have already acknowledged the following causes of mother-baby mix-ups; most of them falling in the human mistake category:

• Mother bracelet information or Misreading infant .

• Bracelet falling off wrist on ankle, which is mainly common with newborn babies, whose legs and arms may reduce in size after birth due to water deficit.

• Bed mix-ups, in which a newborn baby is fetched for treatment or bathing then returned back to the or wrong bed.

• Mix-ups of newborn babies with identical or similar names.

• Misreading of ID numbers or sequential names.

• Inadequate physical [28] security mechanisms.

• Parents who are not fluent [28] in the staff's native language.

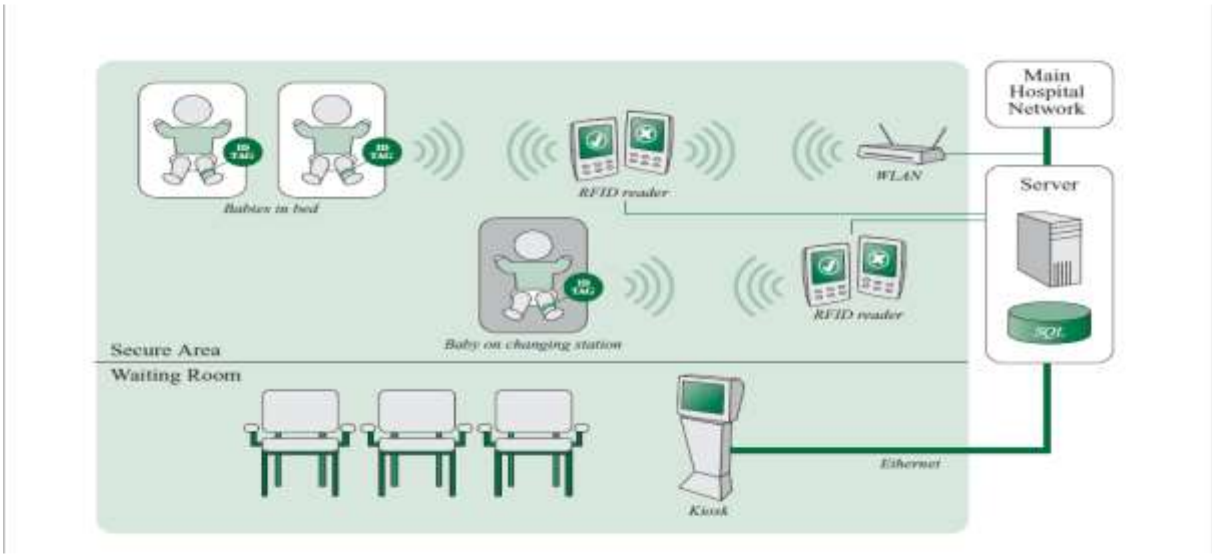


Figure 2.14. Neonatal care unit system showing RFID [28] tags and readers, mobile devices, kiosk, and wireless network .

A backscattering method is used to allow the tag to execute the reverse link. Here described how it works: the power fraction that comes as of the reader is reflected by the transponder dipole antenna back to the reader [28] depending on the tag's antenna reflection cross-section. This quality parameter can be changed by switching on and off a load resistor [28] linked in parallel to the transporter antenna. You can take profit of this approach to broadcast data from the tag to the reader by [28] modulating the power fraction reflected back, this is shown in fig2.15

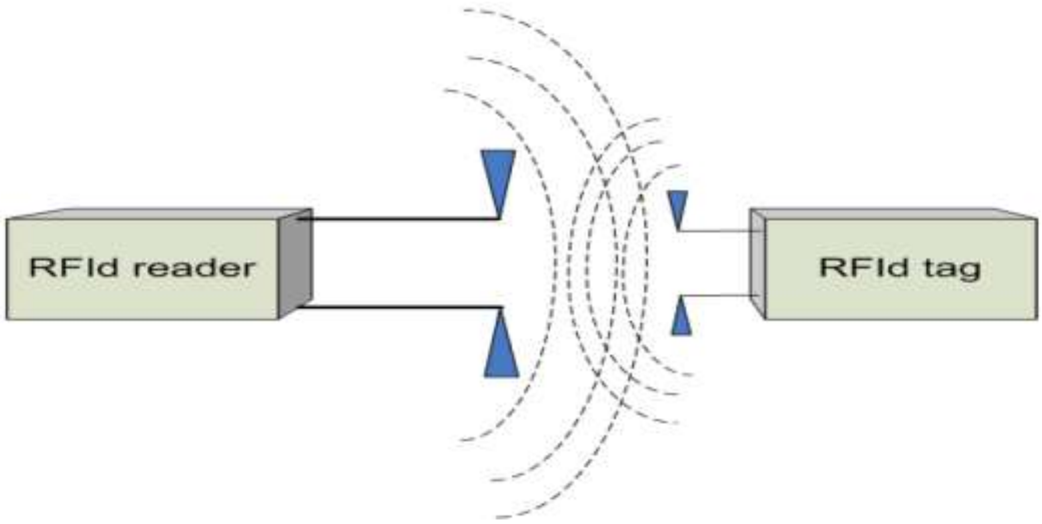


Fig .2.15 Backscattering coupling (UHF) in RFID

Here below a patient tracking flowchart is showed which is used in most of the hospitals to track the baby-mother mix-ups. It contains most possible situation can occur during the hospital period.

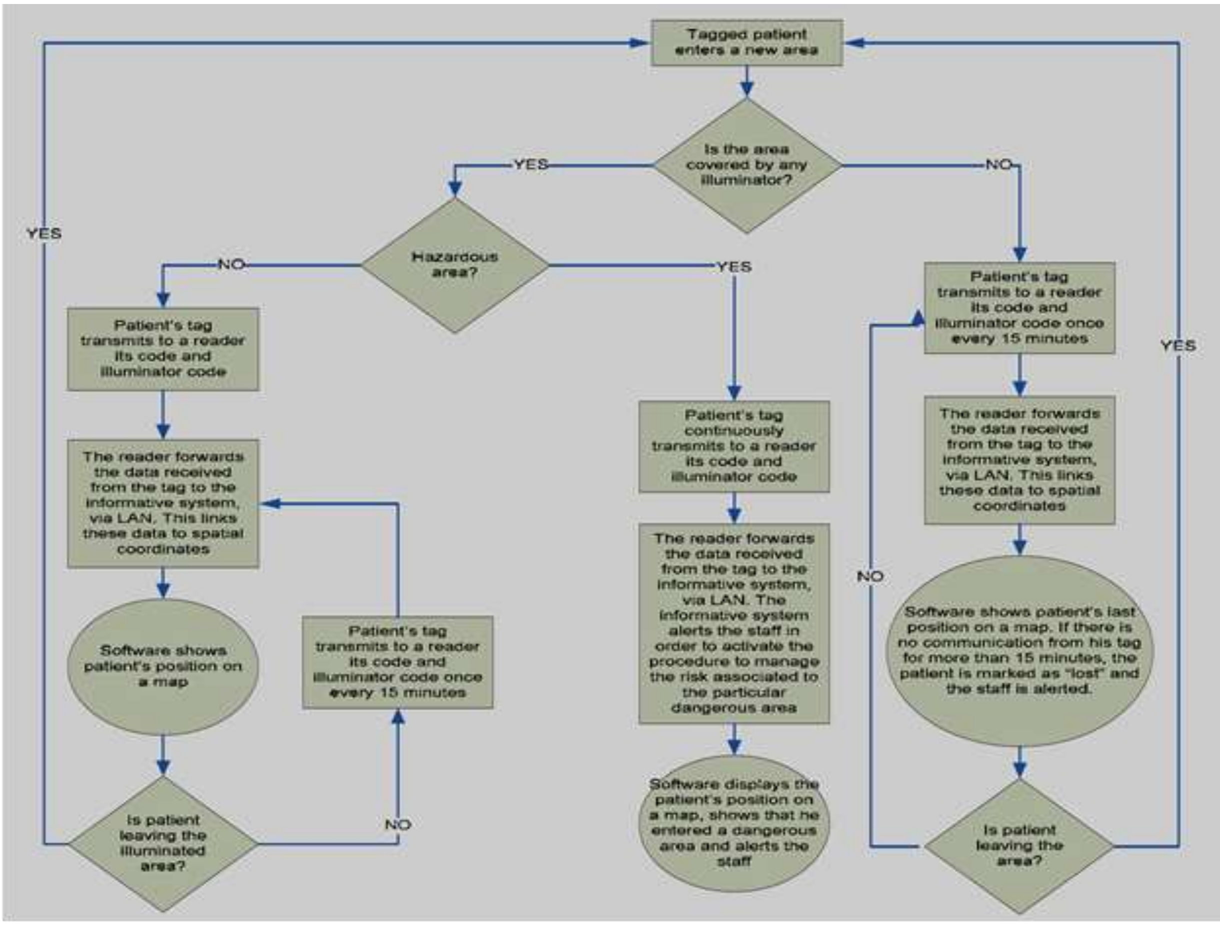


Fig 2.16. Patient Tracking Flow Chart

2.3.4 Ear Identification Method

Ear identification is a long studied issue and various challenges have been acknowledged by the scientists or researchers including illumination, pose, and occlusion. Since it is hard to make the newborn babies sit stable and give good quality ear images, they can be measured as unhelpful users of biometric identification. They may display different poses, particularly if they felt uncomfortable while taking the ear image. In many cases occlusion also is an important problem because just after the birth many parents put some kind of thread or ear ring due to their old tradition. Shrikant Tiwari et al [27] had tried to use fine ear images with less covariate. Fig 2.17, 2.18 and 2.19 shows the various samples collected by S.Tiwari [27].

Fig2.17. Illumination Variation in Ear Identification

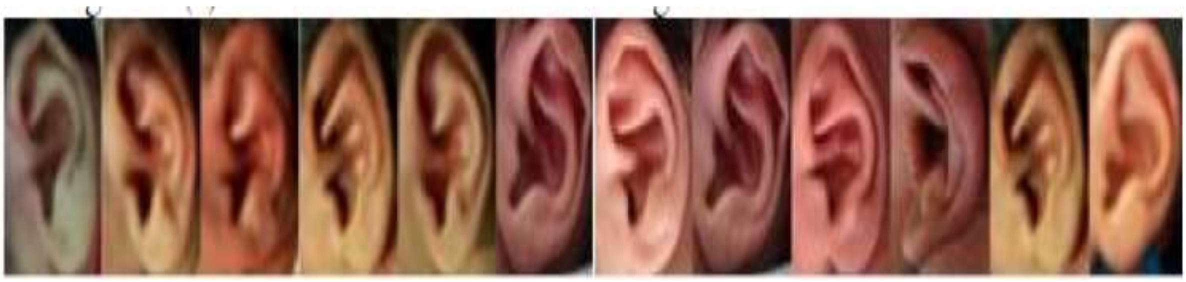


Fig2.18. Pose Variation in Ear Identification

Fig 2.19 . Occlusion Variation in Ear Identification

In the projected framework, the biometric identification system is divided into the following two subsystems. These two subsystems are [27] the primary biometric system which consist of ear and the secondary biometric system [27] consisting of soft biometric qualities like weight, height, gender and blood group. Figure 2.20 shows a personal identification system architecture that uses of both soft biometric measurements and ear. Similar to ear fusion and soft [27] biometric is performed.

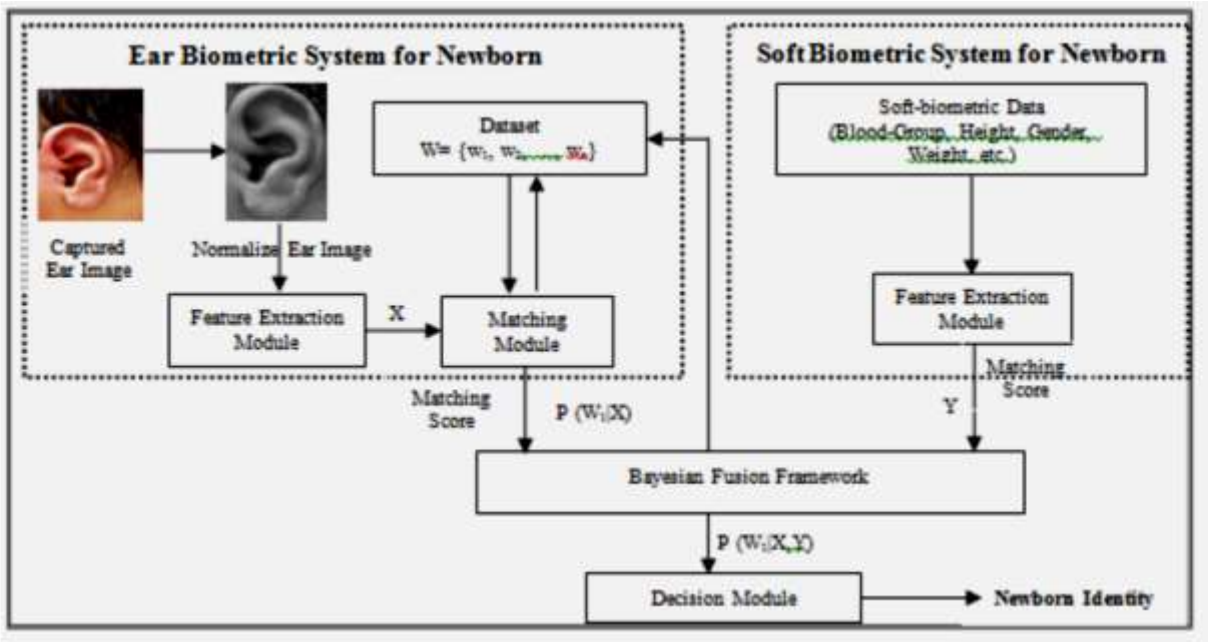


Fig2.20 . Framework for fusion of primary and soft biometrics [27]

The objective of research done by S.Tiwari was to make evident that ear with soft biometric identifiers such as blood-group weight, height, and gender could be very useful in newborn recognition. This research received the accuracy of 85.13% by implementing HAAR algorithm and after fusing it with soft biometrics it got 90.72% accuracy. But soft biometric characteristics are not as stable and consistent like the traditional biometric identifiers as an ear; they provide little knowledge about the identity of the newborn.

2.4 PREVIOUS WORK ON FACE RECOGNITION USING HMM AND SVD

There are various approaches based on the HMM and SVD techniques. Major researches have been implemented for the facial recognition of humans using the techniques. Hossein M.Naimi and Pooya Davari (2008) [29] proposed the "A New Fast and Efficient HMM-Based Face Recognition System Using a 7-State HMM Along With SVD Coefficients" in this research the combined approach of using HMM and SVD approaches were implemented. The system was evaluated standard Olivetti Research Laboratory (ORL) face database and Yale database. Training half of the images in ORL database the research obtained 99% of the recognition rate. For the YALE database [29] recognition rate of 97.7% was obtained. The addition of two new face regions, chin and eyebrows was done. The utilization of small number of quantized SVD coefficients as features describing blocks of face images was performed. Pre-processing system used an order-statistic filter operation. The consideration of a top-down chain of coinciding sub-image blocks was evaluated. Each face was considered as a numerical sequence that can be effortlessly [29] implemented by HMM using quantized SVD coefficients of these blocks.

Image size	64×64	32×32
# of train image(s)	5	5
Training time per image(second)	0.63	0.46
Recognition time per image(second)	0.28	0.15
# of symbols	1260	960
Recognition (%)	99	92.5

Table 2.1. Comparing results of different image size of ORL[29]

H. Miar-Naimi et.al. (H. Miar-Naimi et.al., 2008) resized YALE DB from 231×195 into 64×64 jpeg face images [29]. No other variations like cropping the images or background cutting were performed. Among most of the papers which examined their systems on this DB no specific number of train captured images were testified, so they got their system results on 1 image to 10 images for training [29] using 960 symbols, which means they quantized their first feature (W11) into 8, [29] second feature (W11) 6 and their third feature (U11) into 20 levels. Table 4 shows Comparative results on this DB [29].

Method	% Recognition	Training time per image	Recognition time per image
PDBNN [13]	96	20min	$\leq$ 0.1 sec.
n-tuple [25]	86	0.9 sec.	0.025 sec.
1DHMM + Wavelet [30]	100	1.13 sec.	0.3 sec.
Pseudo-2D HMM [24]	95	n/a	240 sec.
DCT-HMM [12]	99.5	23.5 sec.	3.5 sec.
1D HMM + SVD (The proposed system)	99	0.63 sec.	0.28 sec.

Table 2.2 . Comparative computational costs and recognition results of some of the other methods as reported by the respective authors on ORL face database[29]

They projected a system that has the best identification rate when several training images are greater than five. Here, though the LDA has good performance [29], but for ORL DB the proposed method had very higher performance than LDA [29]. They notice that all distinct face recognition approaches in Table 2.3 use 231×231 resolution of Yale face DB or in [32] they cut out the face images background, where they use 64×64 image size, leaving a high [29] speed system. Table2.3 shows testing of the proposed method on the Yale DB.

# of train image(s)	MRF [29]	LDA [29]	PCA [29]	NN [29]	1D HMM + SVD (this paper)
1	81.6 %	N ∝ A	60. %	68.31 %	78 %
2	93.11 %	91.23 %	75.2 %	80.49 %	82.22 %
3	95.2%	98.2 %	79. %	83.5%	90.83 %
4	95.9 %	99.41 %	79.8 %	84.0 %	94.29 %
5	96.11 %	99.69 %	81.1 %	83.51 %	97.78 %
6	96.67 %	99.87 %	81.1 %	82.8 %	100 %
7	98.67 %	99.97 %	81.9 %	82.63 %	100 %
8	97.33 %	100 %	81.2 %	81.6 %	100 %
9	97.33 %	100 %	81.7 %	82.2 %	100 %
10	99.33 %	100 %	81.7 %	83.07 %	100 %

Table2.3 . Experiments on YALE face database [29]
(Our accuracy obtained on 64×64 resolution face images)

2.4.1 Related work in HMM:

HMMs are generally used to model 1D (one dimensional) data but in the previous recent years, they have been used in visualization: face finding, texture segmentation, face identification and object identification. The reader may refer to each HMM is connected with an observable states and a non-observable (hidden) sequence originated by the hidden states independently for a deep knowledge about HMMs.

As the reader is expected to understand, observation vector is a theory that commonly is used in the HMM models. Certainly the test process and training of HMM models are performed in the OVS. Every OV is a vector of observation symbols of length T. T is defined by user based on the in hand problem.Figure 2.21 shows the partitioned image using HMM.

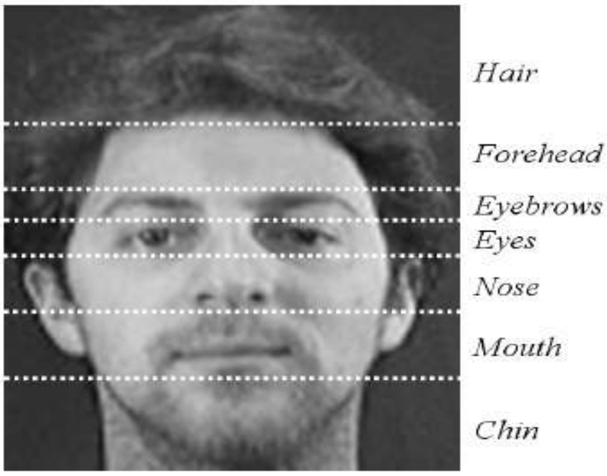


Fig 2.21. shows equivalent one-dimensional HMM model for a partitioned image into seven distinct regions[29].

Domenico Daleno et.al (Domenico Daleno et al., 2010) tested different Hidden Markov Model [30] structure on a DB obtained as a mixture of the Olivetti Research Laboratory DB together with other images of persons masked wearing glasses, bandage or scarf , in order to test system consistency. The results are shown in the Table 2.4, here below.

Hidden Markov Models	**The exact identification** $100 - \frac{n^{\circ} errors}{5,1}$
Pseudo 2D **3-3-3-3-3**	99.80 % (1 error on 510 photo)
Pseudo 2D **3-6-6-6-3**	**100 %**
Pseudo 2D **6-6-6-6-6**	99.80 % (1 error on 510 photo)
Pseudo 2D **6-6-6-6-6-6**	99.80 % (1 error on 510 photo)
5-Ergodic	98.82 % (6 error on 510 photo)

Table 2.4. Rates of recognition obtained from [30] the different implemented P2D-HMMs

The identification rate was good for all the HMM tested architectures, but the system using the HMM structure 3-6-6-6-3 gave a percentage (%) of recognition of 100%, that is to say that any of the 520 photo tested were properly acknowledged.
Subsequently was made an experimental evaluation of the final results obtained with the hybrid system ANN-P2DHMM [30] (using an HMM with structure 3-6-6-6-3) with the most important face identification algorithms projected in the literature when applied [30] to the ORL images.

Hidden Markov Models	The exact identification $100 - \frac{n^\circ errors}{5,1}$
Pseudo 2D **3-3-3-3-3**	99.80 % (1 error on 510 photo)
Pseudo 2D **3-6-6-6-3**	**100 %**
Pseudo 2D **6-6-6-6-6**	99.80 % (1 error on 510 photo)
Pseudo 2D **6-6-6-6-6-6**	99.80 % (1 error on 510 photo)
5-Ergodic	98.82 % (6 error on 510 photo)

Table 2.5. Comparative results on ORL database [30].

Methods	Recognition Rate	Reference
Eigenface	90.5%	Samaria, 1994
Pseudo 2D HMM feature: gray values	94.5%	Samaria, 1994
Convolutional Neural Network	96.2%	Lawrence et al., 1997
Pseudo 2D HMM feature: DCT Coefficients	99.5%	Eickeler, 1998
Ergodic HMM + DCT	99.5%	Kohir & Desai, 1998
Pseudo 2D HMM + Neural Network Coefficients	**100%**	**This work.**

Table 2.6. Comparative other results on ORL database [30].

Table2.6 shows the results obtained and focuses that the hybrid system that joins Artificial Neural Networks (ANN) and Pseudo 2D HMM produced the finest Identification Rate (IR). This result inspires the prosecution of the research to obtain a basic surplus to improve the P2D-HMMs potentiality, allowing an efficient and sure [30] personal identification process.

2.4.2 Related work in SVD

Lamia Mezai et.al. (Lamia Mezai et.al., 2008) proposed the score fusion [31] of two statistical methods namely SVD and DCT-RLDA for face detection. The major advantage of the DCT transform is that it castoffs redundant information and it [31] can be used as a feature abstraction step. So, computational complexity of RLDA is significantly reduced. RLDA has a powerful discriminate ability and is an efficient dimension reduction technique. We have used the left and right singular vectors of SVD instead of the singular values in order to obtain a better performance. The experimental results show that in addition to the significant gain in the training time, the recognition rate using SVD+DCT-RLDA gives best result compared to each methods taken individually.

Chapter 3 Proposed Approaches for Newborn Face Recognition

3.1 Overview

This chapter elaborates the basic system developed for the face recognition among the newborn. The major work of the research is divided into several sections. As already discussed the proposed system uses the combination of HMM and SVD coefficients .The Matlab tool is used as the programming medium. The major factors for involving Matlab as a programming language are: (a) the user friendly GUI of the tool (b) the presence inbuilt function in the program (c) the line by error correction system including an interpreter (d) wide range of function for image processing (e) easy facilitations for the graph generation (f) lucid program constructs (g) easy language considering beginner in programming language.

The outline of the chapter goes as in section 3.2 the explanation of HMM and SVD coefficients are explained. The fundamental concepts of HMM and SVD coefficients are well elaborated in the subsection of the section3.2. Following the Section 3.4 introduces the proposed approach for the FR system meant for the identification of a newborn baby and comparison of it with the database generated for the parents. Section 3.5 explains the generated system basics for the face recognition of an infant.

3.2 Introduction to Markov Models and Singular Value Decomposition Coefficients

The fundamental method employed for the development of FR system is use of HMM and SVD. The SVD quantizes the face into numerical data and each face is considered as a numerical sequence that can be simply modelled by HMM. As a prepossessing option order-statistic filter has been deployed. Then a top-down sequence of overlapping sub-image blocks is generated. Finally, further process following the quantization of each facial block using SVD and then HMM training and recognition. The further sections explain the fundamentals of HMM and SVD with the mathematical notations.

3.2.1 Preliminaries of Hidden Markov Model

Markov Model is used in probability theory it is a stochastic model (random) that assumes the Markov property. A random model represents a process where the state depends on previous states in a non-deterministic way. It follows the Markov property if the conditional probability distribution of upcoming states of the process (conditional on both past and present values) depends only upon the current state; that is, given the present, the next step does not depend on the past[33].

The most common Markov Models can be summarised in Table 3.1

	System state is fully observable	System state is partially observable
System is autonomous	Markov chain	hidden Markov model
System is controlled	Markov decision process	partially observable Markov decision process

Table 3.1 Summary of Markov Model [33]

The Markov Model was developed by using the Markov property of probability theory. The model was named after a Russian mathematician Andrey Markov.

A **Hidden Markov Model** (HMM) is a statistical Markov model in which the system being modelled is assumed to be a Markov process with unobserved (hidden) states [34]. “A HMM can be considered the simplest dynamic Bayesian network[34].”

In simpler Markov models such as Markov chain, the present state is directly visible to the observer, and thus the transition probabilities of the states are the only parameters. In a hidden Markov model, the present state is not directly visible, but output is visible, over which depends over the present state. Each state bears a probability of distribution over the possible output tokens. Therefore the series of tokens generated by an HMM gives some knowledge about the series of states. Note that the word 'hidden' refers to the state sequence through which the model goes through, not to the parameters of the model; even though the model parameters are well known exactly, the model is still 'hidden'[34].

A hidden Markov model can be understood as a generalization of a mixture model where the hidden variables, which manage the combination of component to be selected for each observation, are associated through a Markov process other than being independent of each other.

Coin toss example L. R. .Rabiner ,B. H. Juang(1986) [35]

To get the picture of the concept relating HMM, consider the following simplified example presented by L. R. .Rabiner ,B. H. Juang(1986) [35]. Suppose, you are in a room with a obstruction (e.g., a curtain) through which you cannot see what is happening. On the other side of the obstruction is another person who is acting upon a coin (or multiple coin) tossing experiment. The other person will not reveal anything regarding what he is doing exactly; he will only reveal the result of each coin flip. Thus a series of hidden coin tossing experiments is executed, and you only observe the resultant of the coin flip, i.e.”

O= H, T, H, T, H, H, T,T,T,H,H [35].............

$O_1, O_2, O_3, O_4, \ldots\ldots O_T$[35]

Where ‘H’ means heads and ‘T’ means tails. Associating with the above experiment, the challenge is how to build an HMM to describe the observed series of heads and tails. This is called as “l-fair coin” model. Two states are present in the model, but each state is uniquely related with either heads (state 1) or tails (state 2). Hence this model is not hidden because the observation series uniquely defines the state. The model represents a “fair coin” as the probability of producing a head (or a tail) followed by a head (or a tail) is 0.5; hence there is no partiality on the current observation: This is an example that shows how independent trials, as tossing of a fair coin, can be explained as a set of chronological events. Of course, if the person behind the obstruction is, in fact, tossing a single fair coin, this model should illustrate the outcomes very well.

Elements of HMM:

1. The finite number of states, 'N' in the model
2. At each time 't', new state is entered based upon a *transition probability distribution* which depends on the previous state(Markov Property)
3. After each transition is made, an observation output symbol is produced according to a probability distribution which depends on the current state. This probability distribution is held fixed for the state regardless of when and how state is entered. Thus, there are 'N' such observation which represents random variables in the stochastic process.

The explanation of these notations can be given by using the urn and a ball model L. R. .Rabiner ,B. H. Juang(1986) [34]. Using the illustration present in fig.3.1. There are 'N' urns, each filled with a large number of coloured balls. There are 'M' possible colours for each ball. The observation sequence is generated by initially opt for one of the 'N' urn (according to an initial probability distribution), choosing a ball from the primary urn, and then keeping a log of its colour, followed by restoring the ball back, and finally choosing a new urn according to a transition distribution associated with the current urn. The typical observation sequence is shown using table 3.2

Clock time	1 2 3 4........T
Urn(hidden) state	$q_1q_2q_3q_4.......q_{N-2}$
Colour (observation)	RBYYYBB......Y

Table 3.2 Observation sequence for urn and ball model

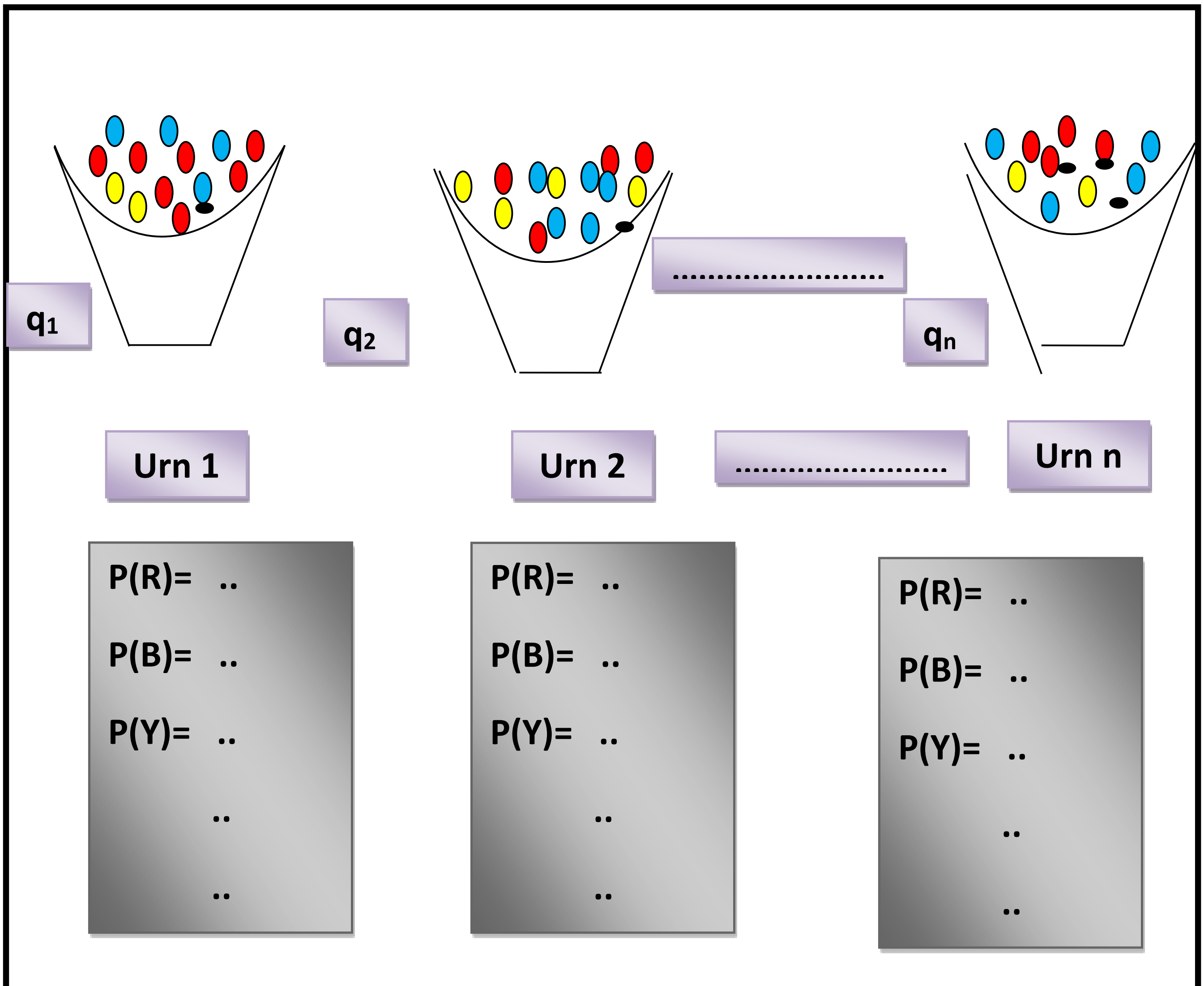


Figure 3.1 An Urn and Ball model which illustrates the general case discrete symbol HMM. Each of N urns (N is the number of states in the Model) contains large number of coloured balls. The proportion of each coloured ball, in each urn is different and is governed by the probability density of colour for each urn. The observations from the Urn ball model consists of announcing the colour of the ball drawn at random from the selected urn, replacing the ball, and then choosing a new urn and then selecting a ball according to the state transition density associated

Mathematical Notation:

- N= $|S|$ is the number of all states present in the model, where S= $\{s_1,s_2,\ldots,s_N\}$ is the set of all feasible states. The state of the model at time‘t’ is given by $q_t \in S$.
- M= $|V|$ is the number of the different observation symbols (OS), where V=$\{V_1,V_2,\ldots..V_M\}$ is the series of all possible OS vi(also called the code book of the model). The observation symbol at time‘t’ is given by $O_t \in V$.
- A= $\{a_{ij}\}$ is the state of transition in probability matrix, given by:

$$\boxed{a_{ij} = \mathrm{P}\,[\mathrm{q_t} + 1 = \mathrm{s}_j | \mathrm{q_t} = \mathrm{s_i}\,, 1 \le \mathrm{i,j} \le \mathrm{N}\,, 0 \le \mathrm{a_{ij}} \le 1}$$ Equation (1)

- $B=\{b_j(k)\}$ is the observation symbol probability of matrix, expressed by:

$$\boxed{b_j(k) = P[O_t = v_k | q_t = s_j], 1 \leq j} \qquad \text{Equation (2)}$$

- $\pi = \{\pi_1, \pi_2, \pi_3, \pi_4, \ldots\ldots\ldots \pi_N\}$ is the primary state of distribution expressed by :

$$\boxed{\pi_i = P[q_1 = s_i], 1 \leq i \leq N} \qquad \text{Equation (3)}$$

- In short using the Triplet HMM notation can be expressed by:

$$\boxed{\lambda = (A, B, \pi)} \qquad \text{Equation (4)}$$

The major implementation of HMM in the research work is training the facial images using the HMM training function present in the Matlab image processing tool. The recognising the face provided as an input from the database. The HMM model recognises an image dividing it into several blocks of the identified features. This can be shown using fig 3.2 having equivalent HMM model for a partitioned output image into distinct regions.

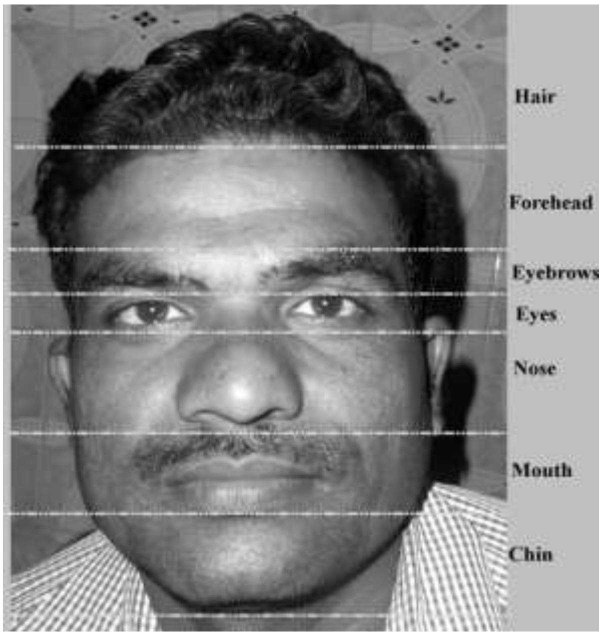


Fig 3.2 An Illustration of the Partitioning performed by using HMM

3.2.2 Singular Value Decomposition (SVD)

“**Singular Value Decomposition** (SVD) [36] is a factorization of a real or compound matrix, with much useful relevance in signal processing and statistics”. The typical representation of SVD coefficients are shown using fig 3.3. The major application of SVD coefficients lays the decomposition of a high-dimensional data set into low dimensional subspace.

Definitions

Rasmus E. Madsen, Lars K. Hansen and Ole Winther (2004)[35] explained the following definition of SVD as :

- The Singular Values of the square matrix **'A'** is defined as the square root of the Eigen values of $\mathbf{A^T A}$.
- The **Condition Number** is a ratio of the greatest to the smallest singular value.
- A matrix is ∑**Conditioned Matrix** if the condition number is too big. The condition number can be very big, before the matrix is ill conditioned, is estimated by the machine precision.
- A matrix is **Singular** if the condition number is infinite. The determinant of a singular matrix is 0.
- The **Rank** of a matrix is the dimension of the range of the matrix. It keeps up a correspondence to the number of non-singular values for the matrix, i.e. the number of linear independent rows of the matrix.

Mathematical Notation:

Suppose for any m×n matrix '**A'**, an algorithm to find matrices U, V, and W given that

$$\boxed{\mathbf{A = U \sum V^T \text{ where,}}} \qquad \text{Equation (5)}$$

'U' is m×n and an orthonormal matrix

'∑' is n×n and a diagonal matrix

'V' is n×n and an orthonormal matrix

In other words U(m×m) and V(m×m) are orthogonal matrix, whereas ∑ is m×n matrix diagonal of singular values with components $\sigma_{i,j}$ = 0, i ≠ j and $\sigma_{i,j}$ >0. Furthermore, it can be shown that there exist non-unique matrices U and V such that $\sigma_1 \geq \sigma_1 \ldots\ldots \geq 0$. The columns of the orthogonal matrices U and V are called the left and right singular vectors respectively; an important property of U and V is that they are mutually orthogonal.

The main theoretical property of SVD relevant to face image recognition is its stability on face image. Singular values correspond to algebraic properties of an image [37]. So because of these reason it is found that SVD is a strong feature extraction technique for face images.

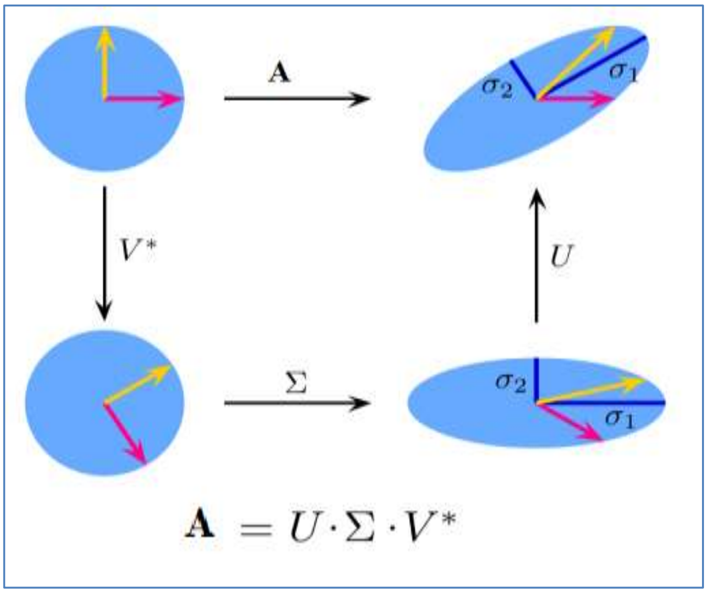


Fig. 3.3 An Illustration of SVD Coefficients

3.3 Proposed Approach for Face Recognition

The backbone for the proposed system is employed as discussed earlier using the Hidden Markov model for the training and recognition of the image. The work flow graph of processing showing the basic function that is followed for the face recognition process is present in fig. 3.6. Each and every block is the step employed in the recognition procedure and it is explained in details in the further sections. Hence major steps involved in the HMM training process are well enlightened in the fig3.6. The output image after applying filtering is shown in fig3.5.

The further Section broadly explained the method implemented for the FR of a new born baby and the major steps employed in the development of a system that recognises an image of a baby with his parents.

3.3.1 Outline of System

The GUI is enabled using Matlab code that is endeavoured to be as simple as possible for any new user. A user can train new images in the database and then can recognise the image using the same GUI. The system generates a warning message for a selection of recognition of images using an empty database. The snapshot of the GUI of the system is present in fig 3.4.

Fig 3.4 Snapshot of GUI enabled in the system.

3.3.2 Database Generation and Training Samples

Database Description:

The Database of the system is inspired from the standard ORL databases present for face recognition purpose. The system obtains the images in 128×128 pixels resolution and in standard Portable Graymap Graphics (.pgm) file form. The reason for selecting PGM files as database is that the (.pgm) files are compressible and are easily converted into other file format. The conversion of (.pgm) file is a hassle free work and does not spoil the quality of the image. In the database generation process, that is used around 10 parents' and their baby's images was collected. Each parent's image had 10 sample images of their face. Similarly the baby's images samples were generated. To overcome the confusion of mixing up of the similar names of the parents, the baby name is given either in number system such as baby1, baby2, etc. or the baby's mother name is given to a female child and father's name to male newborn baby. Therefore, about 300 images samples were presented for the training purpose in the system. In the Fig 3.6 a well maintained database sample is presented showing baby's image in the middle, followed by the father's image at the left and Mother's image at the right side. The illustration in the fig represents the greyscale conversion of the images that are implemented in the system.

Database Generation:

To generate a database in the GUI system of the Matlab program, the images in desired format (.pgm) are first required to be maintained. Each image that is going to be used for database should maintain the resolution of 128×128 pixels. It is desirable that at least 10 samples of each parent's image are recorded. The GUI as shown in fig 3.4 provides an option for data base generation. This arise the following possibilities:

- The database is not trained earlier; hence a warning message for generating database first is displayed by the system.
- The database doesn't contain the image, thus training is required.

Training of Samples:

The training process involves the implementation of HMM model the flow graph of training process is shown in fig 3.6 each block represents the process involved in training procedure. The blocks involved in the HMM training can be explained as follows:

1. Filtering: The pre-processing technique used two dimensional(2D) order-static filtering (OSF)for the proposed system. Most of the FR systems mainly implement pre-processing to enhance the performance. In the proposed system as the initial step, a specific filter is used which precisely influence the speed, accuracy, performance and recognition rate of the system. OSF are nonlinear spatial filters. It operates as follows; a sliding window slides from left to right and top to down with accordance to the steps of size one pixel, at each position the centre pixel is substituted by one of pixels of the window based on the category of filter. For instance minimum (min.), maximum (max.) and middle of pixels of the window might substitute the centre pixel. A 2D OSF, which substitute the centre element of a 56×46 pixels window with the min. element in the window, used in the proposed system. This can be represented by:

$$\boxed{f^{\wedge}(x,y)min_{(s,t)€s_{xy}}\{g(s,t)\}}$$

Equation(6)

In the equation, ‘g(s,t)’ is the grey level of given pixel (s,t) and s_{xy} is the window. As most of the face databases are taken over using camera flash. Using the flash frequently caused highlights in the subjects eyes which affected the classification accuracy [39].

In concurrence to sentences above, the filter is expected recompense the flash effect .Also it reduces brackish noise consequently of the min operation. Figure3.5 shows a simple demonstration of working of min OSF. An image of 128×128 is filtered using a min filter of 56×46 window size.

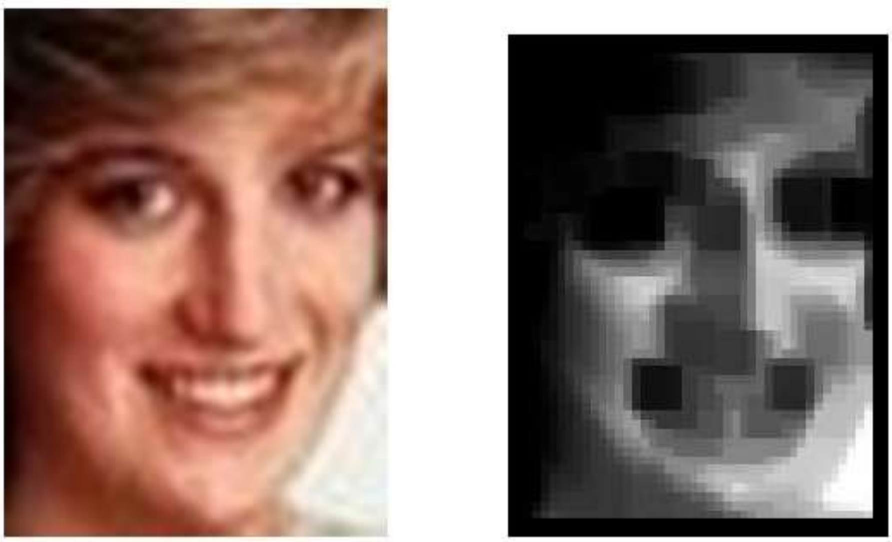


Fig 3.5 An Input and Output of an Image after Filtering.

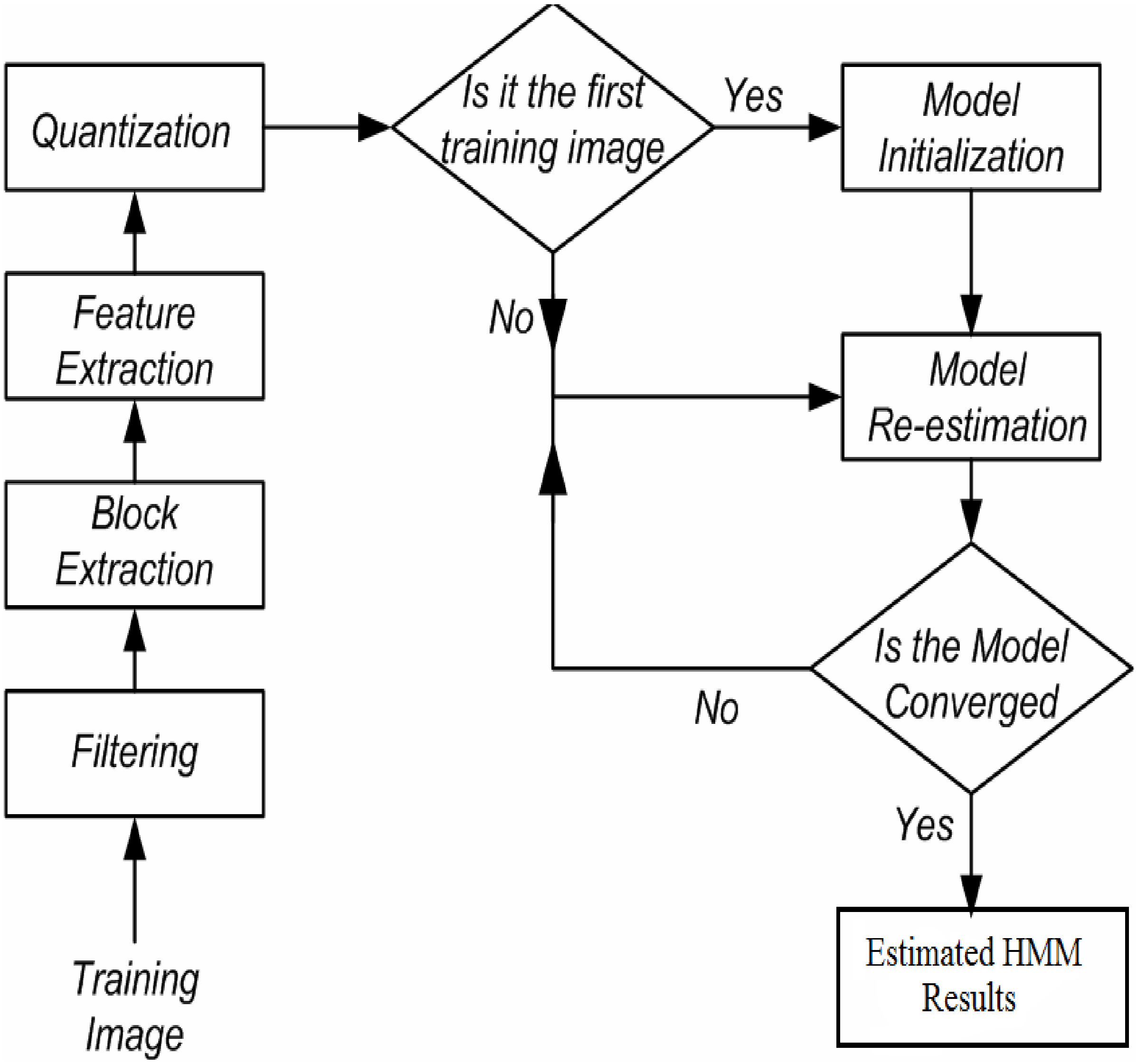


Fig 3.6 Block Diagram of the Training Process involved in Face Recognition.

Sample No.1 Data Folder Name Chavi

Fig 3.7 An illustration sample of section of generated database

2. Block Extraction and Feature Selection: A successful FR system strongly relies on the feature extraction method. One essential improvement of the given system is the employment of SVD coefficients as features as an alternative of gray-values of the pixels in the sampling windows (blocks). The illustration is shown in figure 3.8 .With pixels value as features explaining blocks, boosts the processing time and have an advantage to sharp computational complexity in training and FR procedure. In the research, computation of SVD coefficients of each block and using them as features is implemented.

(a) Original Image **(b) Image after applying SVD coefficients**

Fig3.8 An Illustration of the images before and after application of SVD coefficients.

3. Quantization: The SVD coefficients have naturally continuous values. SVD coefficients compose the observation vectors (OV). If they are judged in the corresponding continuous type, system meets a countless number of probable OV that can't be modelled by HMM. As a result, quantization of expressed features is done. Mainly, it is done by a process of rounding, or various other irreversible, nonlinear processes these all process leads to information loss. To show the quantization process in details, operated in the proposed system, consider a vector X=(x1,x2,…,xn) with continuous components. Suppose x_i is to be quantized into D_i distinct levels[38]. So the differentiation relating two successive quantized values will be given as equation x.

$$\boxed{\Delta_i = {(x_{imax} - x_{imin})}/{D_i}} \qquad \text{Equation(7)}$$

$x_i$max and $x_i$min are the max. and min. values that x_i acquire in all possible observation vectors respectively.

Knowing Δ_i, element xi will be exchanged with its quantized value calculated as below:

$$x_{iquantized} = \left[\frac{x_i - x_{imin}}{\Delta_i}\right]$$ Equation(8)

Therefore all the components of X will be quantized. In the end each quantized vector is linked with a label that is an integer number. So every block of image is mapped

to an integer. Taking into account of all blocks of an image, the image is now mapped into a string of integer numbers that is taken as an observation vector. Thus the images are now interpreted; so that use of HMM can be done for classification.

4. Training Process: Following presentation of each face image by observation vectors, they are modelled by a HMM. Five images of the identical face are used for training the related HMM and the remaining baby's images are used for testing. In the initial step U= (A,B,π) is implemented. The primary values for A and π are preset due to the left to right arrangement of the face model.

The initial values for A and π are given using:

$$a_{i,i} = a_{i,i+1} = 0.5\,; 1 \leq i \leq 6$$
$$a_{7,7} = 1; \pi_0 = 1$$ Equation(9)

The parameters of HMM are approximated using $\lambda^* = \max_\lambda P(O|\lambda)$.The probability of the observation 'O' is associated with image learning is maximized. This process progress into number of iterations to obtain training set of the given observation vectors.

3.3.3 Recognition and Comparison:

For the proposed system the training of parents' image is employed and the test images are the samples of the images of the newborn baby. During the recognition process, the proposed system recognises the image of the parent of test image (baby's image) provided as an input. The comparison of the two images is derived through the calculates of the logarithmic sequence of the trained image of the parents, the nearest value to the selected test(baby's) image is recognised as the parents' image for the test image.

Following the HMM training and learning process, each class (face) is considered to be in association with HMM. Each test image of the newborn baby encounters the block extraction, following by feature extraction and then quantization process respectively. Certainly each test image same as training images corresponds by its own observation vector. For an input face image, simple calculation of the probability of the observation vector (baby's image) given by each HMM face model is performed. A face image 'm' is recognized as face 'd' if:

$$\boxed{P\left(O^{(m)}\middle|\lambda_d\right) = \ max_n \ P\left(O^{(m)}\middle|\lambda_d\right)}$$ Equation(10)

Since the HMM recognition results completely rely over the training of the images. Thus, comparing to the training step the recognition seems to be a simple procedure. Therefore using the mentioned method the FR system can be generated for the facial recognition of an infant .

Chapter 4 Results and Discussion

The security challenges involving the misconception relating the identities of a newborn are increasing day-by-day. The major concerns are associated with the issues of mixing, swapping and even abandoning a newborn baby in dustbins. Therefore, this research project, aims at improving the security of a baby by enhancing the face recognition approaches presented so far.

During the analysis of providing security to the identification process associated with the newborn baby, the proposed system employed the HMM and SVD coefficients. For the training and learning HMM is the best suited method recognised. The SVD coefficients using a number of filtering iteration removed the noise in the images and imparted images that can be easily processed in the system. The combined approach of HMM and SVD enhanced the computational speed and accuracy for the recognition purpose.

4.1 Description of GUI:

The system deployed for facial recognition provided an enhanced program for the identification process. Analysing the program various results and conclusion were obtained.

Using the Matlab, three major modules were developed the given name to each modules and their functions are as follows:

1. Main Menu: The main menu as the name suggests, is the basic and the fundamental program of the system. This part of the program is associated with all of the other modules present in the system. Thus, main menu formulates one of the major part of the proposed system. As it is the very first part in the program that is required to be deployed, therefore it is programmed in a very lucid manner. Being lucid in the program it automatically emerges out as User friendly system. A snapshot of the main menu is shown in figure 4.1. The functioning of the main menu involves a GUI containing the three major buttons naming

(a) Generate Database: This button of the system when selected as the choice by any user, first generates a warning message asking to remove previous data or overlapping the new data into the old one. After having the desired choice from the user this button either trains a new data into it or goes back to main menu. Further details of this button are explained in the 'gendata' function.

(b) Recognise from Image: This button redirects the system to new choice menu for selecting an image for recognition present in the system. The selection window's snapshot is shown in figure 4.2. Basically this button asks a user for input of a test image and then it displays the output. The details of this button are explained in the ‘facerec’ function.

(c) Exit: The selection of this button simply terminates the running program and eliminates the main menu choice buttons. In simple words, the main menu window is closed by the selection of this button.

Fig. 4.1 A snapshot of the Main Menu

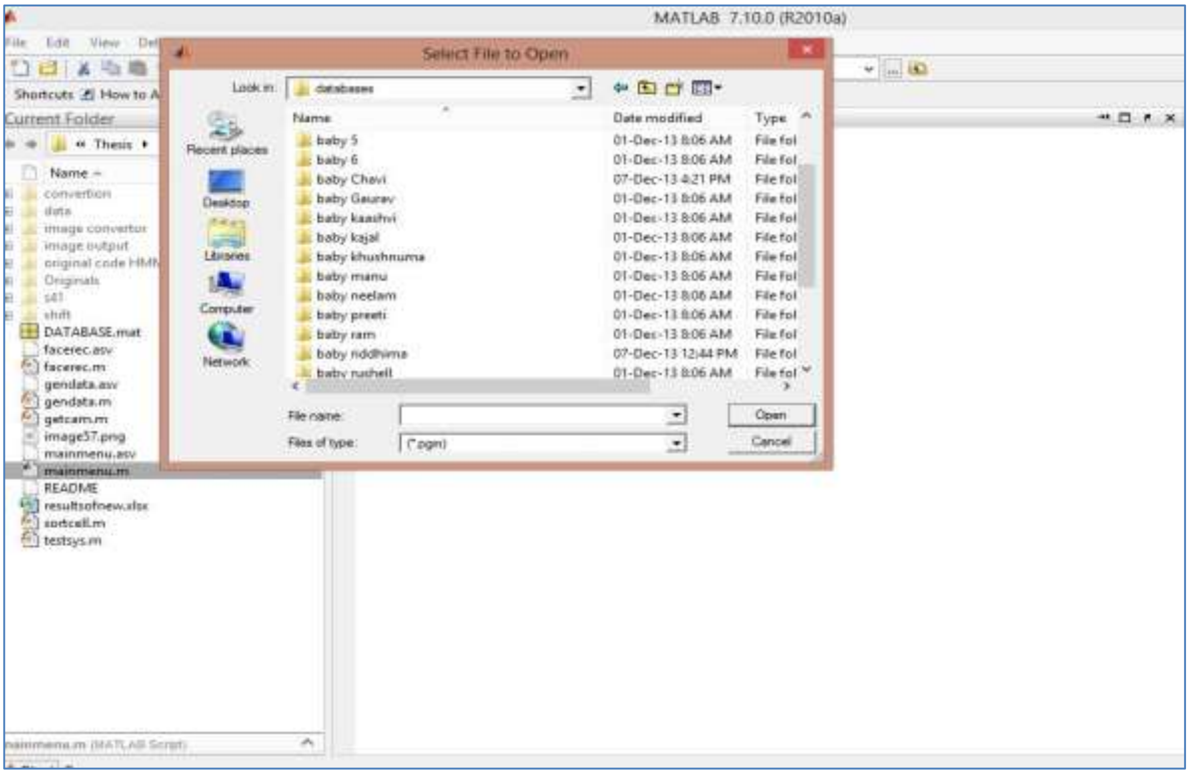


Fig 4.2 Snapshot of the Selection window for the Recognition from image

3. Function ‘gendata’: The function gendata is called when the option for generating a database is opted by the user in the GUI. As mention the warning message for the removing the old data in the database and adding the new data is confirmed from the user first. Figure 4.3 illustrates the warning message in the program. This is done when the options are selected from the menu.

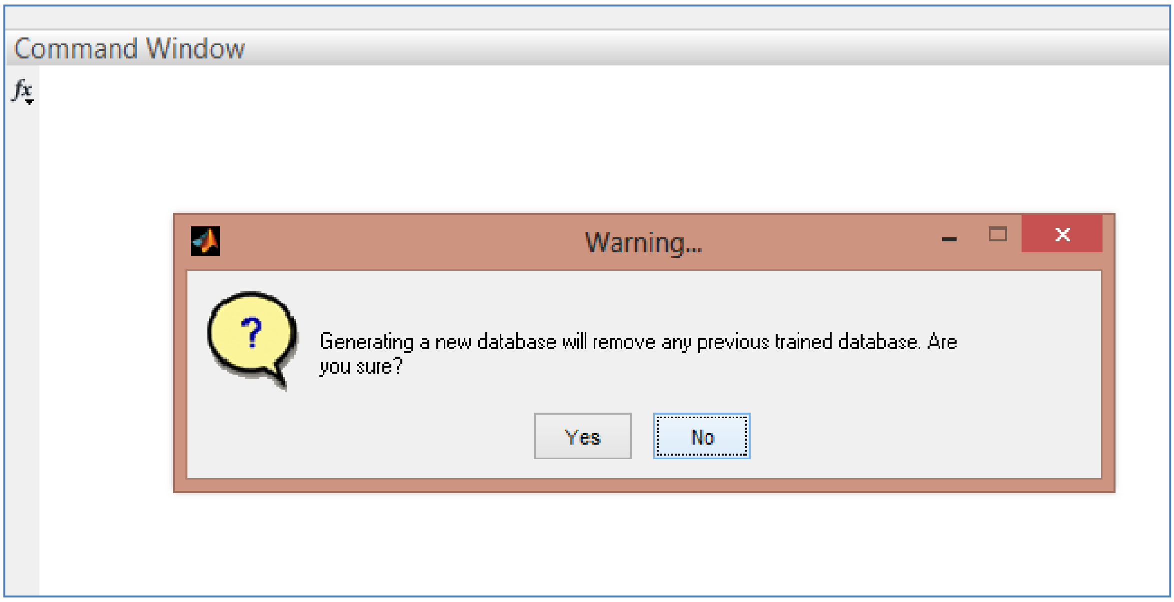


Figure 4.3 Warning message While Generation of Database

Moreover, the execution of this function separately from the main menu this function first loads the data and then shows the matrix dimensions of the trained data. This can be shown using figure 4.4. and Figure 4.5

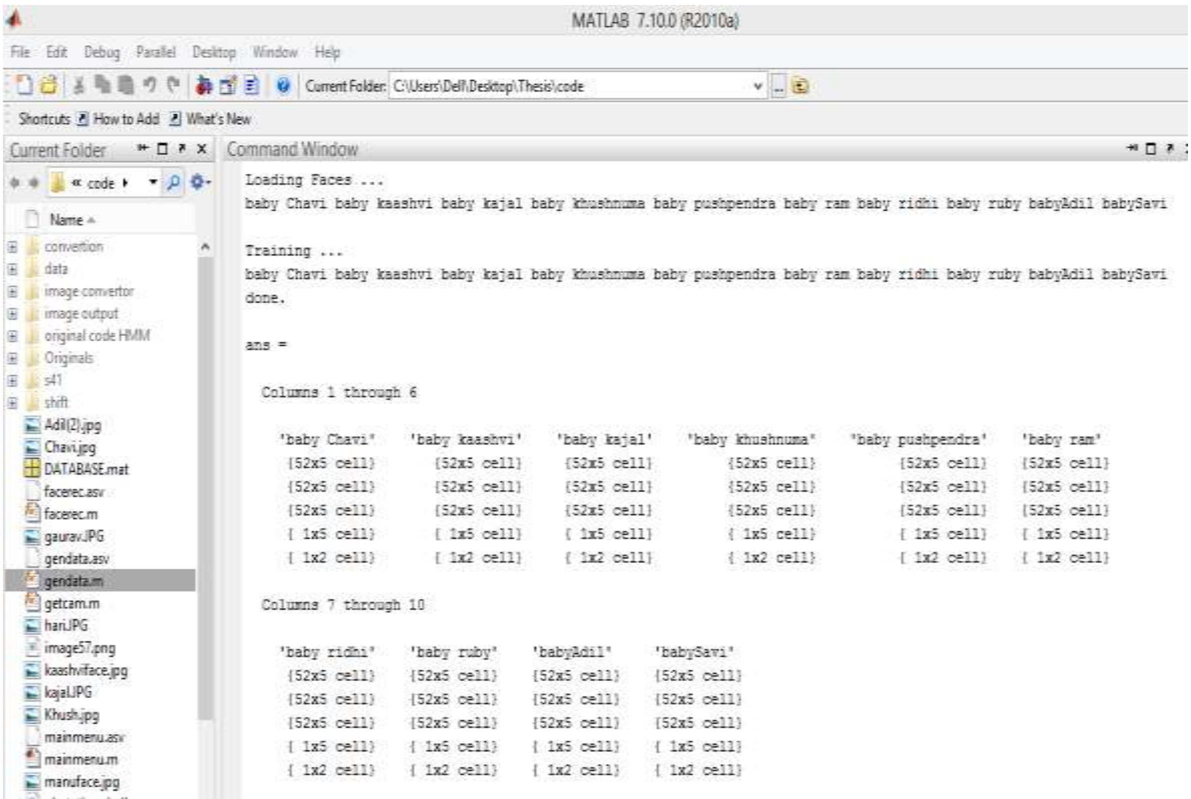


Fig.4.4 Loading and Training of Faces

```
Command Window

  Columns 1 through 5

    'Gaurav'        'Hari'          'baby 1'        'baby 2'        'baby 3'
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
    { 1x5 cell}     { 1x5 cell}     { 1x5 cell}     { 1x5 cell}     { 1x5 cell}
    { 1x2 cell}     { 1x2 cell}     { 1x2 cell}     { 1x2 cell}     { 1x2 cell}

  Columns 6 through 10

    'baby 4'        'baby 5'        'baby 6'        'chavi'         'kaashvi'
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
    { 1x5 cell}     { 1x5 cell}     { 1x5 cell}     { 1x5 cell}     { 1x5 cell}
    { 1x2 cell}     { 1x2 cell}     { 1x2 cell}     { 1x2 cell}     { 1x2 cell}

  Columns 11 through 15

    'kajal'         'khush'         'manu'          'pinky'         'ram'
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
    { 1x5 cell}     { 1x5 cell}     { 1x5 cell}     { 1x5 cell}     { 1x5 cell}
    { 1x2 cell}     { 1x2 cell}     { 1x2 cell}     { 1x2 cell}     { 1x2 cell}

  Columns 16 through 20

    'ridhi'         'satvesh'       'text'          'usha'          'vihaan'
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
    {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
fx  {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}     {52x5 cell}
```

Fig4.5 Snapshot of the Training data and the Matrix Dimension in each cell array

The gendata function employs the HMM training and learning approach to train its database for the recognition process. Learning of trained images follows the further step of recognising an image.

2. Function 'facerec': The major work of the face recognition is employed in this function only. The further steps after selecting an image from the file selection window presented after the 'recognise from image' button is followed at the facerec function. The SVD and order-static filter are applied at this function only. The image selected by the user directly goes as the input to the recognition system of this function. Following, the SVD and filtration of the input test images. The HMM trained data are tested with the test image with an inbuilt function of Matlab named as 'hmmdecode( )'.This hmmdecode( ) function checks for the recognition of the image with the trained data present in the system. In the end, the logarithmic sequence of image is calculated and matched with training set. The trained image's log sequence nearly matching with the test image is selected as the output of the system. Using the Matlab system the Face Recognition system id developed with the recognition rate of 50%. The function also plots the graph of the log sequence for the input image and the number of person trained in the database.

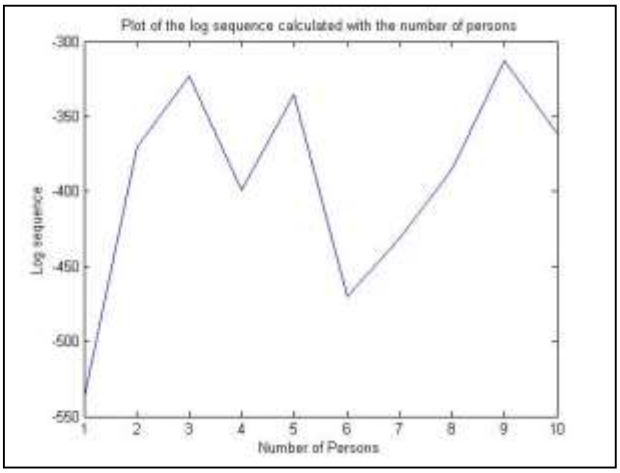
4.2 Results and Graphs:

Understanding the GUI of the developed system followed by observation of the results is paramount in order to check the efficiency of the developed system . Fig. 4.6 illustrates the snapshot of the database including the input and output of the results obtained. While selecting an input image the developed program displays the name relevant to the highest log value calculated , nearest log value of the trained image is obtained as an ouput. In the fig 4.6 the red colored text shows the correct matching results with the output.

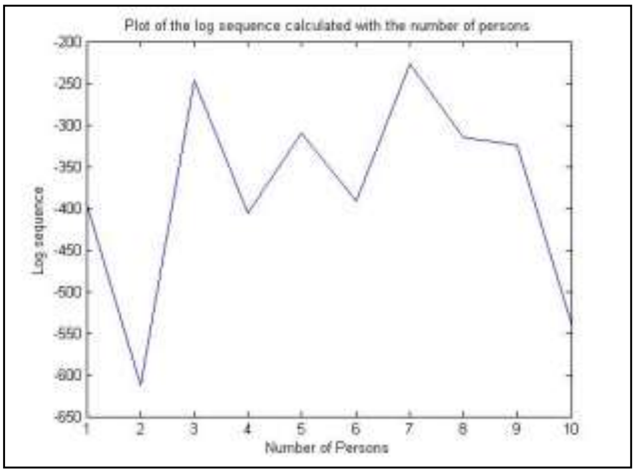
A	B	C
S.No	**Input**	**Output**
1	Adil	Adil
2	Chavi	Riddhi
3	Kaashvi	Riddhi
4	Kajal	Kajal
5	Khush	Savi
6	Pushpendra	Pushpendra
7	Ram	Adil
8	Riddhi	Adil
9	Ruby	Ruby
10	Savi	Savi

Fig 4.6 Snapshot of Results Obtained

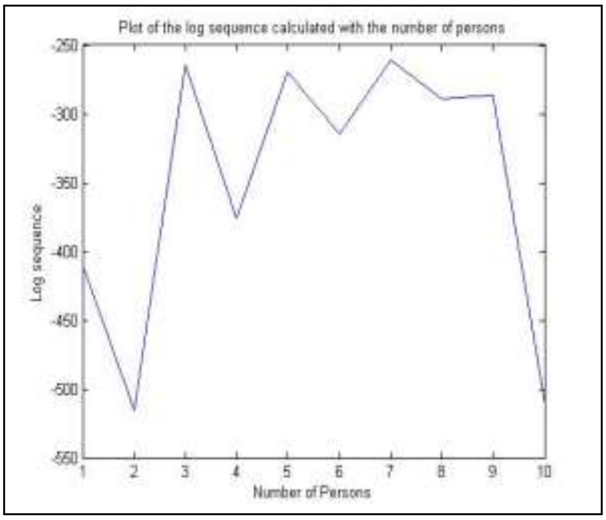
Typical observation of the results can be explained using the graph plot of the resultant output obtained. In the Fig. 4.7 and Fig 4.8 the typical observations of the program are demonstrated. Each graph in the figure displays the result for different input image given as an input to the developed system. For instance the graph for an input image named Adil, displays a plot between number of persons trained and the calculated logarithmic value for Adil. When the index for the highest log value is obtained the plot shows the highest peak in the log sequence of the output. Hence, the name at the selected index number is displayed as the output of the image, considering the example of image named Adil, observing the first graph of fig 4.7 index number ‘1’ , the index number 1 in the database can seen named as Adil in figure 4.6, hence the output of the image is displayed as Adil only. Following the same methodology the system that is developed calculates log sequence of all the images and the trained images also each time the different image is given as input, and nearest index number to the highest peak in the graph is selected for the output. Each observation obtained in the system is hence exemplified in all the graphs presented in fig. 4.7 and 4.8.



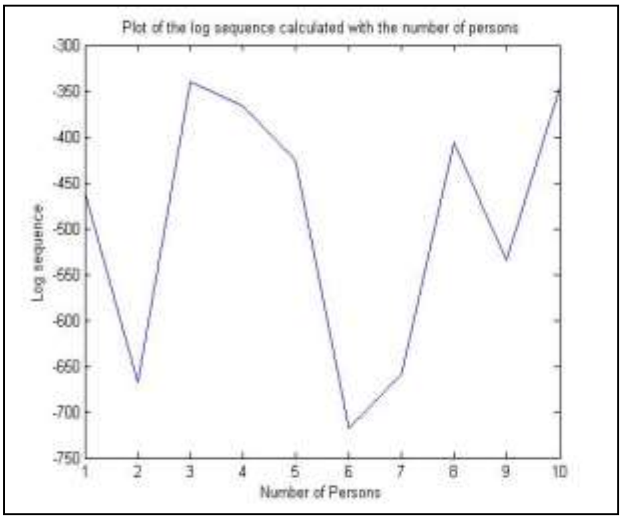
Resultant Graph for Adil



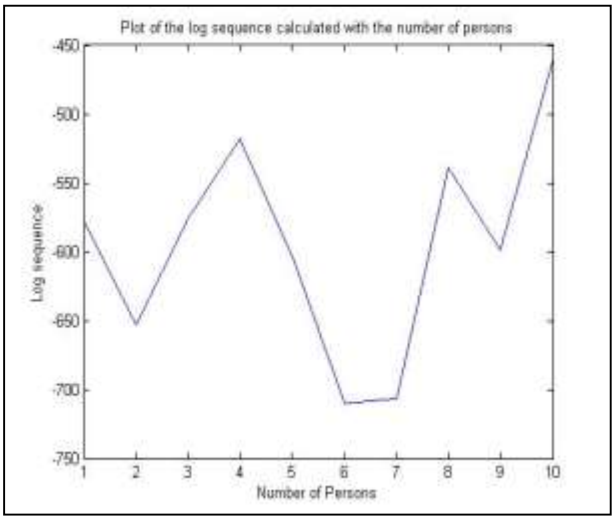
Resultant Graph for Chavi



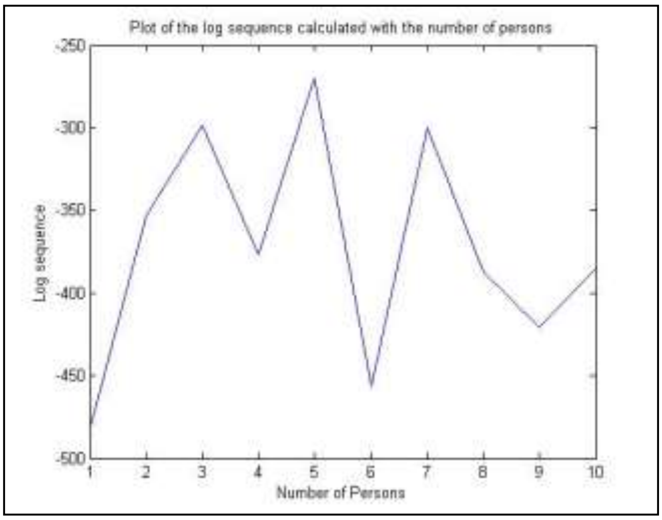
Resultant Graph for Kaashvi



Resultant Graph for Kajal

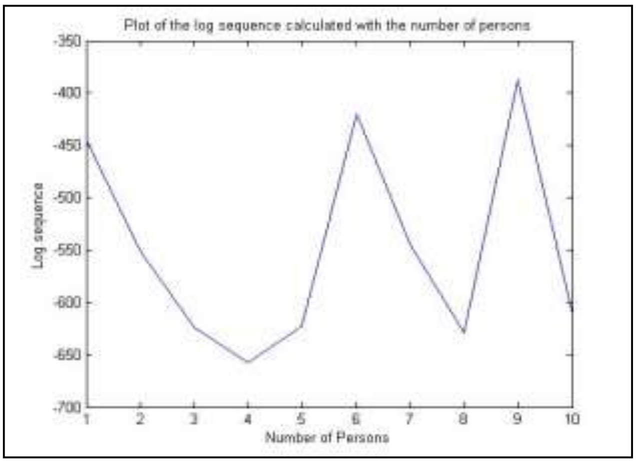


Resultant Graph for Khush

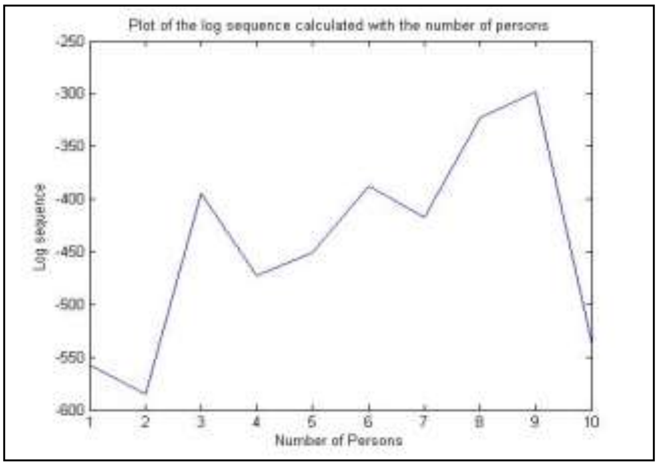


Resultant Graph for Pushpendra

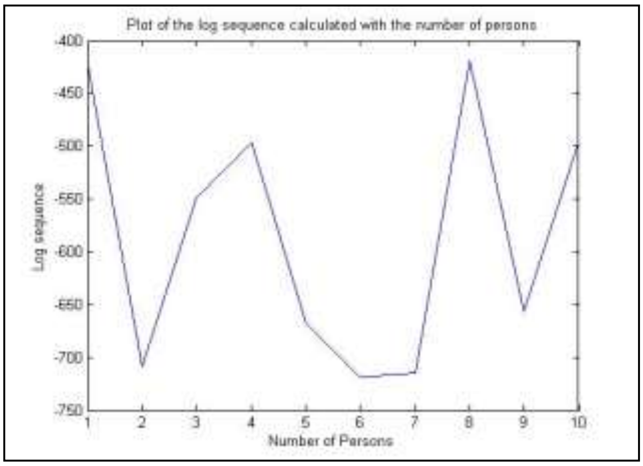
Fig 4.7 Resultant Graphs obtained for each input showing that the highest peak value denotes the output for different inputs given



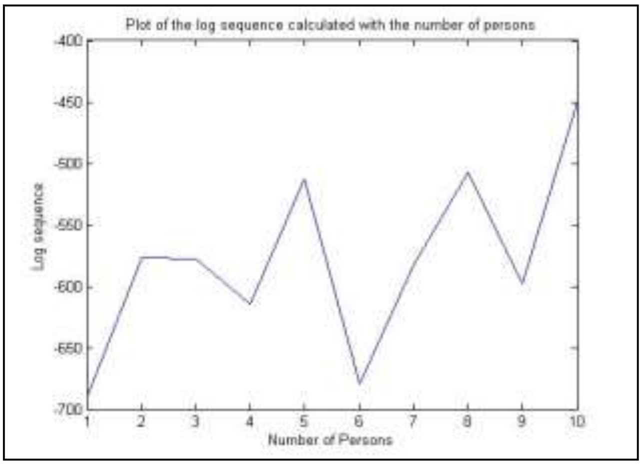
Resultant Graph for Ram



Resultant Graph for Riddhi



Resultant Graph for Ruby



Resultant Graph for Savi

Fig 4.8 Resultant Graphs obtained for each input showing that the highest peak value denotes the output for different inputs given

Thus, after analysing the program built and each resultant graph, this can be concluded that a successful Matlab program is developed for the face recognition and identification of a new born baby. The efficiency of the system can be further improved. The detailed discussion over the summary and conclusions derived is present in the next chapter of the thesis.

Chapter 5 Summary and Conclusions

5.1 Summary

The basic fundamental of the research lies in the 'Biometric' recognition system. The motivation derived from the increasing incidents of newborn babies' adduction, swapping, mixing, etc proposed a need of a well-organised system that can facilitate in the recognition of babies and identifying the real parents of the baby. The Matlab tool was deployed using the Hidden Markov Models with the SVD coefficients generated a system for the face recognition system associated with the newborn and his parent. The system tested around 10 different images each image having 10 different samples, thus 100 images were presented as the initial database for the system. The parents' images were used as the training set and the baby's images as the test image. As an initial pre-processing system using the two-dimensional order-static filtering was employed, following the calculations of SVD and later the training processes. Generating the training sets, the trained images are stored in the database. The application of system provided around 50% of the recognition for parent and their child using the initial database.

5.2 Conclusion Remarks

Surveying the research based on searching the methods for identification of the infants and their related problems; it can be concluded that facial identification can play a significant role and working with these methods provides for better solutions. The face recognition methodologies can be implemented in various hospitals and nursing homes so that a database can be generated well in advance before the problems of infant's abduction, swapping, missing etc arises. The system can be easily used by the nursing staff of the hospitals for the quick recognition of the infant and his parents; this can lead to remove the discrepancies that arise even when multiple babies born around the time period. Moreover, the Hidden Markov Model with the combination of Singular Value Decomposition techniques returns a medium to solve one of the basic problems that has been prevailing in the country since past several years. The demonstration of a fast and an efficient system is performed using these methods. The scope for future work is required in this field also.

5.3Recommendations and Future Scope

In the future, the focus of the system should be over the operation of larger and much more complicated databases to test the system. For the complicated databases it is merely expected that all the database training will provide the totally expected results. Enhancement in the feature extraction and the modelling of the faces is required. The use of 2-D HMM or more complex models may improve the system performance and efficiency.

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