International Journal of Pure and Applied Mathematics
Volume 118 No. 7 2018, 623-628
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue
ijpam.eu

e-vaccination:Fingerprint Based Vaccination Monitoring System

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***Abstract* - Immunization against common childhood diseases has been an integral part of mother and child health services in India. In developing countries, current vaccination status ofinfants is recorded ina paper, which is ineffective in many ways:information which may go missing, process of looking up data is tedious. The main objective of proposed work is to use biometric traits (fingerprint) of an infant to store their vaccination schedule details,thereby automating the vaccination schedule for the infant.Biometrics traits are usedsince fingerprint of infants have great potential to accurately record immunizations and helps greatly in efficiently searching the data. The proposed method aims at developing an application which provides to alerts on a regular basis toparents and Accredited Social Health Activist (ASHA) workers based on the stored vaccination schedule information.**

Keywords--Fingerprint biometrics; vaccination monitoring; Primary Health center; infant recognition

I. Introduction

Vaccination is the most important public health involvement that requires high routine coverage to reduce Infant mortality rate. Various Immunizationprograms are organized by Government with this aim. Around 1.2 million children died of vaccine preventable disease in India in 2015 before celebrating their fifth birthday, a UNICEF report has said in a grim reminder of atrocious state of child healthcare in the world's fastest growing major economy. Most of the infant deaths caused by diseases are easily vaccine preventable and treatable. India has been one among the five countries accounting for half the 5.9 million under-five deaths reported all over the world last year[16].

Technology of identification and verification on unique physiological and behavioral characteristics includes following biometric traits fingerprints ,palm geometry, iris, dental root morphology. Commercial applications also started using biometric application in which finger print is widely used. Fingerprint authentication involves identification of unique pattern which is used for recognition. Due to availability of low cost scanners and ease use of fingerprints made it widely used biometric traits. Fingerprint recognition of infants has a limited influence over growth.

Current Vaccination System suffers with the following challenges like missing of records (vaccination card), recovery, retrieval, search of vaccination details, priorknowledge on availability of vaccine and number of infants getting benefited is required. Our proposed work will help to recover the data of infants in case of parental death during natural calamities. Orphanages are also one of the important beneficiaries of our proposed work.

Collection of fingerprints from infants is a challenge in itself, as infants tends to wiggle around and have a low contrast between ridges and valleys of their small fingerprint patterns.

II. Literature Survey

A child is considered fully vaccinated only if vaccinated with one dose of Bacillus Calmette-Guérin (BCG) and measles vaccine,three doses of pentavalent and oral polio vaccine with the right dosage and boosters at the right age and interval [1].

District-Level Household Survey-4 in Tamil Nadu indicated that only 56 percent of children aged between 12 to

23 months were fully vaccinated during the period 2012-2013, which is lesser than reported in earlier national surveys[11].

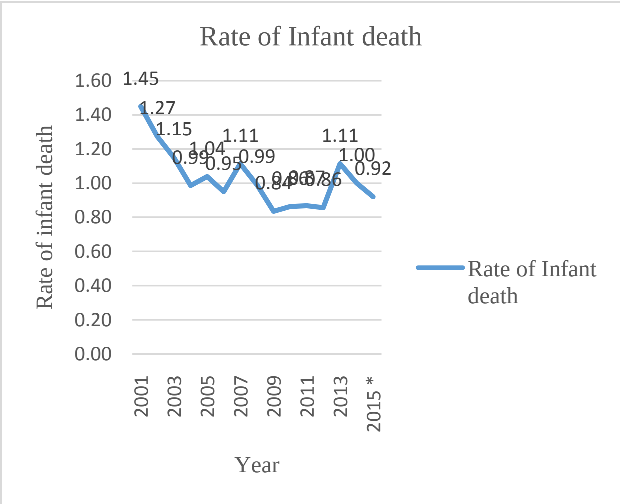

Fig.1: Infant Death Ratio[15]

Efforts to increase vaccination coverage in the country needs to focus on educating the commons about the vaccination schedule and strengthening supervision by implementing a better Monitoring system to ensure that every child is vaccinated at right age and interval . Achievinghigh vaccination rates has been one the greatest challenges in developing countries.

Periodic estimation of vaccination coverage is done to monitor the progress in achieving these targets. About 16 percent of children who received one dose of BCG and 13 percent of children who received first dose of DPT did not complete the full course of vaccination [11].The vaccination analysis of infant includes 108,057 children in which the estimated proportions of fully vaccinated, under- vaccinated, and non-vaccinated children were 57%, 31%, and 12%, respectively[12].

The size of the fingerprint does not have any influence in fingerprint recognition system. The major concern of an infant fingerprint is with the image quality, which is strongly influenced by distance of the ridges and the non-similarities that are introduced by distortion effects, and ill-positioning of the finger. There may occur some resolution problems with the enrolment systems as they operate at one fixed resolution. Smaller ridge distance could have an impact on the ability of algorithms to deal with the non-similarities introduced by distortion effects and ill-positioning of the finger.

Children may behave differently during the enrolment process as compared to adults. This is simply due to the lack of understanding of the process and also because of their children-specific attitude. This can be classified as less cooperative while keeping in mind the main objective to obtain fingerprint images of respectable quality. Fingers of children grow at the same rate as the rest of the body. The time period between the enrolment process and the sample fingerprint image collected during the vaccination to be compared could be long enough to prohibit smooth matching. It is not known, to what extent this growth effect becomes relevant for the matching process and whether algorithms will take this effect into account.

III. PROBLEM STATEMENT

A vaccination monitoring system to take complete control over tracking the child vaccination status and monitor the vaccination schedule.Separate vaccination schedule for each infant in order to provide vaccines at right age and interval.Incorporating with Electronic Vaccine Intelligence Network (eVIN) to monitor and avoid wastage of vaccines[14].It is observed that only 80 percent of parents had a vaccination card and vaccination status are collected or surveyed based on mother's recall. Thus this system provides an improved method to avoid the missing records by using e-vaccination method rather than vaccination cards.This system can also be used in times of natural calamities for identification of children and to prevent illegal adoption.

IV. PROPOSED WORK

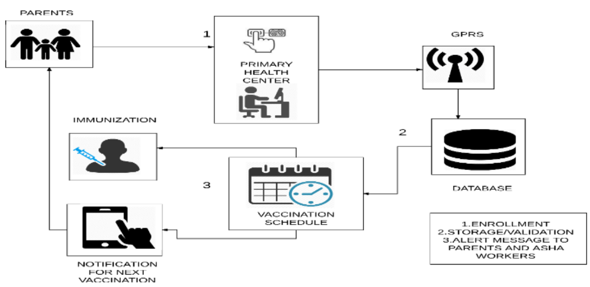

Fig.2: Proposed working of vaccination system

A centralized system to monitor vaccination coverage of each child by providing relevant notifications to parents and health care centers,thereby increasingthe coverage of vaccinations.

The system monitors the vaccination schedule of the child and notifiesif the child is to be vaccinated .In case of any failure or discrepancy, an alternative catch-up schedule is also suggested. Every child's record is stored in the database and notifications are served to the parents based on the vaccination schedule. This is achieved through the biometric trait-fingerprint, which has a higher influence rate than other traits. During the enrollment processthe fingerprint is captured, processedand theencrypted template in stored in the database. During the vaccination period, verification is done and status of vaccination is updated in the database. The goal of the system is to notify the parents in prior about the upcoming or missed dosages, so that the parents can react in a swift manner.

Various Stages in extracting the Infant vaccination information from database involves,

1. Extract features from the input image

2. Match the query template against the one stored in the database depending on age of the infant after classification
3. Verification of fingerprint and retrieve relevant data from database
4. Update the database with relevant vaccination details.

Fingerprint enrollment is done after the birth during the first vaccination cycle where images are collected. The features are extracted and saved as templates in database. During the enrollment process, all the necessary details of the child and parent are collected for further notification process. A vaccination schedule is generated for each infant based on the date of birth and monitoring system is designed for both Parents and ASHA workers to track upon the schedule generated. Thus by which the vaccination schedule for every infant can be monitored. Since infant fingerprint grows overtime, it's important to develop a stable system for verification of fingerprints.

During each vaccination phase, the fingerprint data stored in the database is updated if there is a visible growth in the ridge distance. In the next vaccination cycle, the updated template is used for the matching process and it is further updated if there are any signs of growth.

V. IMPLEMENTATION

A. Data collection

Keeping track of the children who were vaccinated with boosters since birth is important in vaccination coverage to avoid mishaps in health care. In the present day, paper based work is used for identification of infants which is not a reliable way of monitoring. We have captured 100 fingerprint images (500 dpi) of 40 infants and toddlers over a 10-day period in K.G.PUDHAR and ETTIMADAI villages in Coimbatore District of Tamil Nadu State in INDIA

B. Fingerprint processing and matching flow

Main elements of the proposed work are:

1. Acquisition of fingerprint image (by an acquisition device fingerprint scanner).
2. Image processing (to enhance the relevant information).
3. Feature extraction (to encode the found information).
4. Storing and comparison of the fingerprints as templates

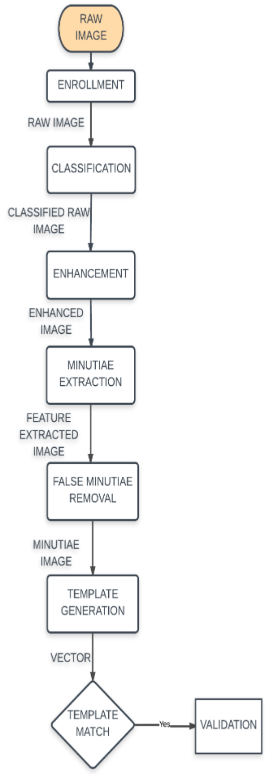

Fig. 3: Overall Framework for Fingerprint Matching System

C. Classification

Various pattern in fingerprints are classified in order to reduce the comparison time with the whole database where the queried fingerprint is compared only with specified pattern.The pattern area is the part of arch, loop or whorl which appears as cores, deltas, and ridges are used in classification of fingerprint templates[6].

Table 1. Classification table: population details

Pattern Name	Population Coverage	Description
Loop	60-65%	Ridge lines enter and exit from the same side of the finger.
Whorl	30-35%	Whorls have one ridge line that makes a complete circle around the finger.
Arch	5%	A pattern where the ridge lines enter from one side and leave on the opposite side in the shape of an arch[13].

D. Steps involved in Processing after Classification:

The fingerprint obtained undergoes various image enhancement techniquesand template is generated as a resultant [1]. Various techniques involved in extracting the features also includes estimation of ridge frequency, ridge orientation, ridge segmentation. The process of bifurcation, histogram equalization, Fast Fourier Transform techniques and normalization are performed during image enhancement [4] [5]. Masking is followed by minutiae extraction and removal of false minutiae whichreturns an extract of minutia which is featured as template.Masking is done with delta and core regions by Morphological operations on binary images with block size. A fingerprint may or may not have cores. Core point is referred as center area.The delta point on a ridge regionor nearest the center of divergent lines.From Minutiae Extraction of fingerprint image identifying the falseminutiae is performed and minutiae features are returned as vector.

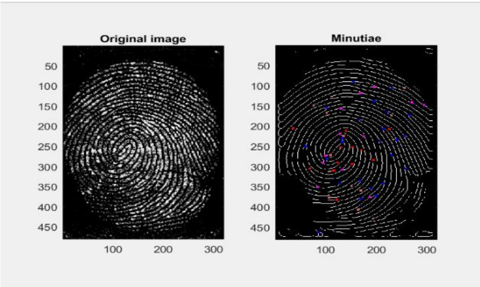

Fig. 4: Minutiae Extraction of Adult fingerprint

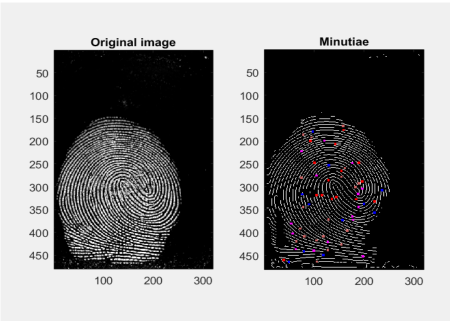

Fig. 5: Minutiae Extraction of Infant fingerprint

Above the images are comparison of extracting features from an adult fingerprint and an infant fingerprint by which an infant is identified by fingerprint.

The algorithm performedextracts minutiae features and storedas vector called minutiae template which contains the values of X coordinate ,Y coordinate of the minutiae point , CN is the Crossing Number and Theta is orientation of minutiae. Similarity Score is also generated using the Euclidean distance which is the based on distance and theta between two templates for which each template which is matched against template which is stored in the database[7]. In order to perform template matching, transformation is performed with index of reference minutia and rotation angle, which provides the new coordinates for template match[11].

VI. RESULTS AND ANALYSIS

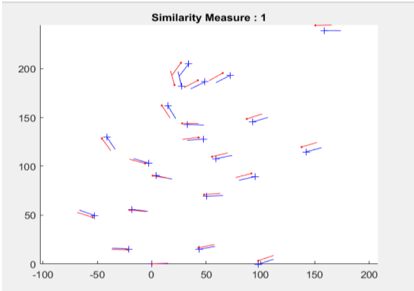

Fig.6 : Similarity measure of matched infant fingerprint

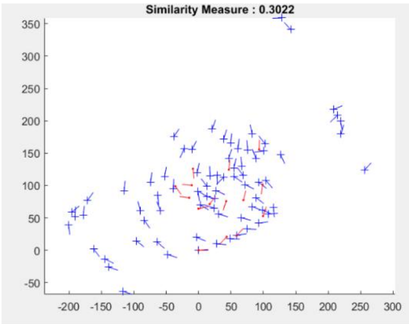

Fig.7 : Similarity measure of un-matched infant fingerprint

Image comparison of calculating similarity measure of an exact infant fingerprint match and mismatch of fingerprint match one to match matching via calculating the similarity score generation. Similarity measure is calculated by finding the Euclidian Distance between two points, fixing threshold values of distance and theta. Based upon these values, similarity index is generated. The fig.6 and fig.7 show the similarity measure of an exact fingerprint match and fingerprint mismatch respectively. We do a one to one matching by calculating the similarity score generation [8].

False match rate (FMR): The likelihood of the system which incorrectly matches input template to non-matching template stored. It provides the measure of invalid inputs which is accepted which depends on threshold value.

False non-match rate (FMNR): The likelihood of the system which fails to detect a correct match of input template and template. It provides the measures of valid inputs which is rejected.

Receiver operating characteristic (ROC): The ROC plot is a trade-off between the FMR and the FNMR higher threshold tends to reduce FMR but still increases FNMR.A common variation is the Detection error tradeoff (DET) obtained via normal deviation on both axes.

From our enhanced algorithm,these are the results analyzed where FMR rate value is at 0.5 , FNMR rate value is at 0.3 and EER (Equal Error Rate) value is at 0.38 in similarity index. Thus the graph is shown below.

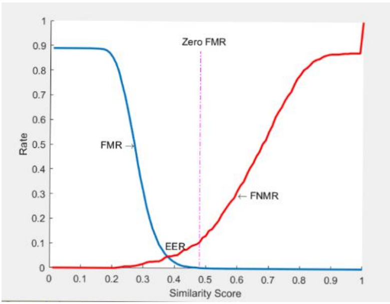

Fig 8: FMR and FNMR ratio

VII. CONCLUSION

Improper vaccination coverage continue to be the root-cause for increasing vaccine-preventable diseases and hence increase in Infant Mortality Rate(IMR). An efficient immunization program is unavoidable to keep track of the vaccination schedule of infants. Our proposed system keeps all information related to vaccination safe electronically rather than manual documentation. In this paper, we have investigated the feasibility of using fingerprints for identifying infants aged less than 4 years. Infant fingerprints could potentially be used for unique identification; in this study high quality images (500dpi) of infants fingerprint was collected. The system can be improvised by exploring various capturing techniques of infant biometric traits and incorporating security features to protect the database for deploying a product[9].

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