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Human Identification using Dental Biometrics

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Abstract-

Dental records have been extensively used in identifying the victims of massive disasters, such as the 9/11 bombing and the Asian tsunami. Dental Biometrics uses dental radiographs to identify victims in situations (e.g., fire victims) where conventional biometric features i.e., face, fingerprint and iris, are not available. The radiographs acquired after the victim's death are called post-mortem radiographs and the radiographs acquired while the victim is alive are called ante mortem radiographs. The goal of dental biometrics is to match an unidentified individual's post-mortem radiographs against a database of labelled ante mortem radiographs. If the teeth in the post-mortem radiographs sufficiently match the teeth in someone's ante mortem radiographs, the identity of the post-mortem radiographs is established. Dental biometrics utilizes dental radiographs for human identification and recognition. The dental radiographs provide information about teeth, including tooth contours, relative positions of neighbouring teeth and shapes of the dental work. The proposed system has feature extraction and matching of dental images. Feature extraction uses anisotropic diffusion to enhance the dental images and a mixture of Gaussians model to segment each tooth. After the enhancement, dental images are matched. The matching has three sequential steps like tooth-level matching, computation of image distances, and subject identification. Radiographs not only give us the information about the shape of the teeth, but also other information such as the artificial prosthesis of the teeth. This project will involve utilizing this information to improve the reliability of person identification and recognition with their dental images.

Keywords—Ante-mortem, Authentication, Post-mortem, Radiographs, Matching.

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I. INTRODUCTION

Determining identity of an individual is becoming very important now days. Biometrics or biometric authentication refers to the identification of humans by their characteristics or traits. Biometrics is used in computer science as a form of identification and access control. It is also used to identify individuals in groups that are under surveillance. Biometric identifiers are the distinctive, measurable characteristics used to label and describe individuals. The biometric systems are divided into two categories as: behavioral biometrics and physiological biometrics. Dental biometrics [1] uses information about dental structures to automatically identify human remains. The methodology is mainly applied to the identification of victims of massive disasters. The process of dental identification consists in measuring dental features, labeling individual teeth with tooth indices and the matching of dental features. Dental radiographs [1], [2] are the major source for obtaining dental features. Commonly used dental features are based on tooth morphology (shape) and appearance (gray level). Dental biometrics utilizes dental radiographs for human identification. The dental radiographs provide information about teeth, including tooth contours, relative positions of neighboring teeth, and shapes of the dental work (e.g., crowns, fillings, and bridges). Dental biometrics requires ante mortem (AM) [1] and postmortem (PM) radiographs for finding unidentified subject. Automated Dental Identification System (ADIS) [13] have four stages: preprocessing, segmentation of radiographs, contour extraction or dental work extraction and matching. Three types of radiograph images [11] are used in dental biometrics. They are

A. Bitewing Radiograph

This is one of the radiographs as shown in fig.1 used in dental biometrics which can be used for revealing the cavities in teeth. It is taken at routine checkups

Fig.1 Bitewing Radiograph

B. Periapical Radiograph

This radiograph as shown in fig.2 shows the entire tooth including the crown, root and the bone surrounding the root.

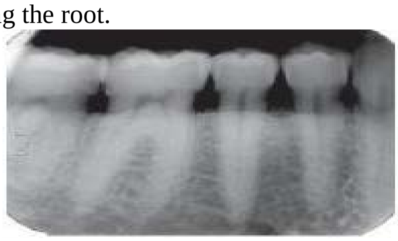

Fig.2 Periapical Radiograph

C. Panoramic Radiograph

This radiograph as shown in fig.3 gives the information not only about the teeth and also their arrangement of upper and lower jaw bones, sinuses and other hard and soft tissues around the region. It gives broader overview of entire dental image.

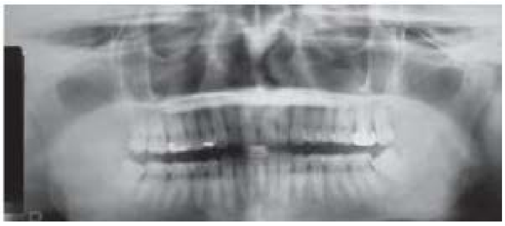

Fig.3 Panoramic Radiograph.

The main purpose of forensic dentistry is to identify the victims for whom means of identification such as face, iris and finger print are not available [1]. This can also be used for identifying the victims of massive disasters. Dental biometrics uses dental radiographs for identification. The radiograph obtained after the victim's death is called post mortem radiograph and those obtained while the victim is alive are called ante mortem radiograph. By comparing the AM and PM radiographs [2], the identity of the person is established. Automating the process of postmortem identification of deceased individuals based on dental characteristics. With the large number of victims encountered in mass disasters (e.g., Asian tsunami), automating the identification process would enhance the scalability of this biometric. By using panoramic radiograph images [3], the pattern of the dental structure is analyzed and identity of a person can be established. To match an individual's PM radiographs against a database of labeled AM radiographs. If the teeth in PM radiographs match the teeth in someone's AM radiographs in the database, then the identity of the victim is established. Dental biometrics utilizes dental radiographs for human identification. The project is aimed at the automatic analysis of dental radiographs to identify the deceased individuals. The goal of dental biometrics is to match an unidentified individual's PM radiographs against a database of labeled AM radiographs.

II. RELATED PAPER WORK

Dental biometrics [2] utilizes dental radiographs for human identification. The dental radiographs provide information about teeth, including tooth contours, relative positions of neighbouring teeth, and shapes of the dental work (e.g., crowns, fillings, and bridges). The proposed system has two main stages: feature extraction and matching. The feature extraction stage uses anisotropic diffusion to enhance the images and a Mixture of Gaussians model to segment the dental work. The matching stage has three sequential steps: tooth-level matching, computation of image distances, and subject identification. In the tooth-level matching step, tooth contours are matched using a shape registration method and the dental work is matched on overlapping areas. The distance between the tooth contours and the distance between the dental works are then combined using posterior probabilities. In the second step, the tooth correspondences between the given query (post-mortem) radiograph and the database (ante-mortem) radiograph are established. A distance based on the corresponding teeth [2] is then used to measure the similarity between the two radiographs. Finally, all the distances between the given post-mortem radiographs and the ante-mortem radiographs that provide candidate identities are combined to establish the identity of the subject associated with the post-mortem radiographs.

Automating the process of post-mortem identification of deceased individuals based on dental characteristics [1] is receiving increased attention. With the large number of victims encountered in mass disasters (e.g., Asian tsunami), automating the identification process would enhance the scalability of this biometric. However, archiving and retrieving dental records from large databases is a challenging task and has received inadequate attention in the literature. This technique concerns itself with the task of efficient fast retrieving dental records from a database in order to assist the forensic expert in identifying deceased individuals in a rapid manner. The proposed method is an appearance-based technique [1] that consolidates the evidence presented by individual teeth in a dental record, i.e., it 'moves' from tooth-to-tooth in order to render a record-to- record matching score.

The proposed method is shown to reduce the searching time of record-to-record matching by a factor of hundred. Experimental results indicate that the proposed approach requires significantly less time compared to the other approaches suggested in the literature thereby underscoring its relevance in real-time applications. Dental biometrics used in forensic science [11] for individual recognition. It utilizes dental radiographs. This radiograph provides information related to teeth shape, teeth contour and relative position of neighbouring teeth, also it gives shapes of dental work like crowns, filling & bridges etc. This paper includes different method used for dental biometrics [11] and related information. Dental biometrics requires ante-mortem (AM) and post-mortem (PM) radiographs for finding unidentified subject. Dental biometrics having three stages: Pre-processing and segmentation of radiographs, Contour extraction or dental work extraction, Atlas registration and matching. Segmentation can be done by various methods that are mentioned in this paper. Contour or shape of teeth and dental work can be extracted by using active contour model (ACM) or active shape model (ASM) methods [11]. Atlas registration is the method used for labelling to teeth, which will help in the matching stage. Matching of AM radiograph with PM radiograph can be done by using algorithms. In this technique, a neural network is trained to relate radiograph image contents to their optimum image compression ratio. Once trained, the neural network chooses the best wavelet compression ratio of the x-ray images upon their presentation to the network. Experimental results suggest that our proposed system can be efficiently used to compress radiographs while maintaining high image quality.

III. EXISTING SYSTEM

In Forensic Dentistry, the human experts perform manual comparisons of ante-mortem and post-mortem dental records. In manual approach, the main characteristics used to compare dental records are:

i. The presence or absence of a specific tooth
ii. The morphology and dental restoration of the teeth periodontal tissue characteristics

Such manual approach may not be useful in case of identifying victims of massive disasters where manual comparison of images may consume a lot of time. Semi automatic analysis of dental radiographs involves the process of segmentation of tooth contours [9], [10], extracting their features and then matching them using their relative distance or matching score between the query image and the database image. But if the deceased individual lost any teeth then the matching score will be low and there is a chance of misrecognition of the individual. There are still a number of challenges to overcome. The shape extraction [3], [5] is a difficult problem for dental radiographs, especially for poor quality images where some tooth contours are indiscernible. For subjects with missing teeth, we need other features for identification, such as the shape of mandibular canals and maxillary sinus. Such discrepancies make the application less reliable.

IV. PROPOSED WORK

Automatic Dental Identification System [13] will enhance human identification in such catastrophic events where the use of biometric identifiers such as face and fingerprints may not be possible. Given a post mortem (PM) dental record, the main goal is to design a search engine that can retrieve potential matches from a large repository of ante mortem dental records thereby assisting the forensic expert in her task of establishing identity. The main goal of the proposed technique is to reduce the dental record retrieval time while maintaining reasonable accuracy. The block diagram for thr proposed system as shown in fig.5.

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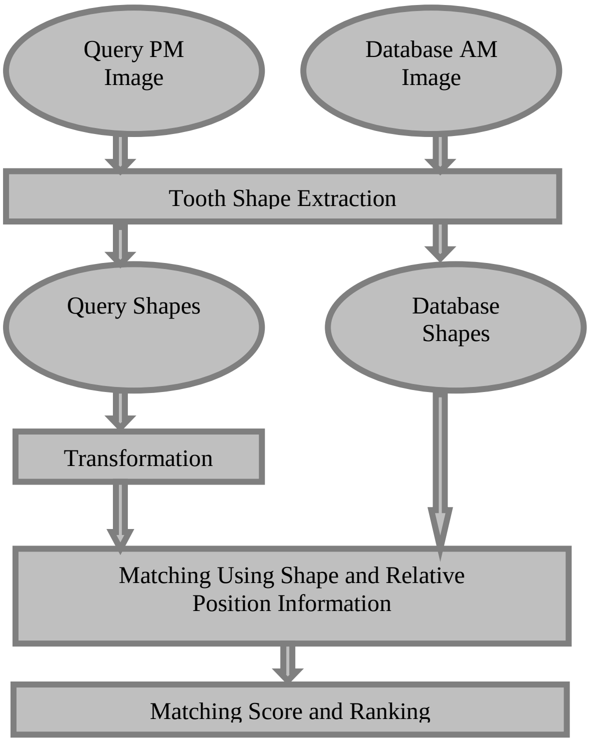

Fig.4 Block diagram for proposed system

The proposed approach depends on dimensionality reduction using principle component analysis (PCA). The accuracy of class-based retrieval (where the tooth class is known) versus class independent retrieval (where the tooth class is unknown) is also compared for few specimens. This proposed technique that is based on PCA. We use Discrete Wavelet Transform (DWT) for easy extraction of the features of the image. A wave is an oscillating function of time or space and is periodic. In contrast, wavelets are localized waves. They have their energy concentrated in time or space and are suited for the analysis of transient signals. Fourier Transform and Short Term Fourier Transform (STFT) use waves to analyze signals, the wavelet transform uses wavelets of finite energy. DWT which is based on sub-band coding is found to yield a fast computation of Wavelet Transform. It is easy to implement and to reduce the computation time and resources required. A sampled input image is decomposed into various frequency sub bands or sub band signals. A two dimensional decomposition can be applied over the image. A simple example of level 2-Decomposing is shown in fig.5. The original image is subdivided into four parts.

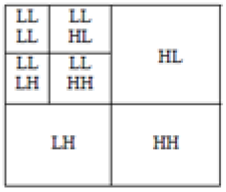

Fig.5 Splitting of images

The LL band contains low frequency contents of the signal, whereas, HH band contains high frequency contents of the signal, which has less importance than LL band. After the features are extracted, the PM image is matched against a database of AM image and then the identity of the person is recognized. We use k-Nearest Neighbour classifier to match the input image against a database of images. k-NN is a method for classifying the objects based on closest training examples in the feature space. k-NN is a type of instance-base learning where the function is approximated locally and all computation is deferred until classification. The k-Nearest Neighbour algorithm is amongst the simplest of all machine learning algorithms: An object is classified by a majority vote of its neighbour, with the object being assigned to the class most common amongst its k-NN (k is a positive integer).

V. System Design

The design of dental identification system consists of four modules as shown in fig.6. They are:

- Preprocessing
- Segmentation.
- Feature extraction.
- Matching.

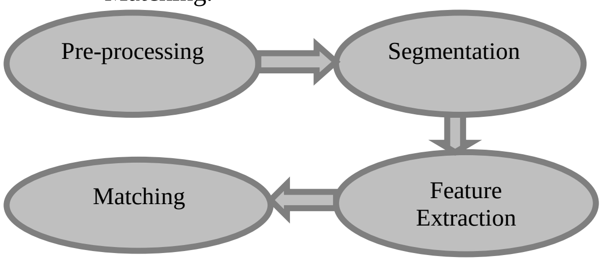

Fig.6. System Design

A. *Pre-processing*

Automatic extraction of dental contours [6] is a very tedious problem. The radiographs are pre-processed to filter out unwanted noise. Dental radiograph initially converted into gray scale image. Region of interest (ROI) are decided on radiograph. Histogram is used to filter out unwanted intensities from the image. Anisotropic diffusion is used for smoothing the pixels inside each region.

B. *Segmentation*

Radiograph is segmented [9], [10] into regions such that each region contains only a single tooth. Segmentation algorithm has three stages:

i. Noise filtering
ii. Thresholding to isolate the teeth from the background.

iii. Analyzing the resulting connected components labelling to determine the ROIs.

C. Feature extraction

Automatic extraction of teeth contours is a challenging problem. In this, manually select a rectangular region R and a point c in the input image I, where R is a region containing the tooth and the point c is inside the crown of the tooth, which is called the crown center. First, we compute the gradient image as shown in fig.7, | I|, of the input image, I, as

$$|\nabla I(x,y)| = \sqrt{\left(I(x,y) - I(x,y-1)\right)^2 + \left(I(x,y) - I(x-1,y)\right)^2}$$

The feature extraction phase extracts the shapes of the teeth in the database radiographs and query images as shown in fig.8.

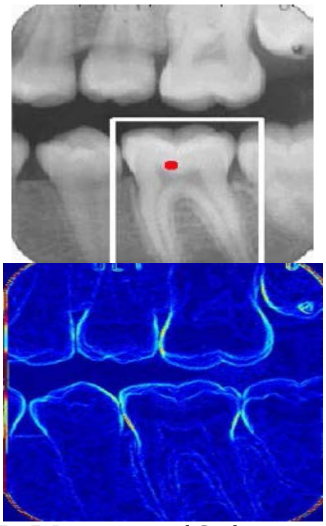

Fig.7. Input image and Gradient image

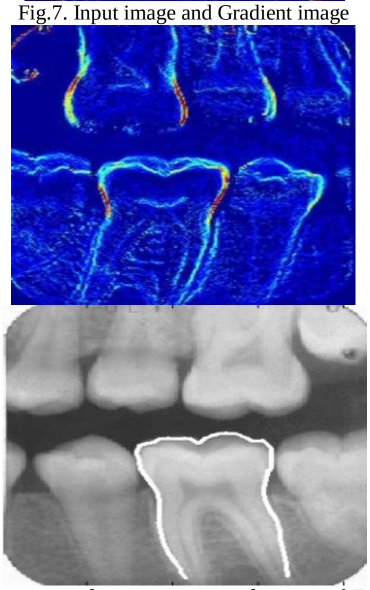

Fig.8. Gradient image after removing interference and Extracted tooth shape

D. Matching

The shapes extracted from the query image must be matched to the shapes extracted from the database images as shown in fig.9. In this case the affine transformation should be removed. Given a query image, from every database image [4], [7] we generate several sub-images, each containing the same number of teeth as the query image, labelled as 1, 2,..., from left to right. Then teeth with the same label in query and database sub-image form a pair. Given the matching distance between two images, the similarities between the subjects are computed. The algorithm for subject identification has five steps.

Algorithm

Step1: To compute the matching distances between one PM image and the entire AM image

Step2: If two images do not have any tooth in common, their matching distance will be large.

Step3: So the smallest distance is chosen to represent the matching distance between the image and the subject.

Step4: The image to subject distance is averaged over all images of the subject to obtain the matching distance between the subject and the images in the database.

Step5: A candidate list is generated based on the results. Based on this the image having close resemblance is identified.

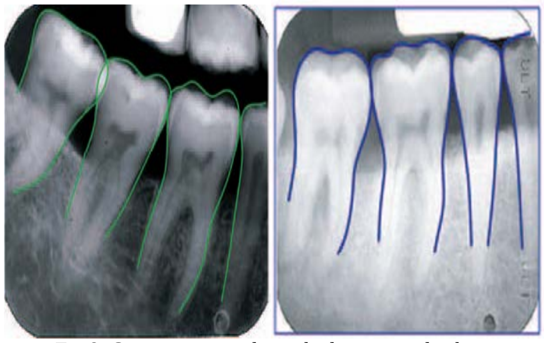

Fig.9. Query image and matched image in database

E. Implementation

This proposed algorithm is being implemented using MATLAB R2008a, Lenovo think centre M71e desktop PC with 3.1GHz CPU. The proposed system is implemented with five modules. They are

1) Data Collection
2) Analysis of the problem
3) Design specification
4) Implementation
5) Testing

1) Data Collection:

In this phase collection of various ante-mortem dental radiographs are done. They are stored in a template and thus constitute a database. The information such as name and address of the person to which the radiograph belongs is stored separately.

2) Analysis of the Problem:

Analysis is the process of gathering and interpreting facts, diagnosing problems, and using the information to recommend improvements to the system. In this phase the noise in the radiograph image should be removed and the images are to be made in to same size for easy storage and retrieval purpose. The problem is analyzed as follows.

i. The features of the input image and the database image should be extracted
ii. The images are matched by using the extracted features
iii. Finally the victim is identified

3) Design Specification:

Design is the process of planning a new business system or one to replace or complement an existing system. But before this planning can be done, we must thoroughly understand the old system and determine how system can best be used to make its operation more effective. In design phase, the older techniques used for identifying deceased individuals are analyzed to make this system effective.

i. For extracting the features of the input and the database images PCA method is used.
ii. For training and testing the database k-NN classifier is used.

4) Implementation:

After the design phase is done, implementation of the design is done by coding. Several pseudo codes are analyzed to code the entire design.

5) Testing:

After implementation is done the application is tested for correctness. The application is subjected to a series of testing strategies such as white box testing, black box testing etc..,

The result of the proposed system as shows in fig.10, 11, 12, 13.

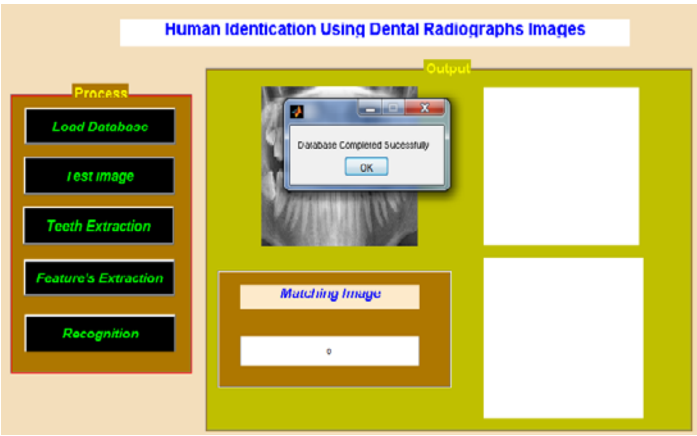

Fig.10. Loading Database

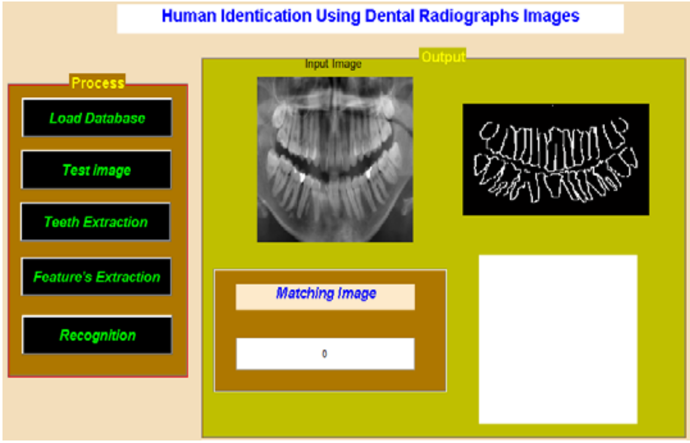

Fig.11. Teeth Extraction

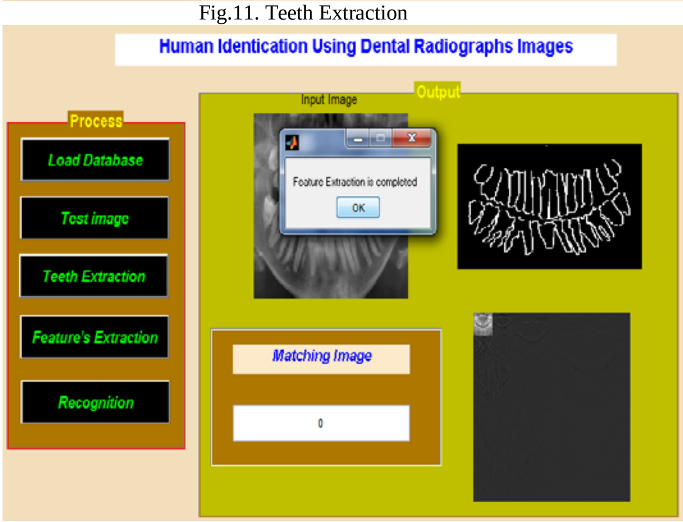

Fig.12. Feature Extraction

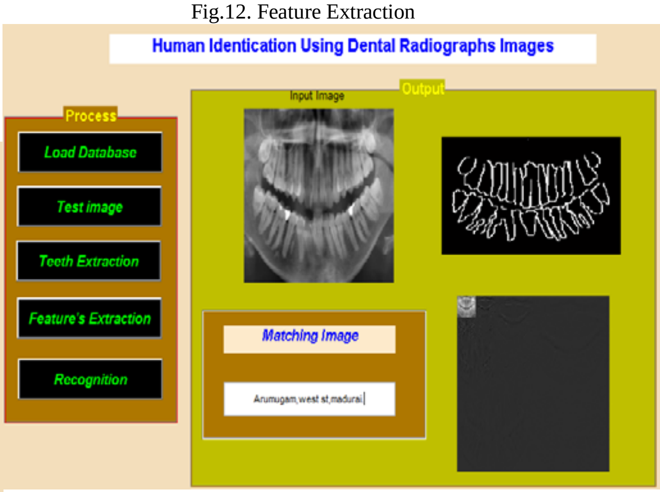

Fig.13 Matching

VI. Conclusions

Dental biometrics is used to recognize persons in the forensic domain. This work presents an automatic method for matching dental radiographs. Experimental results show that this approach is promising and very fast searching mechanism. There are still a number of challenges to overcome. The shape extraction is a difficult problem for dental radiographs, especially for poor quality images where some tooth contours are indiscernible. We are also in the process of collecting a larger database for evaluating the algorithm.

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