Dental Radiographs and Photographs in Human Forensic Identification

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Abstract— Forensic dentistry involves the identification of humans based on their dental records, mainly based on dental radiographs/photographs. The method developed, deals with identification of human using dental information. Many works in this field proves that it is possible for identifying humans from dental radiograph records, matching ante-mortem and post-mortem data. This method is used in the time of disasters causing mass loss of human life. In those cases when other biometric data may be missing or cannot be used, dental data is considered for forensics. The proposed method deals with identification of human from dental photographs and radiographs, since radiographs may not be available always. A semi-automated algorithm for matching teeth from available photographic and radiographic images is implemented. In this research, intensity features are used for matching. In the case of photographs, homomorphic filtering is used to normalize the brightness across the image and to increase contrast of the image. Finally, matching of images based on intensity features using Euclidean distance is used.

Key words: Human Forensic Identification, Dental Radiographs

I. INTRODUCTION

In mass disaster situations like Tsunami, Earth quakes and terrorist attacks conventional means of biometrics are helpless. Dental records have been widely used as a prime tool in forensic identification. Forensic odontology is the branch of forensics which deals with the human identification based on dental features. Dental features can be considered as a way to identify humans if there is no other means of con-ventional biometrics such as palm prints, finger prints, iris etc., are found. Human identification using dental images has been proven to be the best under certain circumstances if there is no means of biometrics avail-able. Teeth and bones are treated as the hardest part in human body which have the ability to resist to mod-est force effects, high temperatures upto 1100 Celsius. In a recent tsunami disaster with a count of thousands of victims, around 50-70% of cases are identified using dental radiographs. The goal of forensic dentistry is to identify people based on their dental records, mainly using radiograph images. Here a human identification system is build using dental images.

The concept behind the proposed work is to identify humans from photographs and radiographs. A semi-automated system for matching teeth from available photographic and radiographic images is implemented for this purpose. In this work, matching is done based on the horizontal and vertical features extracted from images. Homomorphic filtering is used to normalize the brightness across the image and to increase contrast of the image. Finally, matching of extracted features is done using Euclidean distances and similarity is scored.

Based on different dental features, the identification of victim can be done, and this branch of forensics is called Forensic odontology. This type of human identification becomes a necessity during the situations of natural disasters. Mainly, the existing methods for human identification are based on dental radiographs. But it's a fact that dental radiographs of people may not be easily available compared to the availability of dental photographs. So in such situations where den- tal radiographs are not available, human identification can be done with the help of dental photographs. This work intends to implement a system for human identification by using both dental radiographs and photographs.

II. RELATED WORK

The Jain and Chen, introduced a semi-automated contour method for shape extraction and pattern matching[9]. The shortcomings in their approach include, if the image is too blurred and severely occluded, their algorithm may not be pertinent. The computation time for this algorithm is higher because the crown and root shape extraction is done separately. For contour extraction the morphological corner detection produces comparatively better hit-rate whereas it fails to handle severely occluded dental radiographs. The shape extraction is further efficient by using connected and fast connected component la-belling, which uses Mahalanobis distance as the measure of matching. The person matching was analysed with various similarity and distance metrics. Said et al. offered a mathematical morphology approach, which uses a series of morphology filtering operations to improve segmentation and by using connected component analysis the desired region of interests are obtained. Human identification is also explained using shape and appearance of the tooth, in which panoramic dental images are not handled. Nomir and Abdel-Mottaleb achieved the efficiency improvement by combining three different matching techniques[10]. Matching of dental records using hierarchical distance proves to be an efficient in terms of retrieval time. Based on analysis of tooth anatomy and tooth growth direction, a dental radiograph segmentation algorithm was developed. Individual identification is supported by classification and numbering of teeth. Mesiodistal neck detection is introduced for molar and premolar classification. One of the notable issues of automated dental identification system is missing tooth. A concept of finding missing tooth using classification and numbering was done in order to aid content-based retrieval of dental images. In case of absence or inaccuracy of dental records, the person identification can be done by family photographs. It is evident from Thailand tsunami victim identification that, weak and absence of dental records did not stop forensic odontology team from their contribution towards person identification. It can even be done with the availability of photograph of upper anterior teeth. In case of inadequate availability of dental radiographs, it could be interesting to analyse the family albums or photographs taken during functions for the missing person identification based on its dimension, size and alignment of the teeth.

Shubhangi Dighe and Revati Shriram used histogram equalization so as to pre-process the radiograph[11]. Sobel operator is used for the edge detection in the image horizontally and vertically. The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Morphological and image cropping operation are done for single tooth extraction. And matching is done based on histogram. But missing tooth in dental image can cause errors. Chen and Jain proposed a biometric sys-tem for semiautomatic process and matching of dental images for human identification. This methodology extracts the form of teeth from the AM (ante-mortem) and PM (post-mortem) radiographs, and affine re-model was applied to suit the shapes of PM pictures to those in AM pictures[1]. Jain and Chen proposed a way for alignment and matching of dental radiographs. This technique uses the data regarding the teeth contours and dental work for identification. The active contour models were used for extraction of tooth contours[2]. Mahoor and M.Abdel developed an automated algorithm to classify teeth in X-ray lm dental images using Bayesian classification and assigned variety to every tooth supported the common numbering system. Nassar and Fahmy proposed a method for teeth segmentation in digitized dental X-ray lm using mathematical morphology. The contrast stretch transformation was used to improve performance of teeth segmentation [3]. O.Nomir developed a new technique for identification based on the shape and appearance of teeth from dental x-ray radiographs. Each tooth was representing a feature vector obtained by the energy function of gray scale image of the tooth. The method could overcome the drawbacks of using the contours of the tooth, which could be affected by the quality of an image [4]. Nikaido and Koichi developed an efficient dental radiograph registration algorithm using phase based image matching for human identi fication [5]. Je and Omanovic proposed an automated scoring and ranking method for human identification using the sum of squared differences (SSD) cost function [6]. S.Kiattisin and Leelasantitham proposed a method for matching x-ray teeth film, using image processing based on unique features of tooth. This method will assist the medical doctors to t honestly a pair of enamel, the use of special functions of teeth[7].

III. PROPOSED METHODOLOGY

The proposed method comprises five main process-ing stages; the initial stage is pre-processing, that is, initial work on dental data then the single tooth segmentation step is done, that is for getting the relevant part of teeth from the dental images. Then horizontal, vertical features and orientation of each extracted tooth is done. And then, matching is done based on the extracted features.

A. Pre-processing and Segmentation

Pre-processing is the first and foremost step in den-tal image processing and has its importance as the whole processing is based on it. Images of bad quality create difficulties at every stage of feature extraction and matching. Here the system takes the radiographs or photographs images, which is further processed for identification of individuals. The RGB images are con-verted to gray scale images in this stage. In almost all photographs, along with teeth, due to reflection in lips, noise are created, which will affect further measurements of horizontal and vertical features. To avoid this, homomorphic filtering followed by global segmentation is done. Homomorphic filtering is a generalized technique for signal and image processing, involving a nonlinear mapping to a different domain in which linear filter techniques are applied, followed by mapping back to the original domain. Homomorphic filter is used mainly for image enhancement in image processing. It simultaneously normalizes the brightness across an image and increases contrast. In this work, the homomorphic filtering is used to get uniform illumination in the image. The illumination of an image is made uniform by increasing the high frequency components and decreasing the low frequency components. Because the high-frequency components are assumed to represent mostly the reflectance in the image, whereas the low-frequency components are assumed to represent mostly the illumination in the image. The figure 4.3 shows the image after applying homomorphic filtering.

The goal of segmentation is to find region of interest associated with the part of image that comprises some desired teeth of the image. Single tooth is separated in the case of radiographs and global segmentation is done in the case of photographs for further processing.

B. Feature Extraction

The aim of dental identification system (DIS) is to authenticate humans on the basis of dental information. The evaluation of image quality is done by comparing the images in the database. The objective is to implement a system where matching is done based on horizontal and vertical features. The algorithm is de-signed and then implemented in MATLAB software.

In this section, the features are extracted from radiographic and photographic images. Here it requires the ante-mortem dental records to be captured and kept before the post-mortem images. So, in both dental records, the viewing angle may be different. In or-der to solve this, we use horizontal and vertical intensities as features in the case of both dental radiographs and photographs. Thus by using these features, a feature vector is created and matching is done.

C. Matching

Accurate matching leads good identification, which is the desired goal. In matching stage, the post-mortem image features are compared with the ante-mortem features present in the database. The identification of humans on the basis of features depends on the scored level of similarity resulted in the matching stage. Euclidean distance (ED) is used for observing the similarity in both the ante-mortem and post-mortem dental records.

D. Experiments and Results

The work was implemented as a summary of the results are given in this chapter. The results are di-vided into different modules. The system consists of mainly two phases. First phase for processing the post-mortem images and the second for processing ante-mortem images.

PM image processing phase is designed for training the system with images and their measures, such that they can be stored as features for later matching.

AM image processing phase is designed for testing the images and for matching the images in database. The measurements are calculated for features ex-tracted and the most matching image is selected.

The following section describes the experimental set up and results obtained from the implementation of the system. The method is tested on two databases: that is, dental radiographs and colored teeth images and the results are highly encouraging. The proposed system consists of pre-processing, segmentation, feature extraction and matching stages.

For the following calculations twenty photographs and twelve radiographs are used from the database named:

1) Radiographs r1 - r12
2) Photographs p1 - p4

The data set which comprises of dental radiographs of twelve persons from which nine are found to be matching and photographs of twenty persons from which six-teen are found to be matching. The result shows high accuracy using this proposed methodology.

In each radiographic query image, each tooth is separated and corresponding tooth horizontal, vertical features and orientation are found. And from in each photographic images, global segmentation is done and connected extra components are removed and segmented teeth is resulted. The three query images that were not correctly matched in the case of radiographic images are examined and identified the following reasons for the mismatches: (i) poor quality of images, resulting in errors in tooth extraction, (ii) some tooth were only partially visible and (iii) the inherent similarity between teeth shapes of different individuals.

The four query images that were not correctly matched in the case of photographic images are examined and identified the following reasons for the mismatches: (i) poor quality of photographs, result-ing errors during global segmentation, (ii) damage of teeth during disasters, (iii) inherent similarities.

Table 1 shows matching result of query image and database image in the case of radiographic images.

Data Set	Total Person	Correctly Identified Persons	Identity Rate
Radiographs	12	9	75%

Table 1: Matching Results of radiographic images

Table 2 shows matching result of query image and database image in the case of photographic images. Experiments were carried out, to match the query image with the database images using the features extracted. The results showed those features in the databases that have: horizontal features mean, the vertical features mean and the angle at which they are aligned similar to the query image gave a true output; else a false output was obtained. Table 3 explains the performance of identification system.

Data Set	Total Person	Correctly Identified Persons	Identity Rate
Photographs	20	16	80%

Table 2: Matching Results of photographic images

Measure	Radiographs	Photographs
Precision	81.8%	94.11%
Sensitivity	90%	84.21%

Table 3: Performance Measures

IV. Conclusion and Future Work

Developing an automated dental identification sys-tem is a demanding challenge at present. This novel focus of this work is the usage of dental photographs if there is unavailability of dental radiographs. The dental records of ante-mortem and post-mortem data collected from the same person. It is an attempt to provide an aid for forensic law enforcement with the help of photographic images too. The work mainly aims to create a human identification system which uses intensity features extracted from dental images for matching. The method is tested on two databases: that is, dental radiographs and photographic images and the results are highly encouraging. The photo-graphic images with high resolution helped a lot in extracting good intensity pro les. The dental intensity features are extracted made similarity measures based on distance metric and on the basis of these distances the human identification is performed.

In future, an effective method to eliminate the ef-fects caused due to the poor quality of dental records which includes the effects caused due to the blurring of image. The proposed methodology provides highly encouraging results, but it takes more time since the segmentation is done manually. So the next step is to find an automated system for segmentation.

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