Dental Work Extraction for different Radiographic Images in human Forensic Identification

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***Abstract*—Dental biometrics is used to identify the individuals in the forensic domain. Forensic identification is used to identify the person by comparing postmortem and ante mortem dental images. The dental radiograph image provides the information about teeth, tooth contours and in addition to that dental work (DW) is one of the notable issues for forensic identification. This dental work includes crown filling, root canal and crown mineralization for tooth. In this paper addresses the dental work identification for different radiographic images such as bitewing, periapical and panoramic dental images with Mahalanobis distance based matching. The proposed system contains preprocessing, feature extraction and matching. Experimental evaluation gives the satisfied results which will abet for dental biometrics.**

Keywords—Forensic identification, biometrics, dental work (DW), morphological operation, dental radiographs, dental photographs.

I. INTRODUCTION

Forensic odontology usually has a leading role in the forensic team when dental records are the only source of information for the identification of human remains. The resistance of teeth and their supporting tissues, even to fire and decomposition, makes them extremely useful for identification purpose. The identity of decomposed and severely burnt corpse is a challenging task in all biometric laboratories. The disasters by very nature are unpredictable and varied. No team could have ever predicted the disaster that struck the Indian Ocean in December 2004. More than two lakhs people in 12 countries were died due to the Tsunami attack. In this Tsunami attack, dental records were proven as a primary identifier of victims. As per the survey collected, a total of 951 victims had been identified for that 837 had been identified as dental records alone and further 42 were identified by the combination of both dental records and other methods. David R Senn et al [1] have explained the identification of a person from dental records by a qualified forensic dentist has long been established and accepted by courts as a means to provide the identity of an individual.

. The various issues addressed in the literature include 1) tooth misalignment, 2) severe occlusion, 3) Dental work information, and 4) Missing tooth identification. Phan Lan Lin et al [2] proposed the dental work extraction from the tooth and matching is performed by Hausdorff distance. Chun Hung Kuo et al [3] explained the concept of dental work which has similar shapes but different orientation and position for some genuine dental works. This concept was explained, only for bitewing radiograph images and it fails to explain periapical, panoramic radiograph images. There are four forms of radiographic images such as bitewing, periapical, palatal or occlusal and panoramic dental radiographic images are shown in Fig.1.

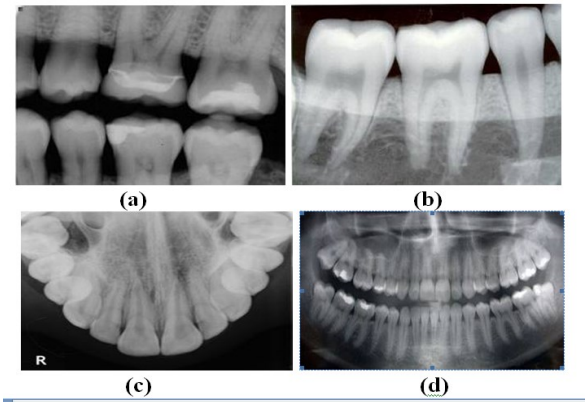

Fig.1. Dental radiographs. (a) Bitewing. (b) Periapical. (c)Occlusal. (d) Panaramic

Bitewing images can be captured by keeping the x-ray film as inside the month. When the patient bites a paper tab, the crown portions of the top and bottom teeth together yields bitewing images. Periapical view shows one or two complete teeth from crown to root. A palatal or occlusal x-ray captures all the upper and lower teeth in one shot, while the film rests on the biting surface of teeth. Panoramic x-ray gives broader overview of entire dentition. It shows not only the teeth also sinus, upper and lower jawbone [4]. The ante mortem and post mortem radiograph of a same person is shown in Fig.2.

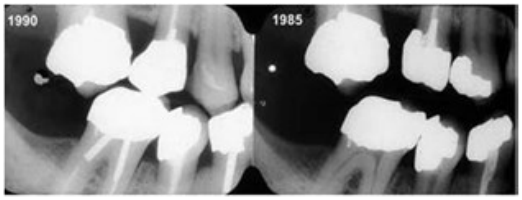

Fig.2. (a) Postmortem Radiograph, (b) Ante mortem Radiograph

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Hofer [5] explained the concept of dental biometrics for human identification based on dental works. In this work, dental code is prepared based on position, size of dental work and neighboring dental work. Section II explains the concept of proposed methodology and dental work extraction and results and discussion will discuss in section III and IV.

II. PROPOSED METHODOLOGY

First the input image is preprocessed by using median filter and then the preprocessed image is taken for dental work extraction. After dental work extraction some of the performance evaluation measures are used to match both Ante-mortem and post mortem dental images. The proposed flow diagram is shown in Fig.3.

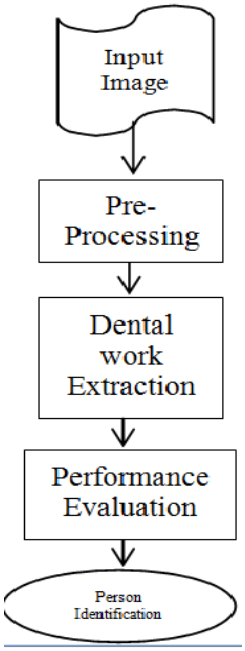

Fig.3. Proposed Flow diagram

1. *Pre- Processing*

Preprocessing is more important to remove unwanted information presented in the image. Median filtering is used to smooth the image and it preserves edges present in an image while reducing noise [6]. It can preserve discontinuities in an image and can smooth a few pixels whose values differ significantly from their surroundings without affecting the other pixels. Here the median method was performed by 3×3 windowing operator over the image. It replaces the value of component with the median of neighborhood pixels. To calculate the median by sorting the whole component values from the neighborhood into numerical sort and then replace the component with the middle component worth. If the neighborhood below condition constitutes a good pixel worth, the common of two middle component values is the median.

2. *Dental Work Extraction*

In addition to dental work extraction, missing tooth is also considered as one of the issue for victim identification [7]. The dental work for different radiographic images is extracted by using clustering technique. Clustering is a technique that assembles similar gray level pixels into groups. The clustering methods allow classification of the data, even when no apriori information is available. Clustering technique examine the unknown pixels in tooth x-ray image and aggregate them into a number of layers based on the natural groupings or clusters present in the image values. There are numerous clustering algorithms can be used to determine the natural spectral grouping present in the dataset. One common form of clustering, called k-means approach, accepts from the number of clusters to be located in the data. The algorithm of k-means clustering is given below:

In k-means clustering, $X=\{x_1,x_2,.....x_n\}$ be a set of data, where n is the number of data points [8]. $V=\{v_1,v_2,....v_c\}$ is the corresponding set of centers, where c is the number of clusters [9]. The aim of k-means algorithm is to minimize the objective function $J(V)$; in this case a squared error function is given as,

$$J(V)=\sum_{i=1}^{c}\sum_{j=1}^{c_i}\left\|x_{ij}-v_j\right\|^2 \qquad (1)$$

Where $\left\|x_{ij}-v_j\right\|$ is the Euclidean distance between x_{ij} and v_j. c_i is the number of data points in the cluster *i*. The i^{th} cluster center can be calculated as,

$$v_i=\frac{1}{c_i}\sum_{j=1}^{c_i}x_{ij} \quad and \quad i=1,2,.....c \qquad (2)$$

The steps involved in the k-means clustering as,

1. Initializing cluster centers randomly.
2. Calculation of Euclidean distance between the cluster centers.
3. Grouping the pixels to those clusters whose center yields the minimum distance from the feature vector.
4. Updating the cluster centers by computing the mean of the feature vectors of the pixels belonging to that cluster.
5. Assessing the changes, so as to decide on the continuance of iteration.
6. This process is continued until convergence occurs otherwise
7. it is repeated step2.

III. Results And Discussion

In this section, an experimental result of our algorithm was discussed. This algorithm was implemented in Matlab 2013a. For radiograph images are collected from Dental Digital x-ray Madurai, which includes bitewing, periapical and panoramic images. This algorithm is evaluated with database of 75 radiographic images. Few of the database images are considered with dental work such as crown filling, crown mineralization and dental implants etc. Some of the sample dental work radiographic images are shown in Fig.4.

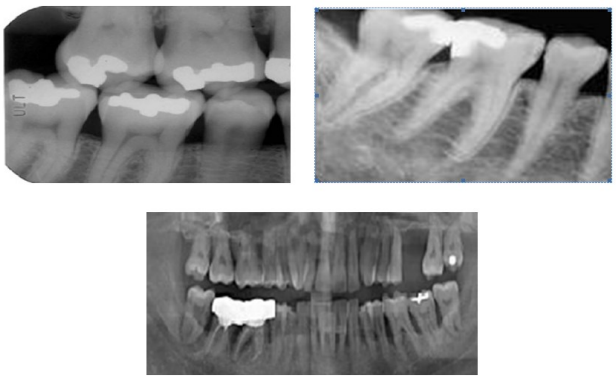

Fig.4. Sample dental work radiographic images

The dental work can be extracted by using k-mean clustering algorithm. It can be extracted for different radiographic images such as bitewing, periapical and panoramic images. Victim identification can be made perfect by considering each single tooth separately rather than the whole image by itself. The dental work extraction by using k-means clustering is shown in Fig.5.

Fig.5. Dental Work Extraction

1. Center Point Calculation

In this work, the features are calculated by measuring the centroid, size of the dental work and the distance between two neighbor of the dental work [10].

The x and y coordinates of centroid is denoted as x_c *and* y_c is defined as,

$$x_c = \frac{1}{N}\sum_{i=0}^{N-1} x_i \qquad y_c = \frac{1}{N}\sum_{i=0}^{N-1} y_i \tag{3}$$

where N is the number of points on the tooth boundary. The center point of an dental work as shown in Fig.6.

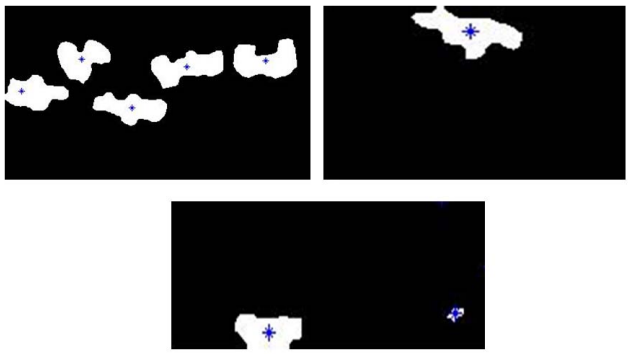

Fig.6. Center point of a DW

2. Distance between the neighboring DW

In order to make the matching as more sensitive, the distance between two neighboring dental works are calculated. After determining the center point of dental work, it is used for distance measurement. The distance is defined by the amount of pixels between the center points of two DW. The distance between two neighboring of DW is shown in Fig.7.

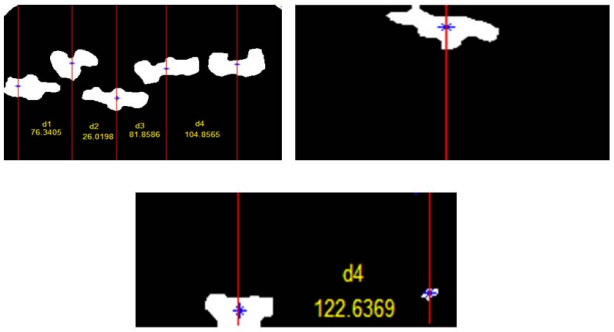

Fig.7. Distance between two neighboring DW

From this Fig.7, the Euclidean distance measurement of two centroids is calculated. The periapical image contains only one dental work part. So the distance is not calculated. By using the distance between two DW of Ante-mortem and post mortem image matching is performed. The sample bounding box of a single dental work is shown in Fig.8. The dental work matching can also be performing by calculating length and width of each individual DW. The matching can also be perform by calculating some of the performance metric like area, length, width and the distance between two neighboring dental work.

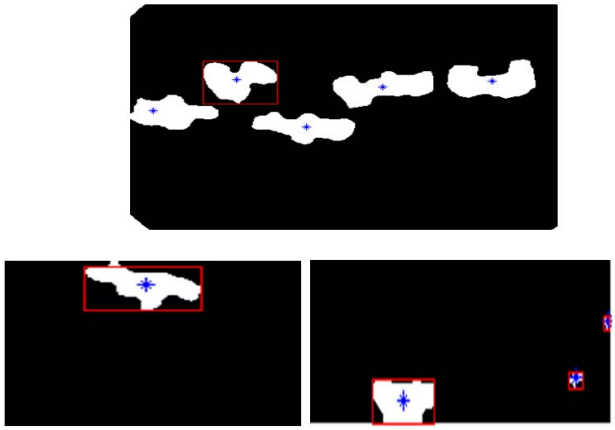

Fig.8. Bounding box of Dental Work Extraction

The contour of Dental work for a tooth is shown in Fig.9. It can also be used for shape based matching.

Fig.9. Contour of an Dental Work Extraction

The performance evaluation of dental work extraction is tabulated in Table I.

TABLE I. PERFORMANCE EVALUATION OF DENTAL WORK

Sample images taken	Area	Distance between neighboring DW	Centroid coordinates	Elapsed Time(s)
Dent 3	569	26.01	(30.61,157.74)	09.25
Dent 7	757	48.31	(111.13,115.64)	10.11
Dent 11	432	11.58	(76.50,15.97)	06.54
Dent 24	965	65.84	(160.66,113.67)	11.37
Pano12	607	122.63	(192.38,37.39)	12.92

The one way of matching is shape based matching and it can be performed by matching both contour shapes of ante-mortem and post-mortem dental work images. Feature based matching can also be performed by comparing both extracted features of dental work present in ante mortem and post mortem dental images.

Both shape based and feature based matching the matching distance will be varied. The shape based matching can also be performed by Mahalanobis distance measure. A well-known distance measure which takes into account the covariance matrix is the Mahalanobis distance [11]. When comparing with Euclidean distance, this distance measure takes into the account the correlations of the dataset and is scale invariant. The Mahalanobis distance is given by,

$$D_i^{Mahalanobis} = \sqrt{D_i} = \sqrt{(X-\mu_i)^T \Sigma_i^{-1} (X-\mu_i)} \qquad (4)$$

where Σ_i^{-1} represents the inverse of the covariance matrix of class {I}. The Mahalanobis distance is also known as weighted Euclidean distance where the weight is determined by using the covariance matrix. The matching distance for shape based matching is tabulated in Table II.

TABLE II. MATCHING DISTANCE

Input images taken		Shape based Matching	
Post mortem images	*Ante mortem images*	*Mahalanobis Distance*	*% of similarity*
Dent 13	Dent 3	6.23	93.77
	Dent 7	4.71	95.29
	Dent 11	2.56	97.44
	Dent 24	5.95	94.05
	Pano12	3.20	96.08

In order to obtain the perfect matching, shape based matching alone does not perform for efficient matching. So in addition to the shape based matching feature based matching is also used. Some of the features extracted from postmortem images are compared with ante-mortem images. The comparison of query DW matching with database DW images are shown in Fig.10.

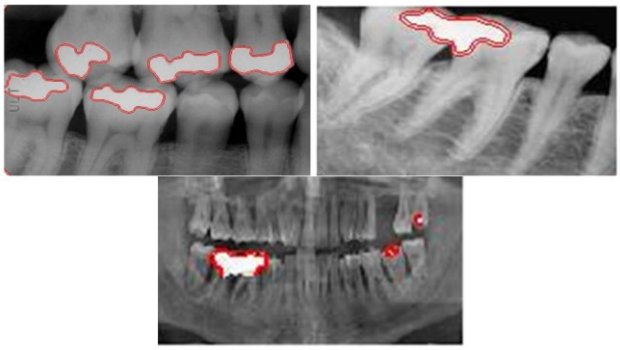

Fig.10. Genuine image for Dental work Extraction Conclusion

In this paper addresses the problem of dental work extraction and matching technique in person identification is presented. This will be helpful for forensic dentistry to identify the missing person in some critical mass disaster situations. After analysis, it is observed that this algorithm proved to automatic, less complex and produces satisfying results. The contours of dental work extraction are extracted to be a better shape extraction technique for individual person identification.

ACKNOWLEDGMENT

The authors would like to thank University Grants Commission, New Delhi, for funding this project. We would also like to thank Department of ECE, Thiagarajar College of Engineering, Madurai, Tamilnadu, India for providing all the facilities to carry out this work.

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