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A Proposed Feature Extraction Technique of Dental X-ray Bitewing Image for Human Identification.

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Abstract- The purpose of forensic dentistry is to identify persons based on their dental characteristics. For human identification, dental X-ray plays an important role. The branch of forensics, Forensic odontology, deals with human identification based on dental features. Biometrics such as iris, fingerprint, etc. are vulnerable to early decay and decomposition but dental x-rays remain invariant over time and resist early decomposition, fire, etc. therefore we can use it for human identification purpose. The aim of dental image processing is to match the post-mortem (PM) radiograph with the ante mortem (AM) radiograph based on some feature of the radiograph. We search a database of AM radiographs for given PM radiograph in order to retrieve the closest match with respect to some salient features. Because of poor quality and low contrast of dental image, image enhancement is necessary in first step. After that various segmentation algorithms are applied to the enhanced dental image. Segmentation of dental X-ray image helped out to find two major regions: 1) gap valley, 2) tooth isolation. The different features of the individual tooth of PM are extracted and match it with AM for human identification. In this area we are trying to find out two region using canny adage detection algorithm of Segmentation and after that we extract characteristics of dental image for matching purpose.

Keywords- ROI, region growing, median filter, erosion, AM, PM

I. INTRODUCTION

Dental X-ray play an significant role in human identification. Human identification based on dental features has always played a very important role in forensics [6]. The first step is to enhance the radiograph because quality of dental images is poor. After that segmentation is performed and followed by feature extraction which produces a ROI (region of interest) which is unique for each individual [1]. After that the feature vectors are generated for individual images and stored in database. That will help for matching with query image for human identification. The dental radiograph is classified in three region known as teeth area, bone area and background area. Numerous techniques are used for segmentation of dental radiograph and extracting two main regions, gap valley and tooth isolation. In [8] Anil Jain et.al proposed a segmentation algorithm for the detection of ROI which needed to automatically find the contours of the teeth. The segmentation algorithm proposed in [1,5] uses "gray level integrated intensity curves to fit a curve called as Sv curve between lower and upper jaw teeth (gap valley). The segmentation algorithm proposed in [4] used "binary integral edge intensity curves" to fit a curve called as Sv curve between lower and upper jaw teeth (gap valley) to detect ROI. That is shown in figure 1.

In this paper we are extending this work to extract each and every individual tooth from a dental radiograph. Then we are extracting geometrical features of individual tooth known as area, centroid and perimeter. We store these features of all teeth in a vector form for a dental radiograph. We do this process for all the dental radiographs available in a database. In section II we discuss the difficult of dental X-ray image segmentation and feature extraction. In section III we focus on numerous tools used in proposed algorithm. In section IV we examine the proposed algorithm. Section V deal with the results and analysis. Section VI concludes the paper.

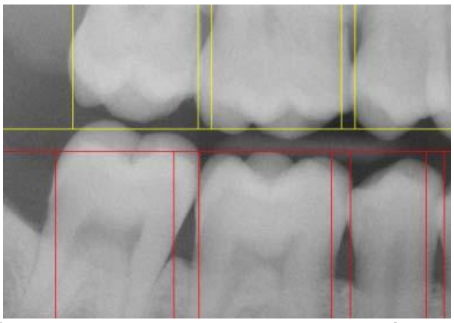


Figure 1: Identifying tooth isolation and gap valley from binary integrated edge intensity curves [4]

II. DENTAL RADIOGRAPH SEGMENTATION AND FEATURE EXTRACTION PROBLEMS

Thresholding based methods usually fail to distinguish between teeth and bone areas as their intensities are more or less alike. To solve that problem, In [8], the authors suggested extraction of tooth contour as a feature as they remain more invariant over time compared to other features of teeth. The matching algorithm was divided into three main tasks 1) radiograph segmentation, 2) contour extraction, 3) shape matching. Radiograph segmentation is done based on gray level integrated intensity of dental radiograph images. After that crown extraction is done to divide crown part and root part. At last, a matching distance between PM and AM images is found and ranking of database images is generated with respect to their minimum matching distance. A smaller matching distance gives better match**.** In [7], the authors proposed iterative and adaptive thresholding and after that horizontal and vertical integral projection is used for separating the jaws and individual tooth. They match distance between signature vector of AM and PM. Then rank them for identification. In [1], the authors proposed a novel method to extract five features 1) Fourier descriptors, 2) energy, 3) contrast, 4) correlation and 5) homogeneity. After that matching is done by finding mean square error between the query and database images. In [4], the authors proposed a simple and novel algorithm for automatic selection of ROI for dental radiograph segmentation. They use Canny edge detection technique to find out edges of tooth and use "binary integrated edge intensity curves" to find out ROI for gap valley and tooth isolation. It automatically finds the ROI both for gap valley and tooth isolation in 83% dental radiograph images without rotation [4].

III. BACKGROUND OF VARIOUS TOOLS

A. Region growing approach [5]

We start with a single pixel *p* and wish to expand from that seed pixel to fill a coherent region. Let's define a similarity measure $S(i, j)$ such that it produces a high result if pixels *i* and *j* are similar and a low one otherwise. First, consider a pixel *q* adjacent to pixel *p*. We can add pixel *q* to pixel *p*'s region if $S(p, q) > T$ for some threshold *T*. We can then proceed to the other neighbors of *p* and do likewise. Suppose that $S(p, q) > T$ and we added pixel *q* to pixel *p*'s region. If we continue this recursively, we have an algorithm analogous to a, flood fill but which works not on binary data but on similar grayscale data.

B. Median filter [3]

Median filter is a nonlinear filter used to take away the impulsive noise from an image. It creates a 2-D mask that is applied to each pixel in the input image, by centering the mask in a pixel, evaluating which brightness value in the masked window is the median brightness value, and replacing the pixel value by it. It is a more useful method than the traditional linear filtering, because it preserves sharp edges. Filtered images have usually strong changes in their statistics, due to noise removal by smoothing. Salient points depend on edges, so measurements should not be affected by this transformation, and visual appearance of the image should be improved.

C. Erosion

In binary morphology, an image is viewed as a subset of a Euclidean space R^d or the integer grid Z^d, for some dimension *d*. The basic idea in binary morphology is to probe an image with a pre-defined element, giving conclusions on how this element fits or misses the shapes in the image. This simple "element" is called structuring element. It is basically a binary image. Let *E* be a Euclidean area, and *E* include binary image *A*. The erosion process of binary image *A* using the structuring element *B* described by:

$$A \ominus B = \{z \in E \mid B_z \subseteq A\} \qquad 1$$

Where B_z is the conversion of *B* by the vector z, i.e.

$$B_z = \{b+z \mid b \in B\}_{,}\ \forall z \in E \qquad 2$$

When the structuring element *B* has a center (e.g., a disk or a square), and this center is located on the origin of *E*, then the erosion of *A* by *B* can be understood as the locus of points reached by the center of *B* when *B* moves inside *A*. The erosion of *A* by *B* is also given by the expression:

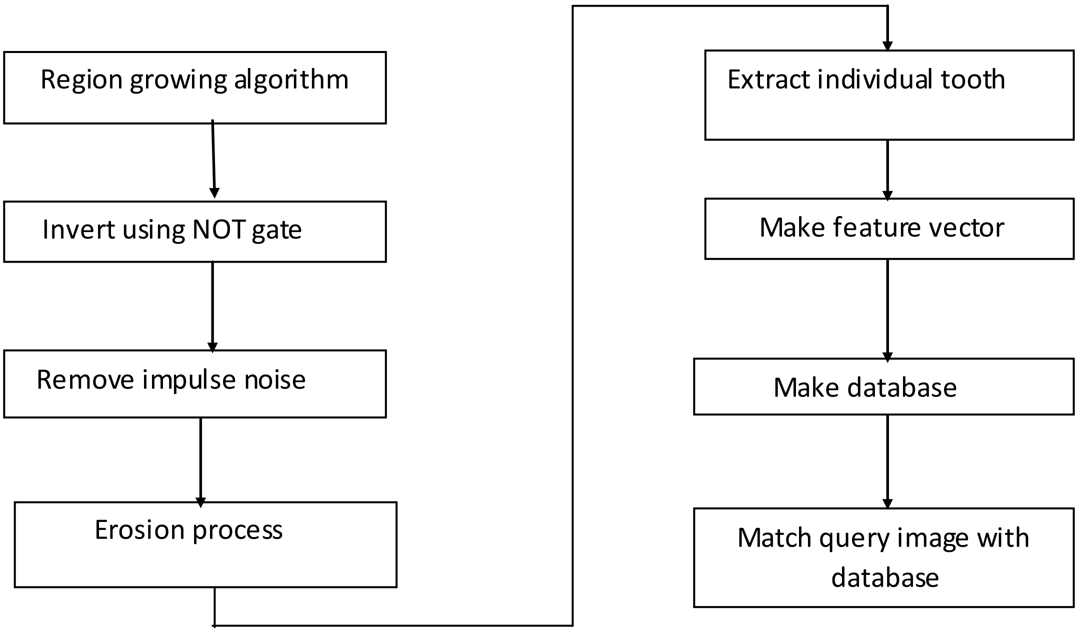
$$\mathrm{A} \,!\, \mathrm{B} = \bigcap_{b=B} A_{-b} \qquad 3$$

IV. PROPOSED ALGORITHM

In this section we propose an algorithm of tooth extraction, feature extraction of dental radiograph and recovery of a PM radiograph from the database. Figure 2 contains the proposed algorithm.

In proposed algorithm [4], the authors plot the *Sv* lines using upper and lower jaw binary integrated edge intensity curves for segmentation of dental radiograph. Using peaks and valleys co-ordinate of binary integrated edge intensity curves, we are extracting the individual tooth from dental radiograph.

Figure 2. PROPOSED ALGORITHM



We take an alternative approach for fusing the region in which the dental features are available. To attain that firstly we apply region growing method on the dental image. We get the regions as shown in figure 4 in which gap valley and tooth isolation areas are fused with equal intensity [4].

Figure 3: Dental image [4]

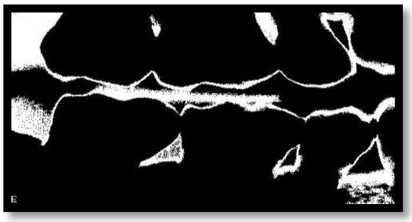


Figure 4: Image after region growing algorithm

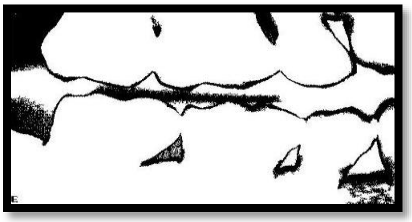


Figure 5: After Invert the

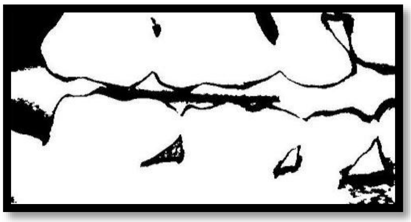


Figure 6: Image after appling

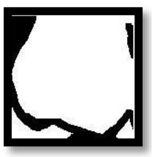
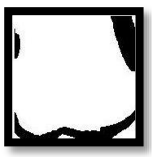
region growing image ***median filter***

After that we convert gray image into binary image and apply logical NOT operation and convert white region into black region and black region into white as shown in figure 5. But in resulting image some small artifacts appears near tooth boundary. So to remove these artifacts we apply median filter on image 5. The resultant image is as shown in figure 6 which filtered out from artifacts but still there are unwanted regions present between teeth and both jaws. To remove unwanted regions we use morphological erosion operation on resultant image. For that we use disk type structuring element which is size of somewhat smaller than the object. Resultant image is as shown in figure 7.

To extract teeth, we are using gap valley and tooth isolated image using binary integral edge intensity curves (figure 1). From binary integral edge intensity curves we can get the peak and valley co-ordinates which are used to crop individual tooth from erosion image. Resultant image is as shown in figure 8.

Figure 7: Image after Erosion

Upper jaw first tooth ***Upper jaw second tooth*** ***Upper jaw third tooth***


Lower jaw first tooth ***Lower jaw second tooth*** ***Lower jaw third tooth***

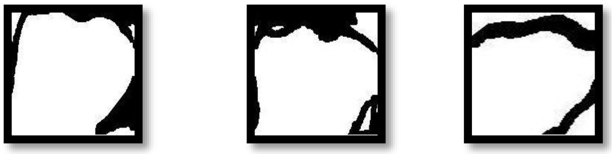


Figure 8: Individual tooth Extraction.

After tooth extraction we find geometric features of individual teeth. We extract tooth area, centroid and perimeter of individual tooth (table I). Then we combine all three features of dental radiograph in a single feature vector (FV) of individual tooth for upper jaw and lower jaw as shown in table II (FVT1 to FVT6). Then we combine all teeth feature vectors of upper and lower jaws and form a common feature vector for particular dental radio image which are FV1 to FV6 as shown in table II. We generate database of feature vectors from FV_1 to FV_{30} for 30 different dental radiographs. The database contains radiographs with different number of teeth in both upper and lower jaws. The database also contains upper bitewing as well as lower bitewing images.

After that we generate a query image (figure 10) by rotating original image (figure 9) by 2º and change brightness and contrast. The first step of image retrieval is to find the dental radiographs from the database having same number of teeth to the teeth in query image. Here, the query image contains three teeth in upper jaw and three teeth in lower jaw. So, in the first step, the radiographs having three teeth in upper jaw and three teeth in lower jaw are extracted. We apply proposed algorithm on query image and generate feature vector FVQ for query image and then the feature vectors of those images and the query image feature vector are compared.. Thereafter we compute the distance vectors (DV) for the query image and extracted dental images from the database having same number of teeth as in the query image. To find distance vector we us the following equation as given below

$$D_n = \sum |FV_n - FVQ| \qquad (4)$$

Where D_n is a total distance value of image n, FV_n is feature vector of image n where n = 1 to 6 and FVQ is a feature vector of query image.
Based on the minimum value of distance vector we conclude which dental image is better match with database.

Figure 9: Bitewing dental image *Figure 10: Query image*

V. RESULTS AND ANALYSIS

In proposed algorithm, for region growing we take the values of the structuring element *s* and *t* to be 100 and 30 respectively [4]. For morphological operation erosion, we use disk type structuring element with a size of 3. All these values are selected experimentally and found to be optimum for the results [4]. We apply proposed algorithm on different 30 dental radiographs and we are extracting three features namely tooth area; centroid and perimeter of individual tooth for different dental radiographs. Feature vectors size and formation for dental radiographs are as shown in table II. We have done it for all 30 images and stored in database.

We calculated the distance vectors between query image and database images. We select the dental images which are having same number of teeth from database to match feature vector of query image. We calculated distance vector between feature vector FVQ of query image (Figure 10) and the feature vectors FVn of database images. FVQ is generated from original dental image (Figure 9) as shown in table II. Thereafter we calculated the values of distance vector using formula given in (4) between query image and dental radiographs which are having same number of teeth in upper and lower jaw in database. By observing the distance vector in table III, the distance value of dental image FV_1 is minimum compare to all dental images which indicates closest match with query image and accuracy is around 90%.

V. CONCLUSION AND FUTURE WORK

In this paper we have proposed a feature extraction technique of dental X-ray bitewing images for human identification. We have extracted geometrical features such as tooth area; centroid and perimeter which describe the boundary of teeth. Also, we have calculated distance vectors between feature vectors of query image and database dental images for identification purpose. In future there is scope to extend this work where it will work well in critical situations like major accident.

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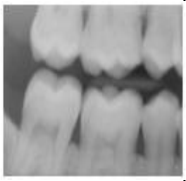
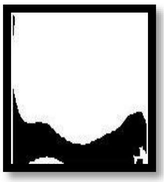
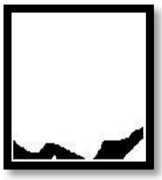
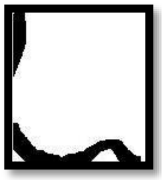
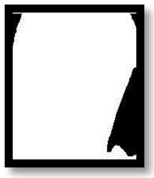
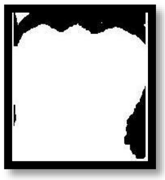
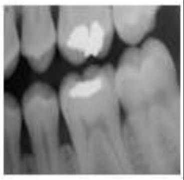
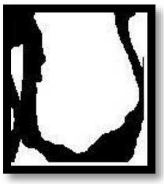
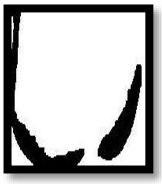
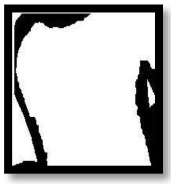
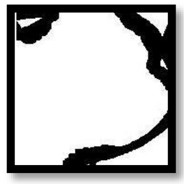
Table I: Result of feature extraction of two dental radiographs

DR	UJT1	UJT2	UJT3	LJ1	LJ2	LJ3
T1	T1U1	T1U2	T1U3	T1L1	T1L2	T1L3
						
Tooth area	16415	19439	13668	27502	26202	12532
Centroid(x,y)	(71.86,58.78)	(72.06,67.66)	(56.52,66.96)	(74.64,95.25)	(77.44,105.51)	(59.05,12.98)
Perimeter	522.7523	559.8823	507.0955	734.6518	710.0488	608.8772
T2	T2U1	T2U2	T2U3	T2L1	T2L2	T2L3
						
Tooth area	7542	16096	6792	2443	20924	21337
Centroid(x,y)	(5.91,44.87)	(1.96,44.87)	(53.89,32.05)	(1.6,1.6)	(3.53,3.86)	(9.12,12.75)
Perimeter	362.6934	748.5341	349.9655	234.8528	653.8061	615.1198

DR= Dental radiograph; UJT= upper jaw tooth; LJT= Lower jaw tooth

Table II: Formation of feature vector and comparison of selected dental radio images with a query image

Image (FVn)	FEATURE	UPPER JAW			LOWER JAW			**TDV**
		FVT1	FVT2	FVT3	FVT4	FVT5	FVT6	
FV1	TA	7542	16096	6792	2443	20924	21337	**6061.48**
	CEx	5.9125	1.963855	53.89355	1.6	3.533333	9.126411	
	CEy	44.87188	44.87188	32.05109	1.6	3.866667	12.75169	
	PE	362.6934	748.5341	349.9655	234.8528	653.8061	615.1198	
FV2	TA	16415	19439	13668	27502	26202	12532	**54395.5**

	CEx	71.8611	72.06173	56.52451	74.64493	77.44878	59.0545	
	CEy	58.78654	67.6649	66.9662	95.25653	105.5143	12.98285	
	PE	522.7523	559.8823	507.0955	734.6518	710.0488	608.8772	
FV3	TA	4287	8421	3110	5830	8389	1723	**50405.23**
	CEx	26.324	3.641304	4.061947	37.26878	1.571429	21.12525	
	CEy	43.69652	11.42391	15.95133	50.87702	8.428571	5.977778	
	PE	388.8528	377.5219	240.9949	364.6102	475.5219	191.6396	
FV4	TA	15003	16777	8974	16992	13755	6606	**43148.59**
	CEx	76.54076	69.42731	42.81569	5.013889	2.041667	42.00828	
	CEy	60.96234	65.04703	67.55538	11.18056	17.91667	12.94201	
	PE	504.4924	530.1076	409.7645	524.6346	497.1787	328.5097	
FV5	TA	12148	26339	30005	13739	21420	15867	**51641.01**
	CEx	53.73568	86.14055	80.35177	52.87808	15.57933	2.5	
	CEy	86.52626	87.5113	95.43063	89.1059	12.17613	86.52626	
	PE	598.3919	729.1198	751.3797	521.5807	597.2376	508.1665	
FV6	TA	11425	12283	5690	18507	16189	1137	**48459.63**
	CEx	1.666667	61.40389	34.70562	3.173333	11.01515	19.47778	
	CEy	1.666667	58.3938	61.3297	6.773333	4.878788	12.18081	
	PE	433.5635	482.6934	342.7939	616.7351	622.3919	152.5269	
FVQ	TA	8276	15952	8065	4409	21149	20225	
	CEx	3.821705	79.06375	53.98016	4.027174	2.461538	7.809375	
	CEy	79.06589	53.37682	37.17099	97.84239	2	18.675	
	PE	378.2082	523.7645	360.6518	295.1371	638.0071	570.5341	

