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Preprocessing, Segmentation and Matching of Dental Radiographs used in Dental Biometrics

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ABSTRACT

Dental biometric system is used to identify deceased individual. Dental biometric system is used in forensic science. In this system AM radiograph is matched with PM radiograph to identify unidentified individual. Dental biometrics consists of four steps as: preprocessing of dental radiograph, segmentation, feature extraction and matching of AM and PM radiograph. Segmentation is a method used for feature extraction like shape and size of tooth. These features are used in matching of two radiographs and based on this matching, individuals can be identified. In this paper segmentation is used to extract single tooth and also for the dental work extraction. This paper presents matching of two radiographs based on histogram properties, area of tooth and dental work. For the segmentation and matching we have developed algorithm..

Keywords : Dental Radiograph, Forensic Dental Biometric, Dental Biometric, Segmentation, Matching.

1. INTRODUCTION

A biometric system is used to identify individual. A biometric is a measurable physical characteristic which are reliable than a password. Many biometric systems are employed which work on the basis of image analysis. "Biometrics" is a general term used alternatively to describe a characteristic. The biometric systems are divided into two categories as: behavioral biometrics and physiological biometrics. In behavioral biometric systems a person is identified based on how he performs something. Physiological biometric characteristic are making a signature, walking, typing on a keyboard. In physiological biometric system a person is identified based on a unique characteristic of some body organ of that person. The typical examples of physiological biometric system are Iris biometry, face biometry, figure biometry, dental biometry etc [1][8].

Dental biometry used in forensic identification [9][10]. This technique requires ante mortem and postmortem radiographs. In this both radiograph are segmented [14] and matched for identification of undefined victim. In this paper we are presenting dental radiograph segmentation and matching. In this paper we have extracted tooth and dental work as features by segmentation and used for matching.

A. Forensic Identification

Forensic identification is used for suspect identification and victim identification. Victim identification is done by physical biometrics. Dental radiograph can be used for victim identification based on dental evidences [1].

B. Types of Dental Radiographs

There are three types of dental radiograph (X-ray) (Figure 1). Bitewing X-ray- Bitewing x-ray is taken at routine check-ups. Periapical x-ray- It shows entire tooth, including crown, root and bone. Panoramic x-ray- It gives broader overview of entire dentition. It shows not only teeth also sinus, upper and lower jawbone [4][5][18].

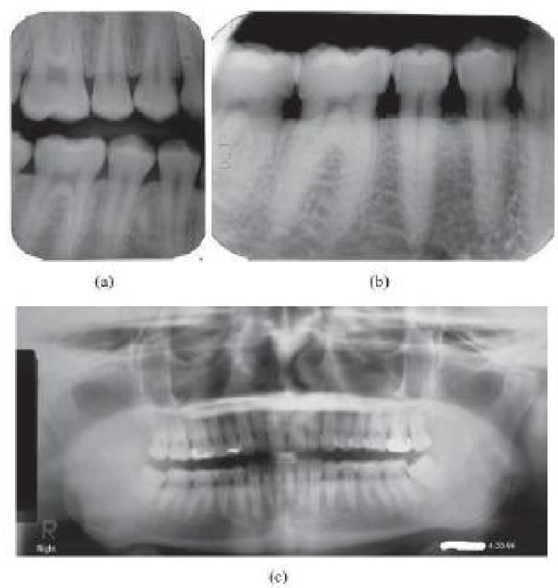

Figure 1: a) Bitewing Radiograph, b) Periapical Radiograph and c) Panoramic Radiograph [1].

C. Forensic Dental Biometry

Forensic dental biometrics used to identify unidentified victims [9]. Automatic forensic identification utilizes dental radiographs [1]. Biometrics can be classified in two category based on characteristic like behavioral and physical. Physical biometric represents iris, fingerprint, face recognition etc. Behavioral biometric represent voice, gait, signature and all behavioral traits of individual. [1] Evaluation of biometrics features requires characteristics such as universality, uniqueness, permanence, performance, collectability and acceptability [1]. Forensic dental biometrics [12] is used when no any other biometry is present. So it is very useful system to identify deceased human.

2. DENTAL IDENTIFICATION SYSTEM

The components of Dental identification system are:
1) Dental radiograph
2) Radiograph preprocessing
3) Feature Extraction
4) Matching

In Dental identification system, dental radiographs of patients are collected for dental identification system. These radiographs firstly preprocessed for filter out unwanted background present with teeth. Then radiographs are segmented for region of interest. Contour of teeth are extracted from radiograph and also contour of dental work present on radiograph is extracted using thresholding segmentation method. Radiograph from database is selected and this radiograph are preprocessed [16], segmented and contour extracted from it. In matching stage features of query image try to match with database image if matching present then we can identify that individual. Algorithm is developed for this. Feature extracted from PM radiograph matched with each of database features and based on matching distance individual get identified [1] [5] [11].

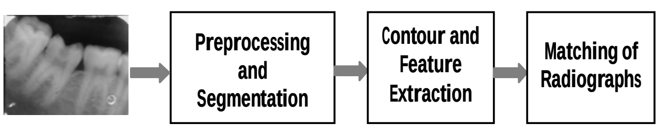

Figure 2: Block Diagram of Dental Identification System

Figure 2 shows our dental identification system. By using this system we developed a dental biometric system for human identification.

3. PREPROCESSING OF RADIOGRAPH

A. Image Enhancement

Dental radiograph initially converted into gray scale image as shown in Figure.3.

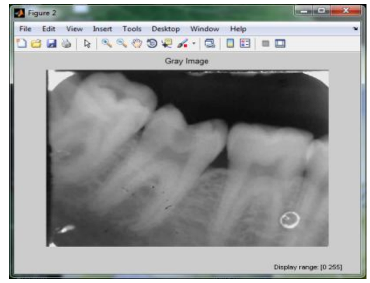

Figure 3: Gray Image

Then histogram is prepared for the grayscale radiograph. The histogram is a plot of number of pixel values versus gray levels. The histogram is shown in Figure 4.

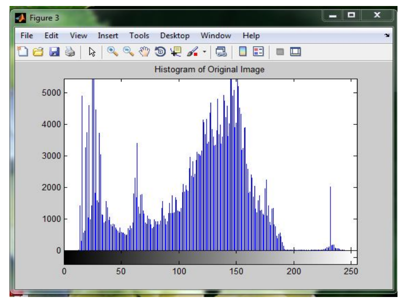

Figure 4: Histogram of Grayscale Radiograph

Histogram equalization is done for image enhancement. Histogram equalization is a technique used for obtaining uniform histogram. For any r in the interval [0, 1], transformation is:

Where, s is level produced for every pixel value r in the original image. The probability density function of transformed gray level is:

$$Ps(s) = \left[\Pr(r)\frac{dr}{ds}\right]_{r=T^{-1}(s)}$$

Consider transformation function:

$$s = T(r)\int_0^r \Pr(w)\, dw$$

$$P_{s(s)} = \begin{cases} 1 \text{ for } 0 \le s \le 1 \\ 0 \text{ otherwise} \end{cases}$$

PDF of output levels is uniform and it used for image enhancement. The result of histogram equalization is increased in dynamic range, which will give higher contrast. Histogram after histogram equalization as shown in Figure.5. We get image after histogram equalization shown in Figure 6. This can give us perfect distribution of pixel values for further processing.

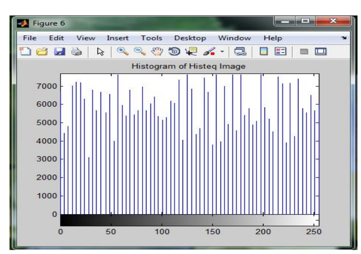

Figure 5: Histogram of Histogram Equalization

Figure 6: Radiograph after Histogram Equalization

B. *Edge Detection*

Edge detection can be done by using different operators as listed below:

1) Sobel operator
2) Prewitt operator
3) Canny operator
4) Robert operator

C. Sobel Operator

It is used to detect edges in the image horizontally and vertically. The mathematical expression for it as:

$$\nabla f = mag(\nabla f) = \sqrt{Gx^2 + Gy^2}$$

Where, Gx & Gy are kernels or masks can be applied separately to the input image, to produce separate measurement of gradient component in each orientation.
The angle of orientation of the edge relative to pixel grid is calculated as:

$$\theta = \tan^{-1}(Gy/Gx)$$

Z1	Z2	Z3
Z4	Z5	Z6
Z7	Z8	Z9

a) 3 x 3 image region

-1	-2	-1
0	0	0
1	2	1

b) Gx mask

-1	0	1
-2	0	2
-1	0	1

c) Gy mask

After Sobel applied on radiograph the output shown in Figure 7.

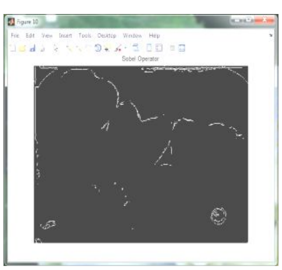

Figure 7: Sobel Operator Output

4. SEGMENTATION OF RADIOGRAPH

A. *Tooth Extraction*

Teeth map the areas with “mostly bright” grayscale; bones map the areas with “midrange” grayscale, and a back-ground that maps “dark” grayscale [2]. The main objective of the proposed segmentation algorithm is to extract at least one ROI that represents exactly one tooth. We used morphological and image cropping operation for tooth extraction [3][17]. Extracted ROI from dental radiograph shown in Figure 8.

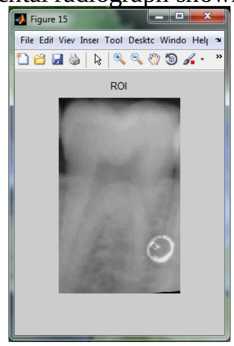

Figure 8: Extracted ROI

B. *Dental Work (DW) Extraction*

Thresholding is used to segment dental work radiograph [6][7]. After reducing the noise, we use threshold operation to separate the desired dental work from the teeth. Thresholding produces a binary image which simplified image analysis. Thresholding gives best result for dental work extraction [13][15]. We have to select threshold value 0 to 255 to extract dental work. For this we checked value for higher brighter region. The dental work extraction results for various radiographs are as shown in Figures 9, 10 and 11.

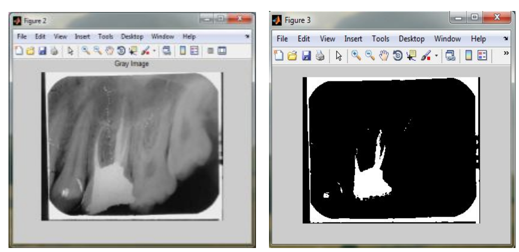

Figure 9: DW Extracted

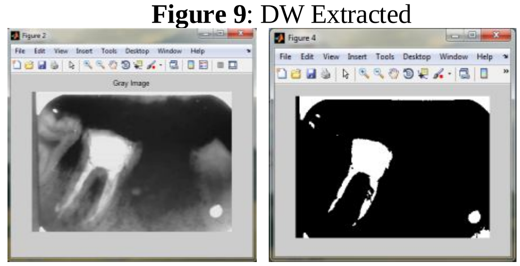

Figure 10: DW Extracted

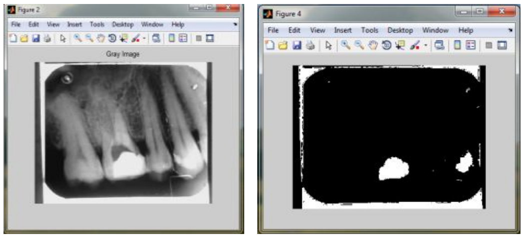

Figure 11: DW Extracted

5. MATCHING

Matching is a last stage of dental biometric system which finds out difference between two dental radiographs. Here we present differentiation between two radiographs based on properties like area of tooth or dental work, mode, median, skewness and kurtosis.

Skewness, kurtosis and mean are the histogram features. Histogram analysis is useful for shape analysis of objects. The shape of an image histogram provides many clues. Positively skewed histogram indicates light image whereas negatively skewed histogram indicates bright image. Mean measures an average intensity.
Mean is calculated by:

$$m = \sum_{i=0}^{255} ZiP(Zi)$$

Skewness is the opposite of symmetry. Skewness of a set of luminance values would mean that you have an unbalance between extents of areas that are lighter or darker than the mean. The skewness measures shape of histogram. The shape of gray-level histogram gives an idea about overall appearance of an image. The light image has positively skewed gray-level histogram, whereas brighter image has negatively skewed gray-level histogram.

Kurtosis measures degree of flatness/peaktedness of a distribution. In other words it gives over or under representation of frequencies in the middle of the range compared to normal distribution. Figures 12 and 13 shows the query image and database image and its histogram respectively.

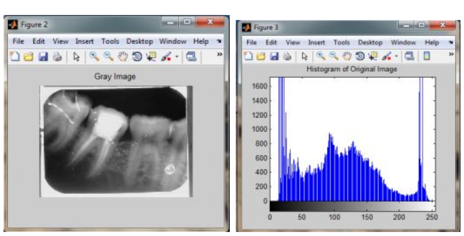

Figure 12: Query Image and its Histogram

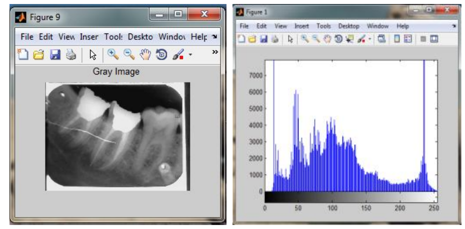

Figure 13: Database Image and its Histogram

Table 1 shows not matching result of query image and database image. Table 2 shows matching result of query image and database image. Table1 & 2 shows result of not matching and matching based on area and histogram features. Table2 shows matching of two radiographs, in this DW area have difference of 100 pixels i.e. within tolerance so we can conclude that these radiographs are matched with each other or these radiographs of same person. Similar algorithm we can apply for finding tooth area of without dental work radiograph and also for finding histogram features of tooth. Our matching algorithm can be applied for dental work radiograph and without dental work radiograph.

Table 1: Not-matching Result

Query -database image not matching properties (DW)			
Property	Query Image	Database Im2	Difference
Area	3300	11240	-7940
Mode	19224	20710	-1486
Median	60000	60000	0
Skewness	3.0382	2.8612	0.177
Kurtosis	15.6465	16.2213	-0.5748

Table 2: Matching Result

Query -database image matching properties (DW)			
Property	Query Image	Database Im1	Difference
Area	3300	3400	-100
Mode	19224	19324	-100
Median	60000	60000	0
Skewness	3.0382	3.05	-0.0118
Kurtosis	15.6465	15.6665	-0.02

6. CONCLUSION AND FUTURE WORK

Algorithm is developed for the semi automatic human identification based on Periapical radiographs. The work has been carried out for the database of 38 dental radiographs. First part of the algorithm is dental image segmentation that handles dental images based on thresholding method. The proposed algorithm includes: 1) thresholding to extract dental work from the background, 2) determine the qualified ROIs based on geometrical properties to extract tooth from radiograph.

In this algorithm the matching of dental radiographs is carried out based on DW area, tooth area and the various image properties. First two methods are based on area and histogram features of tooth or dental work. Our future work will be developing next method of matching based on distance. In this method we will find out distance between teeth. So in case of missing tooth this algorithm can give us perfect analysis of query image.

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