Computerized Approach for Dental Identification Using Radiographs

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Abstract
Dental features have been widely used for forensic identification purposes in cases of mass disasters like, fires, floods, plane crashes etc. when other methods of identification (fingerprints, physical etc.) are not available. However with the increase in the number of cases to be investigated a move towards computer aided system is required. This paper presents a computerized approach for processing and matching of dental radiographic images, with the goal of human identification. Given a dental record, usually as a postmortem (PM) radiograph, we need to search the database of ante mortem (AM) radiographs to determine the identity of the person associated with the PM image by extracting some features namely average pixel intensity, length to width ratio and root center angle to retrieve a closest match.

Index Terms **-** forensic odontology, human identification, dental radiography, image comparison

I. INTRODUCTION

Forensic dentistry is the proper handling, examination and evaluation of dental evidence, which will be then presented in the in the court of law [1]. The main purpose of forensic dentistry is to identify deceased individuals for whom other means of identification are not available [3, 7].Although some biometric identifiers can result in an excellent match (e.g. fingerprints and DNA), they are affected by early tissue decay and, as such, are not always suitable for identification[4]. However teeth are capable of withstanding extreme conditions making them a good choice for identification in the cases involving advanced decomposition [6]. Over the years various methods have been developed for dental identification most of them being manual. However, dental identification in the context of mass disaster situations and missing person cases can be both time-consuming and cumbersome due to the large number of victims. Hence in this paper we are trying to present a computerized method for identification using dental radiographs. Given a PM radiograph, we search the database to find an AMradiograph that best matches with this PM record. The comparison is done based on three parameters i.e. average pixel intensity, length to width ratio and root center angle.

II. DENTAL IDENTIFICATION

Dental identification is based on comparison between known characteristics of a missing individual (ante-mortem) and recovered data from an unknown body (post-mortem). There have also been instances, in both the WTC and the Tsunami disasters where X-rays have been used for the comparison [2]. Radiographs have been proved to be advantageous in human identification due to immediate availability of the images and also due to some new devices there is elimination of film development and processingwhich allows odontology teams to work directly at the site of mass fatalities [10, 16]. The diversity of dental characteristics is wide, making each dentition unique [7]. Being diverse and resistant to environmental challenges, teeth are considered excellent post-mortem material for identificationwith enough concordant points to make a meaningful comparison.

A. Methodology

The main purposes of forensic dentistry isto identify deceased individuals for whom other means of identification are not available. Such cases arise in various situations typical of which are mass disasters, fires, finding human remains. The main procedure followed for identification is the comparison of ante-mortem and post-mortem radiographs. Various methods used for dental identification are as follows:

1. Dental Charting [7]

This is one of the oldest methods for dental identification which involves comparing dental profiles of the given dentitions. Dental profiles are dental charts which are completed by

odontologists [15]. Fig.2 shows an example of a dental chart.The chart notes, for each tooth individually, various distinctive features like tooth present/absent, crown, root morphology, dental restorations etc. The comparison thus involves preparing dental chart of the dentition in question, and comparing this chart with those in a database. However this method becomes very complex and is very time consuming.

Figure 1. Example of a dental chart

2. Comparative Dental Identification Using Radiographs [17, 18]

Digital radiography, which is used for a decade or more by radiologists in most large hospitals, has recently become the solution of choice in mass casualty situations. Here comparison is done by odontologists by manually comparing the AM and PM radiographs.It follows a semi-automatic process of matching the radiographic dental images for human identification. For this, they extract shapes of the teeth from both, the AM and PM images, and compare these extracted shapes. The comparison results are based on the distancebetween the shapes. Fig.1 shows an example of AM and PM radiographs.

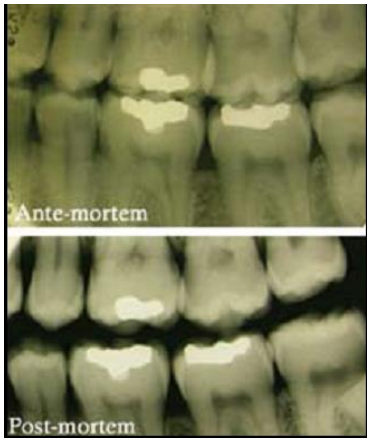

Figure 2. Ante-mortem and Post-mortem radiographs

III. IMPLEMENTATION

The method followed in the paper for comparison of radiographs is a computerized approach to speed up the process and make it more efficient. The algorithm is given below which will be implemented in MATLAB.

A. Algorithm

Fig.3 gives an overview of the steps which is followed for comparison of AM and PM images.

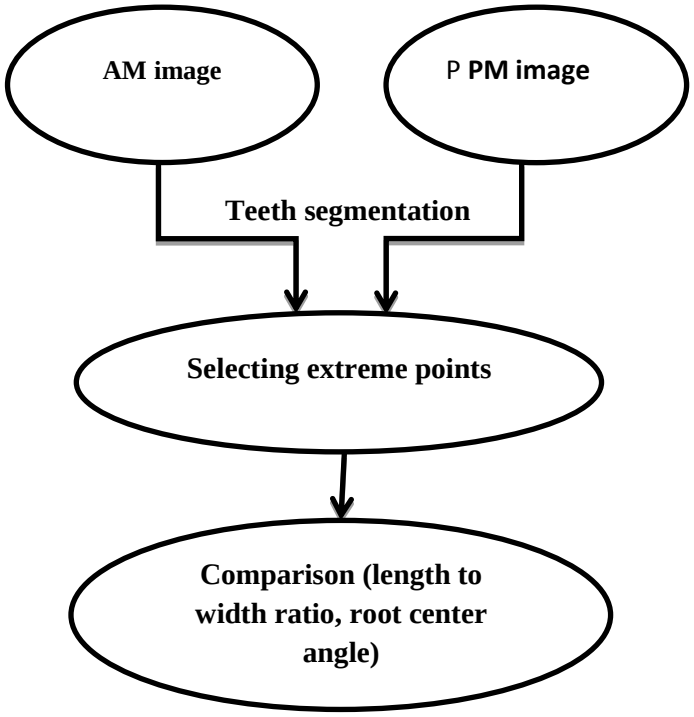

Figure 3. Flowchart showing the steps of comparison

1. Database Formation

A database of the AM images is formed by cropping the required tooth from the radiograph and isolating it. Fig.4 shows an image of the same. Database images used in this paper are shown in Figure 5. A set of three AM images were used as database images for comparison.

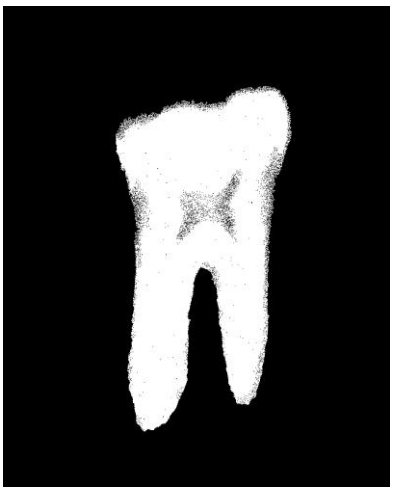

Figure 4. Sample image of database images

Figure 5. Database images (AM images)

2. Comparison

Comparison of the AM and PM images is done by using the following parameters:

1. Length to width ratio

The average length and width measurements are taken and length to width ratio of each tooth is compared for AM and PM images. Measuring the length and width is an automated process in MATLAB. Here two extreme points are selected along the length of the tooth by scanning the radiograph from left, right and then selecting the first white pixel obtained. Fig.5 and Fig.6 show radiograph images with length and width marked.

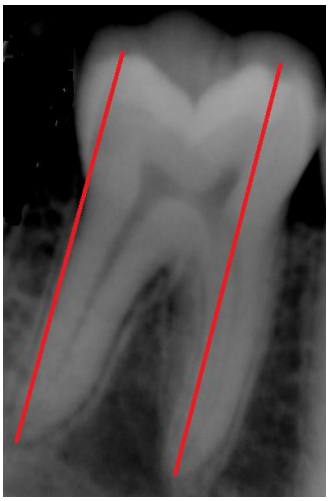

Figure 6. Image showing length of tooth

Figure 7. Image showing width of tooth

If (x_1,y_1) and (x_2,y_2) are the extreme co-ordinates then the length and width can be calculated as:

$$S = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}$$

1. Root Centre angle

In fig.θ denotes the root center angle which is compared for AM and PM images. It can be calculated as:

$$\theta = 180\text{-}\ \{\tan^{-1}\left(\frac{x}{y}\right) + \tan^{-1}\left(\frac{x}{z}\right)\}\ \}$$

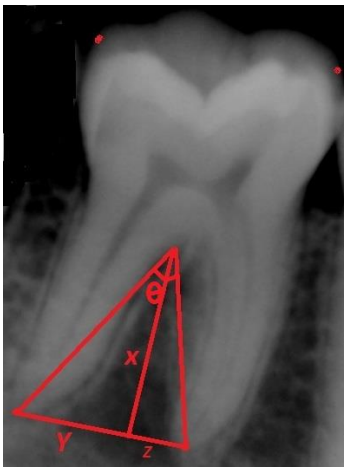

Figure 8. Image showing root centre angle of tooth

IV. Results and Analysis

The algorithm discussed above in sec.3 was implemented on three sets of AM and PM radiographs and the positive results were obtained. Fig.8shows the values obtained for comparison and graphs of the same.

Table 1.Comparison results for the radiographs

Radiograph	Average Vertical length	Average Horizontal length	Length to Width ratio	Root – Centre angle (degrees)
AM - 1	462	280.5	1.647	42.69
PM - 1	439.5	279	1.4798	41.62
AM - 2	538.5	271.5	1.9834	40.5901
PM - 2	482	266.5	1.8086	43.16
AM – 3	462	272.5	1.61	37.69
PM – 3	431	296.5	1.4536	37.95

The time taken to compute vertical length and root center angle was observed to be 1.38 sec and for computing width it was found to be 0.78 sec. Hence the total time taken for the whole comparison process is 2.16 sec.

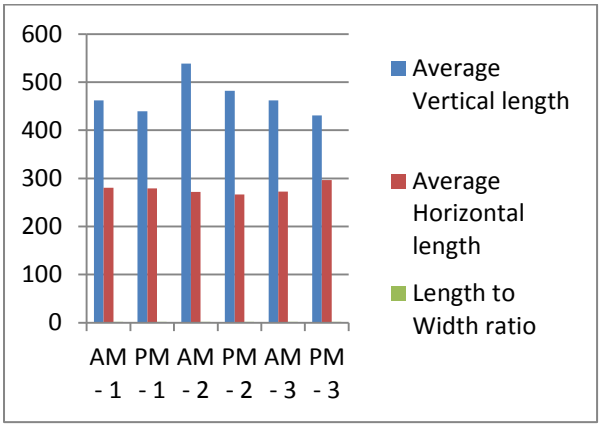

Figure 9. Graph showing the comparison based on length,width and length to width ratio

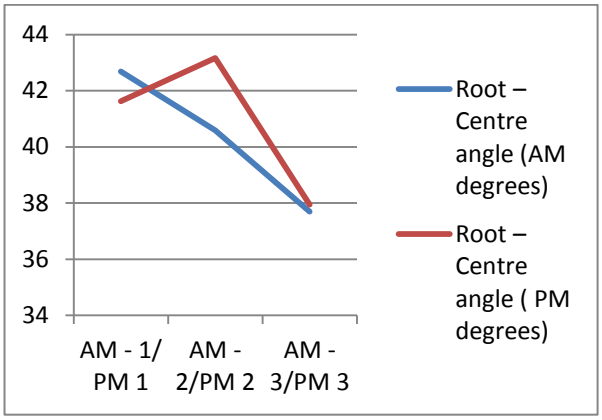

Figure 10. Graph showing the comparison based on root center angle

V. CONCLUSION

We proposed a computer-aided framework for matching of dentalradiographs based on length to width ratio and root centre angle. Experimental results on a small database indicate that this is a feasible approach. The errors can occur due to incorrect radiographic technique: the images are very blurred, or the region of interest is partially occluded so there is not enough information available to characterize the teeth.
The three PM images selected were positively identified and compared with the available database AM images. Also the method proved to be time efficient compared to other methods as discussed in sec. A.
Although there was an average error of 1.3 degrees in root centre angle due to alignment of tooth in radiographs.

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