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Automatic Region-of-Interest Extraction from Dental Panoramic Radiographs for Forensic Personal Identification

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Abstract In this paper we present an automated system for extracting region of interest from raw dental panoramic radiographs for forensic personal identification. The region of interest is acquired by segmenting and separating teeth in raw panoramic radiograph and then extracting a set of signatures for each tooth by applying a filter. The proposed system performs well and successfully processed all images.

Keywords Forensic Personal Identification, Dental Panoramic Radiograph

I. Introduction

Dental radiographs have become increasingly common to be used as media for forensic personal identification. Many features can be extracted from dental radiographs and used together to as stronger discriminator features. Another supporting factor is their survivability. They are regarded as the best candidates to identify victims under severe circumstances, such as those encountered in mass disasters (e.g., airplane crashes) or identification in the postmortem be attempted weeks after the death [1], since teeth usually resist the early decay unlike other body tissues.

Currently, the identification is carried out manually by comparing extracted features from a postmortem (PM) dental record to extracted features from a database of antemortem (AM) records. The forensic experts confirm the identity based on distinctive features such as dental restoration, dental work features, root morphology and tooth morphology [3,4]. In many cases these features are not sufficient for correct identification of individuals, and the manual identification approach is useful only for verifying individuals in a small database. Researches on forensic personal identification [1,13,14] attempt to automate the process of segmenting the dental radiographs and separating each individual tooth. The segmentation is difficult due to the shape and intensity variations within one radiograph and/or among radiographs.

There are not so many published works on the dental image segmentation. In Refs. [9,10], segmentation of 3D images of dental plaster models is presented. In Ref. [11], the segmentation based on active contours for low-contrast radiographs is described, where the authors start with an initial approximation using deterministic algorithms to improve the performance of the algorithm. The watershed algorithm is used in Ref. [12] to find orthodontic feature points such as cusps, apexes, and ridges of teeth from the 3D profile of dental images of imprints. In Ref. [13], the authors proposed a method for radiograph segmentation, pixel classification, and contour matching. They use a semi-automatic contour extraction method. For matching, they use Euclidean distance between the contours of the PM and AM images.

To apply the segmentation and separation methods for forensic personal identification, the region of interest containing teeth and surroundings tissue should be extracted from a raw radiograph, and the residual part should be removed because the residual part contains objects that could interfere with the segmentation and separation process in Refs [11-13] and produce wrong results. In all the above conventional researches, the region of interest is still extracted manually by an expert.

In this paper, we present a new fully automated system for acquiring the region of interest from a raw dental panoramic radiograph, which is used most commonly for the diagnosis of dental diseases [2], and is also easily attainable even for disaster victims. The region of interest is acquired by segmenting and separating teeth in a raw panoramic radiograph and then extracting a set of signatures for each tooth by applying a filter. The goal of the segmentation is to separate the region of interest from the rest of the radiograph. The best filter and thresholding parameter are experimentally determined, and the results show that our system performs well in separating the region of interest from its surroundings.

2. Proposed Method

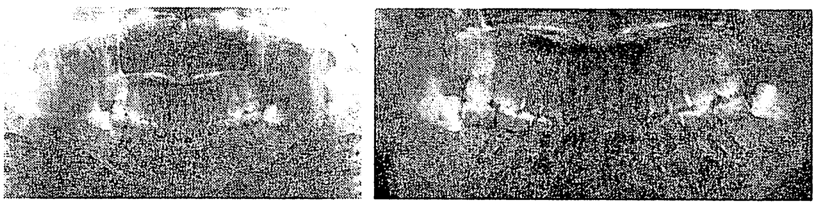
To select the region of interest from a raw dental panoramic radiograph, we employ a two-step method. The first step intends to select the region of interest roughly, and then the second step will refine the selection.

The first step uses the same algorithm as used in a conventional research [1], which is a projection method. To select the region of interest, we cut an unnecessary region vertically and horizontally. To remove the unnecessary area vertically, we used the vertical projection method, which is:

1. Calculating the summation of each column in the image.
2. Starting from the center, search the minimum summation in the left hand side and in the right hand side of the image.
3. Remove the region left to the minimum summation in the left hand side, and remove the area right to the minimum summation in the right hand side.

These same steps are applied in horizontal projection method to remove the unnecessary area horizontally.

After the region of interest is roughly selected by the above procedure, the next step is refining the selection process to get the region of interest. This second step converts the image from spatial domain to 2D frequency domain using 2D-Fourier Transformation [17]. After the transformation, we try to apply some filters [17] to remove unnecessary components in order to refine the selection region, namely:



(a) (b)

Fig. 1. Dental panoramic radiograph: (a) Original Image; (b) Region of Interest.

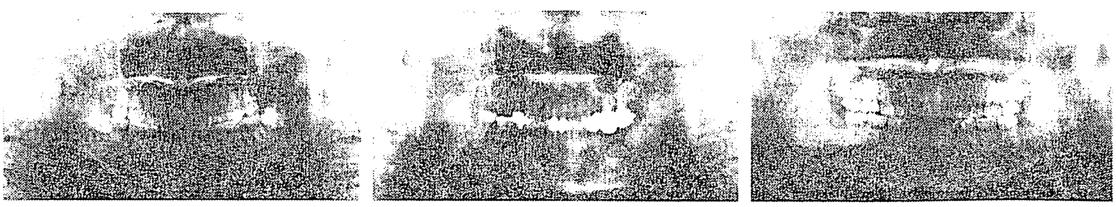
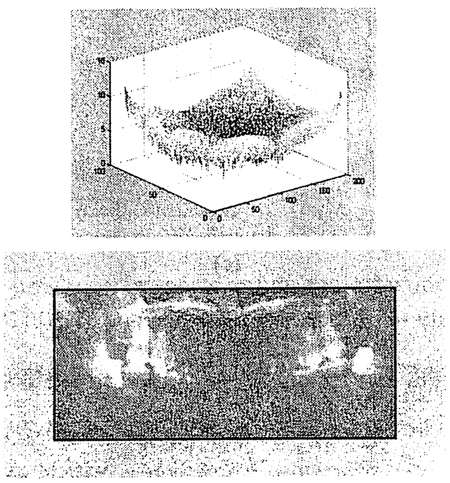


Fig. 2. Examples of raw dental panoramic radiographs.

1. Low Pass Filters, whose cut-off frequencies are set to 40% to 90% of the highest frequency with 5% step
2. High Pass Filters , whose cut-off frequencies are set to 50% to 70% of the highest frequency with 5% step
3. In Band Filters, whose cut-off frequencies are set to 10% to 50% of the highest frequency with 5% step
4. Out Band Filters , whose cut-off frequencies are set to 5% to 25% of the highest frequency with 5% step
5. Bandwidth Filters, whose cut-off frequencies are set to 1% to 10% of the highest frequency with 1% step

We apply again the projection method, which is explained in the above, to the filtered images inversely transformed to the spatial domain for refining the extracted region of interest. Since the tooth region in the radiograph has significant vertical and horizontal frequency components, which are preserved by the filtering, the projection method in the second step is expected to remove unnecessary regions outside of the tooth region effectively.

3. Experimental Results



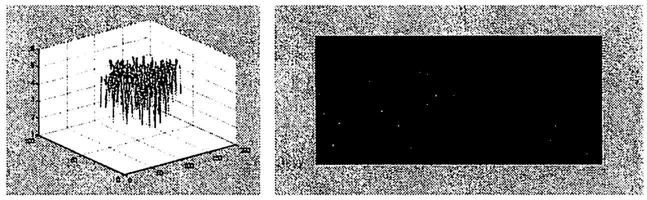
(a)

Fig. 3. Original image: (a) 2D Frequency domain; (b) Spatial domain.

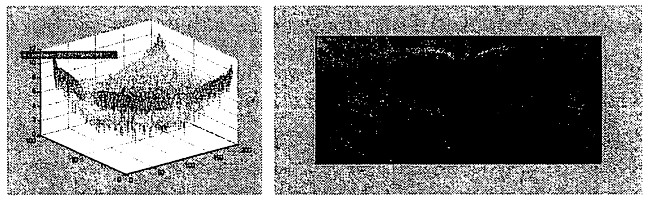
To evaluate the performance of the proposed method, we used 50 raw dental panoramic radiograph images, taken from men and women whose ages lying between 10 and 82 years old. Some of them are shown in Fig. 2.

There are two purposes in this experiment. First purpose is to determine which filter is most suitable for this method. Second purpose is to find the most suitable filter and its parameter to preserve necessary components and remove unnecessary ones.

Some of the results of Low-pass filter applied to original image at Fig.3(a) and (b) for various cut-off frequencies values are shown in Fig. 4(a) and (b).



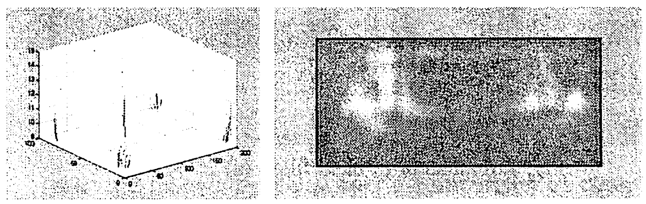
(a)



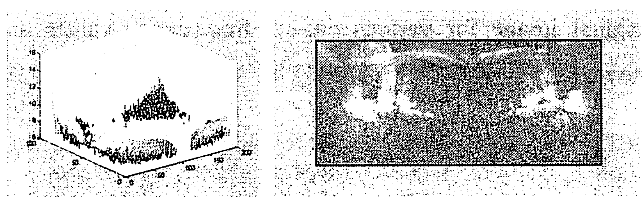
(b)

Fig. 4. Results of Low-pass filter: (a) 40%; (b) 90%.

Some of the results of High-pass filter applied to original image for various cut-off frequencies values are shown in Fig. 5(a) and (b).



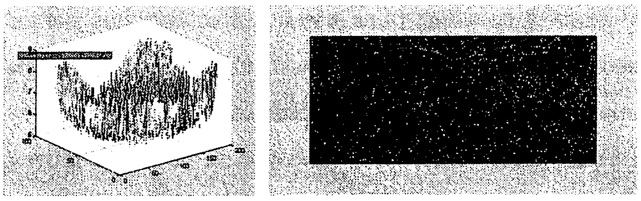
(a)



(b)

Fig. 5. Results of High-pass filter: (a) 70%; (b) 50%.

Some of the results of In-band filter applied to original image for various cut-off frequencies values are shown in Fig. 6(a) and (b).


(a)

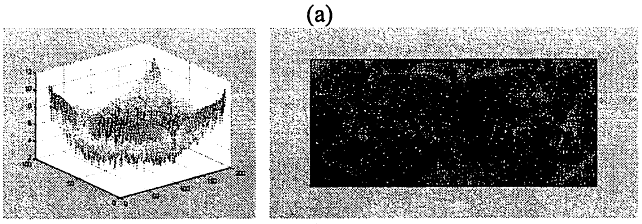
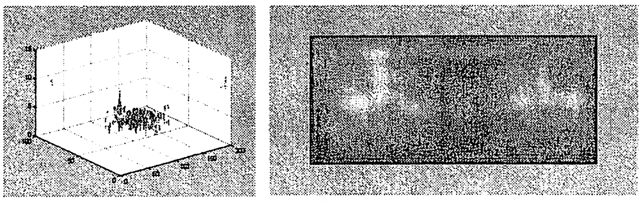

(b)

Fig. 6. Results of In-band filter: (a) 10%; (b) 50%.

Some of the results of Out-band filter applied to original image for various cut-off frequencies values are shown in Fig. 7(a) and (b).


(a)

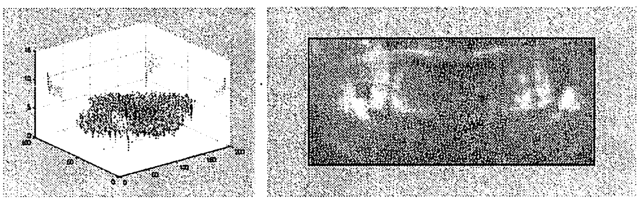
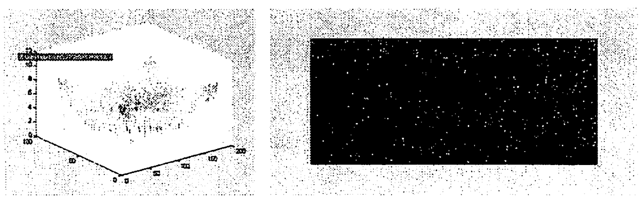
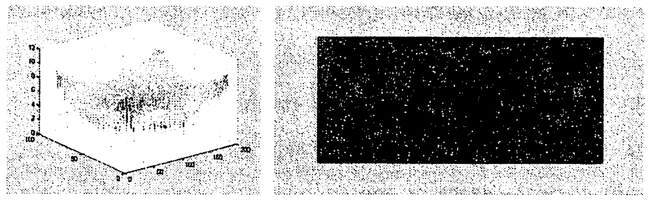

(b)

Fig. 7. Results of In-band filter: (a) 25%; (b) 5%.

Some of the results of Inside-bandwidth filter applied to original image for various cut-off frequencies values are shown in Fig. 8(a), (b), and (c).


(a)


(b)

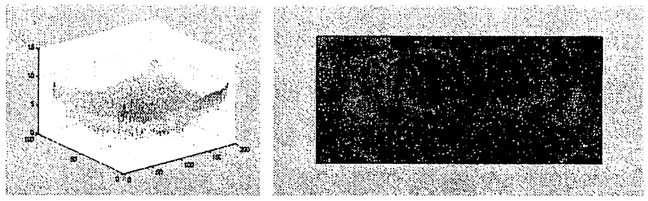
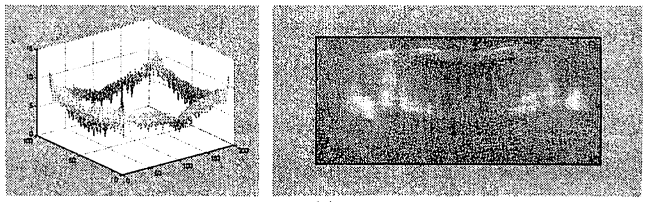
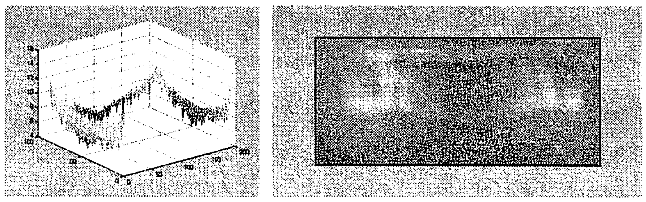

(c)

Fig. 8. Results of Inside-bandwidth filter: (a) 5%; (b) 2%; (e) 1%.

Some of the results of Outside-bandwidth filter applied to original image for various cut-off frequencies values are shown in Fig. 9(a), (b), and (c).


(a)


(b)

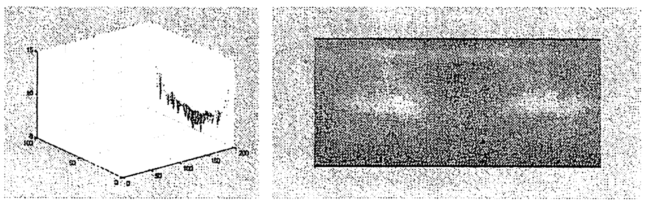
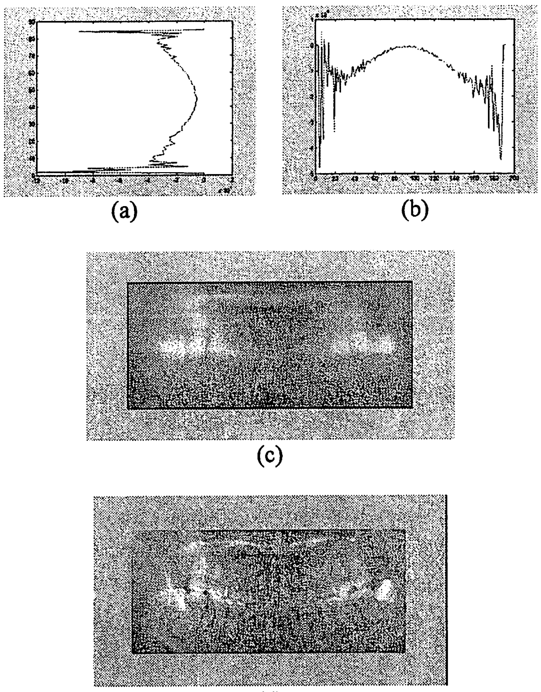

(c)

Fig. 9. Results of Outside-bandwidth filter: (a) 5%; (b) 2%; (e) 1%.

From the experimental results we can see that the best result is obtained with the Bandwidth Filter using Outside Bandwidth and 2% cut-off frequency, which extracts the vertical stripe structure effectively. To ensure this, we in-vesely tranform the image from 2D frequency domain to the spatial domain. After that, the horizontal and vertical projection methods are applied to the filtered images and then the corresponding region is extracted from the original image. One example of the final result is shown in Fig. 10(a), (b), (c), and (d).



(a) (b) (c) (d)

Fig. 10. Example of the final result: (a) Horizontal projection; (b) vertical projection; (c) Invercely transformed image; (d) Resultant Image.

All of 50 test images are satisfactorily processed in our experiment. Some examples of the final results of this method derived from the examples of raw dental panoramic radiographs shown in Fig. 2. are shown in Fig. 11.

4. Conclusions

In this paper, we have proposed an automatic region of interest extraction for forensic personal identification method using the Outside Bandwidth Filter applied to 2D Frequency Domain of image to refine the selection region of interest from raw dental panoramic images. The optimal threshold is determined based on the ability to distinguish the object of interest (mainly teeth) from the other objects. Results obtained from the automatic extraction of region of interest from the experimental images are showing the validity of the method and the system successfully processed all images.

The experimental results also suggest that the ratio of the tooth area to the extracted region of interest is related to the quality of the teeth and surrounding tissue, as shown in Fig 11(b) and (c). It may be a useful feature for forensic personal identification, and we are now working on this matter.

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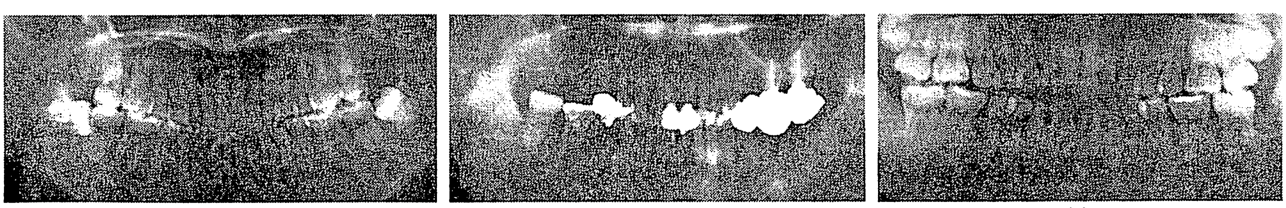

(a) (b) (c)

Fig. 11. Examples of final results.

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