THE USE OF DENTAL RADIOGRAPHIC IMAGE ANALYSIS IN IDENTIFICATION OF DECEASED INDIVIDUALS

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ABSTRACT:

Dental records recently used in forensic medicine to help in human identification, based mainly on radiograph images. The aim of our study is to automate this process, using image analysis and pattern recognition techniques.

Postmortem radiographs, including dental radiographs, with a database of ante mortem radiographs searching, in order to get the closest match with respect to some distinct features. Contours of teeth are used as the feature for matching, since they remain more invariant over time compared to some other features of the body. The work includes two stages: radiograph segmentation, with pixel classification, and contour matching.

Probability model is used to describe the distribution of object pixels in the image.

Results of retrievals on a database of over 40 images are encouraging.

استخدام نماذج تحليل صور اشعة الاسنان في التعرف على هوية الموتى

الخلاصة

تعتمد معلومات صور اشعة الاسنان من قبل الطبابة العدلية مؤخرا للمساعدة على التعرف عن هوية الاشخاص البالغين الموتى، استنادا على صور للاشعة تكون مثبتة ضمن قاعدة بيانات.

الهدف من البحث جعل المقارنة ذاتية باستخدام تحليلات الصور وتقنية معالجة الصور.

صور الاشعة مابعد الوفاة ومن ضمنها صور اشعة الاسنان تقارن مع صور لاشعات محفوظة في قاعدة بيانات للحصول على اقرب تطابق مع الاخذ بنظر الاعتبار بعض الخواص المنفصلة. محيط السن هو الميزة المستخدمة للتطابق وذلك لانها تبقى ثابتة مع الزمن بالمقارنة مع خواص اخرى للجسم.

البحث هو من مرحلتين وهي اولا تقطيع الاشعة واستخدام التصنيف لمكون الصور الرقمية وثانيا مقارنة المحيط الخارجي للسن

الموديل المقترح سيستخدم لوصف توزيع مكون الصور الرقمية للجسم وهنا المقصود السن في صورة الاشعة، والنتائج طبقت على معلومات لقاعدة بيانات مكونة من 40 صورة لاشعة الاسنان

INTRODUCTION

The main purpose of forensic dentistry is to identify deceased individuals, for whom other cues of biometric identification (e.g., fingerprint, face, etc.) may not be available. In forensic dentistry, the postmortem (PM) dental record is compared against antemortem (AM) records pertaining to some presumed identity. A number of distinctive features are noted for each individual tooth. These features include properties of the teeth (e.g., tooth present/not present, crown and root morphology, pathology and dental restorations), periodontal tissue features, and anatomical features. Depending on the number of matches, the forensic expert rejects or confirms the tentative identity. There are several advantages for automating this procedure, such as automatic process will be able to compare the PM records against AM records pertaining to multiple identities in order to determine the closest match, and also, an automatic (or semi-automatic) system can perform *identification* on a large database (Jain and Chen, 2004), while a manual (non-automated) system is useful for *verification* on a small data set. For the automated identification, the dental records are usually available as dental radiographs. Different procedures had been used in this work to determine the best image analysis, such as using canny edge detector, with Gaussion smoothing operator for filtering to deal with problems for finding the true boundaries of objects in the image (Hoffman, 2007), and for the contour Extraction the self organizing map (SOM) based approach called the batch-SOM (BSOM) had been used (Kinouchi et al., 2002). Those to get the best image object to be matched with image objects saved early in a database

METHOD:

The method is to extract the shape or features of the tooth in the radiographic image, then try to use certain mathematical way for the purpose of matching the extracted features with other radiographic images. The feature extracted is the tooth contours. The feature extraction stage consists of the radiograph segmentation and the contour extraction. Since the image is available as radiograph, meaning that we are dealing with gray levels in the image. A probabilistic method is introduced to automatically find the contours of teeth. This automated dental identification system consists of two main stages; Feature extraction and Feature matching.

To reduce the images that have similar features, human experts must be taken into concern. The main stages for image processing used in our work shown in **Fig.1**.

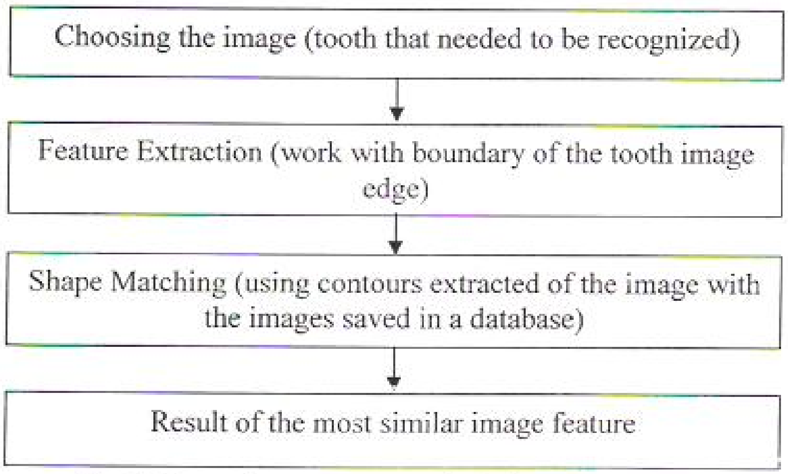

Fig.1: Procedure sequence of the image processing.

During feature extraction stage, certain information and type of mapping equation called intensity level slicing with many processing methods are considered:

a) Image transformation, image segmentation method and edge detection (Umbaugh, 1998).
b) The Use of morphological filter (Hoffman, 2007).

c) Contour extraction (tooth contour extraction) (Langlais and Kasle, 1985).
In this work we used morphological filter depending on Gaussion filter. Also the work with contour extraction had been done by using self organizing map (SOM).

At the feature matching stage, the query image is compared with that stored in our suggested database. A matching score is computed to measure the similarity between the two objects (the tooth) in the given radiographs (Jain and Chen, 2004).

- FEATURE EXTRACTION:

Radiographs are images consist of different gray levels histogram with different pixel intensities. The aim is to extract the Area of Interest (AOI). This can be done by extracting the boundary of the tooth image edge with an ordinary edge detection operation. The steps of image processing that had been chose to be used are shown in **Fig.2**.

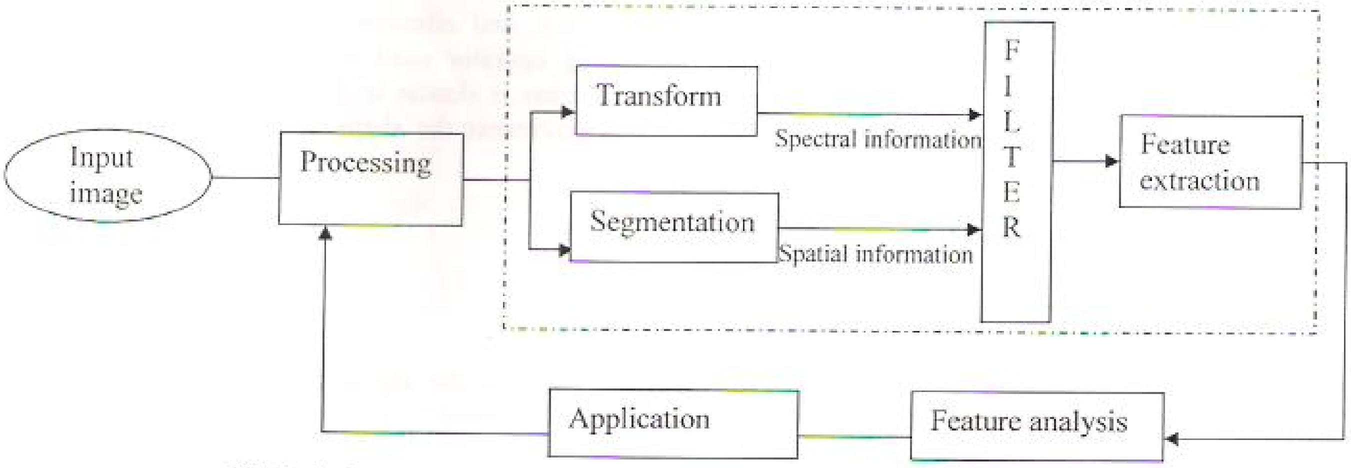

Fig.2: A frame work of image processing and analysis (Umbaugh, 1998).

A. Image Transformation, Image Segmentation and Edge Detection:

This is designed specifically to find lines. The line is a collection of edge points that are adjacent and have the same direction. *Hough Transform* is an algorithm that will take a collection of edges points that found by edge detector and find all the lines on which these edge points lie. The advantage of this method is reducing the search time in finding lines, In order to understand Hough transform; we consider the normal representation of a line. ρ is the distance from the origin to the line along a perpendicular line.

$$\rho = r \cos(\theta) + c \sin(\theta) \quad \text{.......... (1)}$$

Where:

r : row, c : column, and θ is the angle between the r-axis and ρ-line. **Figure 3.** shows the line definition of ρ, r, θ, and c

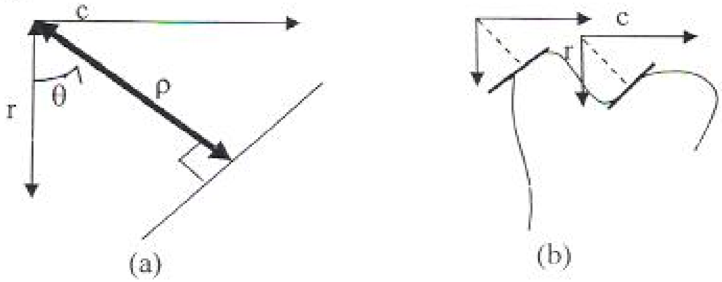

Fig.3: (a) Hough transform (Umbaugh, 1998), (b) Collection of edge points

The goal of image segmentation is to find the area that represents objects; our Area Of Interest (AOI) is the teeth in the radiographic image. Since we are dealing with gray levels image, we will use boundary detection segmentation, which means; finding of boundaries between object and the background in this work. Starting the work by marking points that may be part of the object edge using Hough transform algorithm, these points merge into line segmentation, where then merge into object boundaries. Here Canny edge detector was used (Deriche, 1987), threshold the results by considering the histogram of the image for the edge detection. We merge the existing edge segmentation into boundaries; this is done by edge linking (connecting the points that past the threshold test with maximum distance).

B. Morphological Filter:

This will simplify image segmentation facilitating the search for objects of interest; this is done by smoothing out object outlines, filling small holes, and eliminating small projections (Umbaugh, 1998). In this paper the Gaussion smoothing operator used is a 2-D convolution operator to remove detail and noise from the image. This sense is similar to the mean filter, but it uses a different convolution such as Kernel matrix that represents the shape of a Gaussion bell hump. (Hoffman, 2007)

In 2-D (circularly symmetric) Gaussion has the form

$$G(x, y) = 1 / (2\pi\sigma^2) * \exp\{-(x^2 + y^2) / 2\sigma^2)\} \text{ .... (2)}$$

Where σ is the standard deviation of the distribution. In **Fig.4** the signal flow for a general sharpening filter can be shown, where low-pass filter can be established by a Gaussian bell

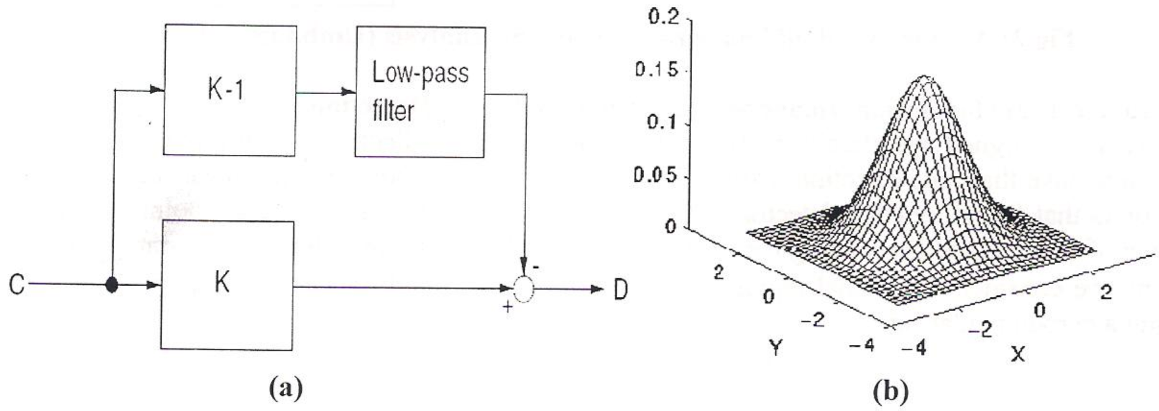

Fig. 4: (a) Frame work of using Gaussian distribution, (Hoffman, 2007). (b) 2-D Gaussian distribution.

Where C is the input value in gray level, D is the sharpened value of the same input, and D = [K-(K-1)G(x, y)]C, the factor K=1 (no sharpening) or K=2 (sharpening) or K=1.5 (less sharpening), and G(x, y) executes the averaging by Gaussian bell using the equation (2)

C. Contour Extraction:

Extraction of boundaries (or contours) of objects from the images are needed for shape description, leading to object localization and recognition, but the conventional edge extraction techniques, being sensitive to image noise and intensity variations, often do not give us the true boundaries of objects in the image. In order to deal with such problems, a Guassian filter (Hoffman, 2007) with the edge-linking techniques had been used.

In this work the object that had been deal with is a single tooth radiograph images. Our goal is to extract the tooth (object) from the background of the image which has different intensities.

The tooth has two main parts, the crown, which is above the gum line, and the root which available in the bone below the gum see **Fig. 5**. Due to the over lap of the tooth root with the image of the jaws the root is not visible as the crown in the radiograph due to the difference in tissue density. The length of the tooth crown is (L/3) from the total length of the tooth, so we can have a crown extraction and root extraction. (Langlais and Kasle, 1985)

Fig. 5: Radiographic image of the tooth (two parts crown and root)

Based on the segmentation output, an enclosing rectangle that tightly fits the segmentation area (AOI) is constructed for the tooth, a point inside the rectangle, which will be used in shape extraction, is chosen and a mark is signed as the crown center *C*. This can be done since the distance of C to the top of the rectangle is one third the length of the (ROI), and the distance of C to the other two sides are equal (W/2) see **Fig. 6** (Jain and Chen, 2004).

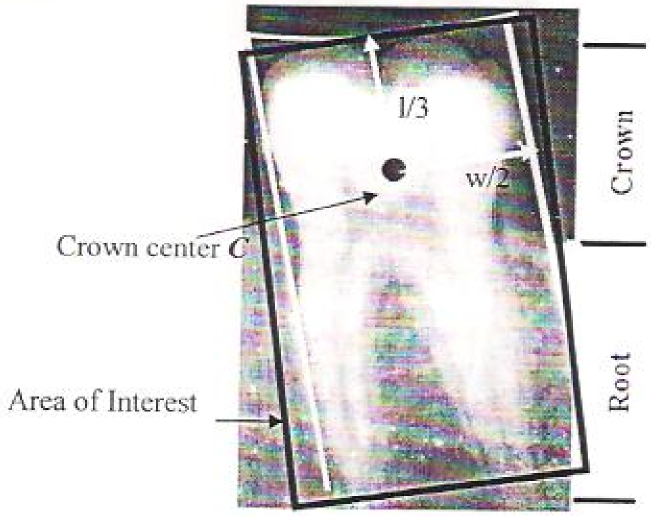

Fig. 6: describe of (RIO) and the crown center point

From Venkatesh (2006) self organizing map (SOM) had been used based approach called the batch-SOM (BSOM) (Kinouchi et al., 2002)
The used algorithm uses a two-layered neural architecture similar to that of the SOM-based for active contour modeling and the training of the network uses a scheme similar to kohonen's algorithm (Kinnebrock, 1995). The output of an edge detection algorithm as applied to the image provides the feature points for training the neural network. Consider the pair of points below:

$P_a = w_i + ke^{\perp}$; and $P_b = w_i - ke^{\perp}$ .... (3)

where $e^{\perp} = (-e_y, e_x)$ is the unit vector that is perpendicular to the contour, w_i is the weights of i^{th} neuron, in this algorithm uses the wrights of the neurons themselves as the new position of the control points, and hence of the contour, I is the image intensity function, and $k \in \{1,2,\ldots,N_r\}$ see Fig.7.

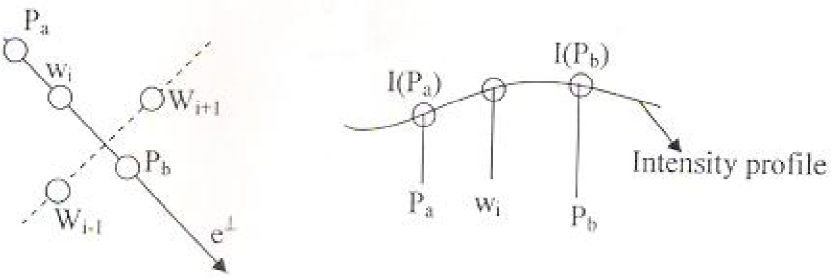

Fig.7: Region boundary, (Venkatesh 2006).

The feature vector in this algorithm uses the coordinate of edge points obtained from standard edge detection operations. In addition, the algorithm uses intensity variations and gradient information in a local region with crown center point C in order to guide the movement of the contour which we had them from the earlier steps of our work see **Fig. 8**.

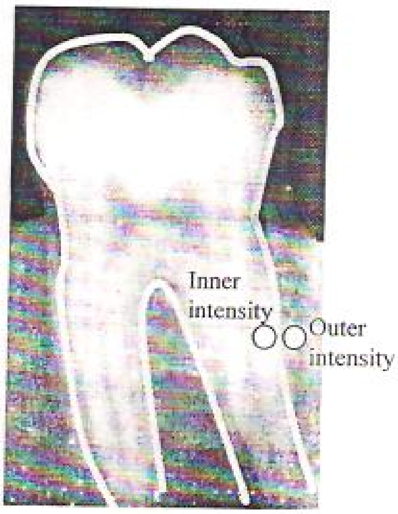

Fig. 8: Final converged contour of an object (human teeth) obtained using the present algorithm

-Feature Matching

The contours extracted from the query image result from the first step must be matched to the contours extracted from the proposed database images and that would be our consideration in the second step of our work. With the match step forensic medicine will be able to recognize the best matching images and with the help of personal observation, the goal would be reached to a good point of the best matching, and that means the forensic medicine identify deceased individuals. This matching can be done either manually or automatically. In this section an idea of Jain and Chen (2004) had been added to help to reduce the execution time, and which converted the work to match images automatically. All changes due to time passing and 2D images angles were insignificant. That means these variations would be omitted.

CONCLUSION

The dental radiograph based identification method has been applied to query radiographic images for the purpose of automated matching process, to be used in the deceased people identification in next future. The proposed work uses different techniques in its two stages, so that to get the most perfect result. This paper can be considered as a start point to initiate a data-base that helps the forensic medicine; this can be done by using collected radiograph images from private clinics and from governmental clinics as a starting point.

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