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A Region based Active Contour Shape Extraction Technique for Dental Images in human Forensic Identification

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ABSTRACT

The identification of unknown person by dental radiographs and smile photograph that defines specific characteristics of each individual has found. The algorithm can be developed by comparing both ante mortem and post mortem dental radiographs. In addition to this radiograph images, this algorithm may also implemented to photographs. This research work proposes a contour shape extraction technique as well as matching algorithm. Online region based active contour model (ORACM) is used for contour shape extraction. Mahalanobis distance based shape matching is done. The experimental results are obtained from a database of dental images for both radiographic and photographic images. The better performance of this algorithm can be validated by cumulative matching characteristic curve

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INTRODUCTION

Forensic odontology usually has a leading role in the forensic team when dental records are the only source of information for the identification of human remains. The resistance of teeth and their supporting tissues, even to fire and decomposition, makes them extremely useful for identification purpose. The identity of decomposed and severely burnt corpse is a challenging task in all biometric laboratories. Teeth are the hardest tissue in the body and it can withstand decomposition, heat degradation, water immersion, desiccation and temperature up to 1600°C. Normally, Person identification is achieved by the forensic odontologist by just preparing a dental chart of a victim's postmortem and comparing it manually with its ante mortem details and by observing the discrepancies and similarities, a conclusion is drawn under four heads. They are positive identification, possible identification, insufficient identification and exclusion. The disasters by very nature are unpredictable and varied. No team could have ever predicted the disaster that struck the Indian Ocean in December 2004. More than two lakhs people in 12 countries were died due to the Tsunami attack. In this Tsunami attack, dental records were proven as a primary identifier of victims. As per the survey collected, a total of 951 victims had been identified for that 837 had been identified as dental records alone and further 42 were identified by the combination of both dental records and other methods David R Senn *et al* (2011) have explained the identification of a person from dental records by a qualified forensic dentist has long been established and accepted by courts as a means to provide the identity of an individual. Phan Lan Lin *et al* (2011) proposed the dental work extraction from the tooth and matching is performed by Hausdorff distance. Chun Hung Kuo *et al* (2010) explained the concept of dental work which has similar shapes but different orientation and position for some genuine dental works. This concept was explained, only for bitewing radiograph images and it fails to explain periapical, panoramic radiograph images. There are four forms of radiographic images such as bitewing, periapical, palatal or occlusal and panoramic dental radiographic images. Bitewing images can be captured by keeping the x-ray film as inside the month. When the patient bites a paper tab, the crown portions of the top and bottom teeth together yields bitewing images. Periapical view shows one or two complete teeth from crown to root. A palatal or occlusal x-ray captures all the upper and lower teeth in one shot, while the film rests on the biting surface of teeth. Panoramic x-ray gives broader overview of entire dentition. Shubhangi Jadhav and Revati Shriram

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(2012) shows not only the teeth also sinus, upper and lower jawbone. Hofer *et al* (2008) explained the concept of dental biometrics for human identification based on dental works. The poor quality image tooth contours are indiscernible. Gradient based contour extraction technique has been proposed by Hong Chen *et al* (2005). The main drawback of this method is not able to discriminate edges in multiple objects. But in this technique, the result shows the edges overlie on boundary of the object. The basic idea of active contour model is to start with a curve around the object is to be detected, and the curve moves towards its interior normal and stops on the true boundary of the objects based on an energy-minimizing model. Many methods have been introduced to improve the active contour model but Osher *et al* (1988) has proposed the most important one. Level set method is based on active contour model and particularly designed to use deformable curve for approximating the boundary of an object. Using better matching of different fusion approaches are explained by Nomir .O *et al* (2008). Human identification using shape and appearance of tooth is explained by Nomir .O *et al* (2009). Vijayakumari *et al* (2012) explained the concept of Fast connected component based contour shape extraction and then matching is performed by Mahalanobis distance. Fast connected component labeling is used to connect the edges but the edges may shows discontinuity in the outer contour and then matching was performed. Hierarchial distance (2008) based matching of dental records proves to be an efficient in terms of retrieval time. Contour feature extraction based on classification and numbering approach is used to classify the teeth in to molars or premolars are explained by Mohammed H.Mahoor (2005). Numbering of teeth is based on universal numbering system and bayesian classifier has been used to classify the teeth. P. L.Lin (2010) explained the concept of classification and numbering based contour extraction. Assign numbers of teeth is based on universal numbering system and then extract contour of the particular region of interest. The main advantage of the ORACM approach provide less time without changing accuracy ratio and parameter free. The paper work is organized as follows. The flow diagram of the proposed work is shown in Fig.1. The first section is explained as preprocessing and projection line integration method. In the section contour tracing using Online Region based Active Contour Model (ORACM) method. The third section is shape matching of the contours traced.

Proposed Methodology:

First the input image is preprocessed by using top and bottom hat filter and then the preprocessed image is taken for integral projection to separate the individual tooth. After the separation of individual tooth shape can be extracted by ORACM technique. Then shape matching is performed by comparing both Ante-mortem and post mortem dental images.

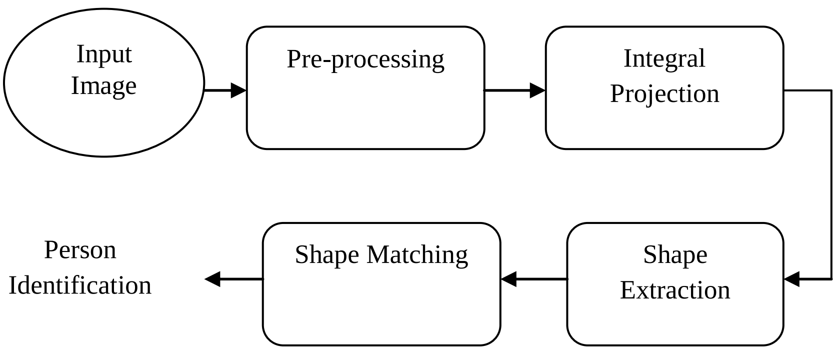

Fig. 1: Flow diagram of the proposed method

Pre- Processing:

The input image is subjected to a top-hat filter to project the image of interest from background. Top-hat filtering computes the morphological opening of the image and then subtracts the result from the original image.

$$I_{top-hat} = I - I_{open} \quad (1)$$

Where I_{open} is the morphological opening operator. It is given by,

$$I_{open} = (I \circ B) = (I \Theta B) \oplus B \quad (2)$$

Where, B is the structuring element. The symbol $\circ$ denotes opening, Θ denotes dilation and $\oplus$ denotes erosion. While performing the top-hat filter, background will be darker than the image of interest. Bottom-hat filtering computes the morphological closing of the image and then subtracts the original image from result.

$$I_{bot-hat} = I_{close} - I \quad (3)$$

Where I_{close} is the morphological opening operator. It is given by,

$$I_{close} = (I \bullet B) = (I \oplus B)\Theta B \quad (4)$$

Where, B is the structuring element. The symbol $\bullet$ denotes opening, Θ denotes dilation and $\oplus$ denotes erosion. While performing the bottom-hat filter, the image of interest will be darker than the background.

Integral Projection:

The separation between each tooth can be calculated by using horizontal and vertical integral intensity projections. Horizontal integral projection is used to separate upper and lower jaws and vertical integral projection is used to separate each individual tooth which was proposed by Anil K.Jain and Hong Chen (2013). Let $f(x,y)$ be the image of size $m \times n$ and summing all intensities in horizontal direction gives the gap valley; whereas summing all intensities in vertical direction will separate each individual tooth. Mathematically, the horizontal integral projection is,

$$H(y) = \sum_{x=0}^{m} f(x,y) \quad (5)$$

Since the teeth usually have a higher gray level intensity than the jaws, due to their higher intensity, the gap between upper and lower teeth will form a y-axis projection histogram which is called gap valley. After finding the gap valley, the vertical line will be drawn to form a vertical integral intensity. The vertical projections of $\{V(x_0), V(x_1).....V(x_n)\}$ will form a graph of integral intensity and mathematically it can be expressed as,

$$V(x) = \sum_{y=0}^{n_x} f(x,y) \quad (6)$$

Where, n_x is the intersecting point of each column and the horizontal separating line of upper and lower jaws.

Shape Extraction:

The main goal of designing shape extraction algorithm is to achieve a higher hit rate with less computation time. In this paper explained about the Online region based active contour model (ORACM) algorithm. It is a well suited shape extraction algorithm for person identification using dental images. ORACM is a region based active contour model which requires no parameter and less time without changing segmentation accuracy. It performs block thresholding process in each iteration. In ORACM algorithm first initialize the inside and outside contours. Inside and outside contours defined as positive and negative values. The generalization of level set function is defined as

$$\frac{\partial \phi}{\partial \mathrm{X}} = H(spf(I(x)))\phi(x) \quad (7)$$

Where $H(.)$ is a Heaviside function, $spf(.)$ is signed pressure function and spf function is defined as

$$spf(I(x,y)) = \frac{I(x,y) - \left((c_1 + c_2) / 2 \right)}{\max\left(\left| I(x,y) - (c_1 + c_2)/2 \right| \right)} \quad (8)$$

Where c_1 *and* c_2 are constants. The average intensities of inside and outside contours is given by,

$$c_1(\phi) = \frac{\int I(x).H(\phi)dx}{\int H(\phi)dx} \quad (9)$$

$$c_2(\phi) = \frac{\int I(x).(1 - H(\phi))dx}{\int (1 - H(\phi))dx} \quad (10)$$

spf function modulates the signs of pressure force inside and outside the region of interest so that the contour shrinks when outside the object or expands when inside the object. After the level set of ORACM, many of the small objects that does not belongs to the object. It is eliminated by morphological opening process and smooth boundaries of the object can be obtained by closing.

Shape Matching:

The one way of matching is shape based matching and it can be performed by matching both contour shapes of ante-mortem and post-mortem dental images. The shape based matching can also be performed by Mahalanobis distance measure. A well-known distance measure which takes into account the covariance matrix is the Mahalanobis distance which is referred from Vijayakumari Pushparaj *et al* (2012) . When comparing with Euclidean distance, this distance measure takes into the account the correlations of the dataset and is scale invariant. The Mahalanobis distance is given by,

$$D_i^{Mahalanobis} = \sqrt{D_i} = \sqrt{\left(X - \mu_i\right)^T \Sigma_i^{-1} (X - \mu_i)} \quad (11)$$

Where Σ_i^{-1} represents the inverse of the covariance matrix of class {I}. The Mahalanobis distance is also known as weighted Euclidean distance where the weight is determined by using the covariance matrix.

RESULTS AND DISCUSSION

In this section, an experimental result of our algorithm was discussed. This algorithm was implemented in Matlab 2013a. For radiograph images are collected from Dental Digital x-ray Madurai, which includes bitewing, periapical and panoramic images. This algorithm is evaluated with a marginal database of 96 radiographic images including images captured from either the left or the right jaw and a limited database of 25 photographic images captured from the front view. Some of the sample dental radiographic and photographic images are shown in Fig.2.

Fig. 2: Sample radiographic and photographic images

The input image is preprocessed by using top-hat and bottom filter. The image of interest is made brighter by suppressing the background using top-hat filter. To adjust the brightness bottom hat filter is used and it is shown in Fig.3. After pre-processing the images can be performed for tooth isolation to separate the individual tooth. To separate each and every tooth integral intensity projection is used. Since the intensity of the tooth region and the background differ, the peak and valley points will exist in the intensity plot. The peak point indicates the presence of tooth and the valley refers to the gap between them.

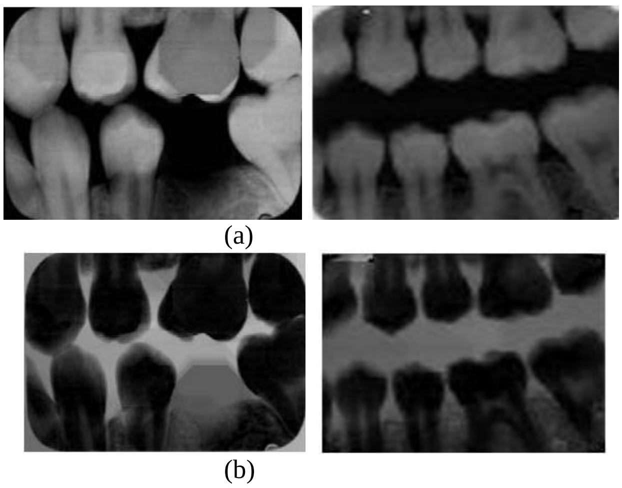

Fig. 3: (a) Top-hat filtered output,(b) Bottom-hat filtered output

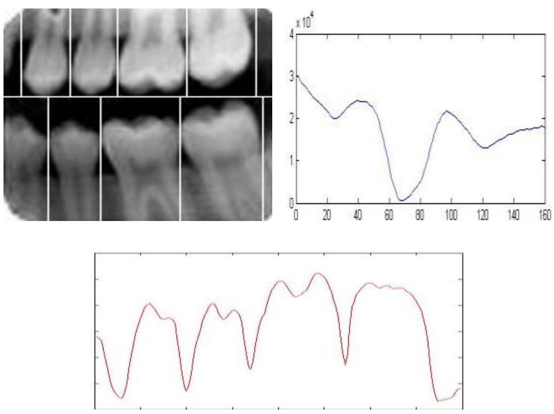

Fig. 4: Separation of Individual tooth

Fig.4 shows the separation of individual tooth by using horizontal and vertical intensity projections.

The result obtained from the integral projections shape extraction of ORACM result is obtained. The result of ORACM for radiographic and photographic images is shown in Fig.5 and Fig.6.

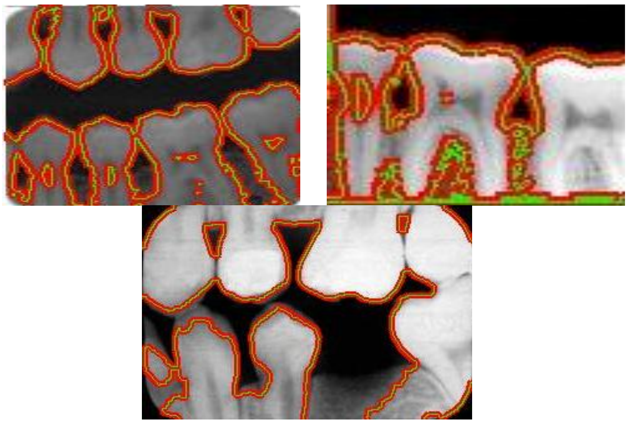

Fig. 5: ORACM for radiographic images

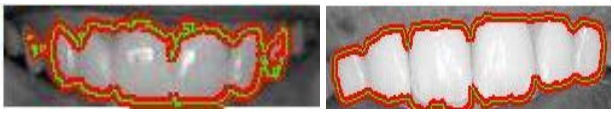

Fig. 6: ORACM for photographic images

The result obtained for ORACM is then performed for shape matching. The performance evaluation of ORACM technique is tabulated in Table.1

Table 1:

Input images taken		Shape based Matching	
Post mortem images	Ante mortem images	Mahalanobis Distance	% of similarity
Dent 12	Dent 16	2.56	94.43
	misstooth21	0.65	98.32
	Dent 32	3.31	95.83
	Peri 21	4.32	94.11
	Peri 24	3.78	94.96

From this table, it is clear that the lowest Mahalanobis distance of 0.65 is observed for the image is best matching. The percentage of similarity is observed for this misstooth21 is top ranking. The percentage of retrieval is obtained using Cumulative Matching Characteristic (CMC) curve. It is also called as hit rate curve. Hit rate is defined as the ratio of number of matching obtained in the top-1 ranking to the total number of images considered. Ranking is allotted based on the Matching Distance (MD) metric

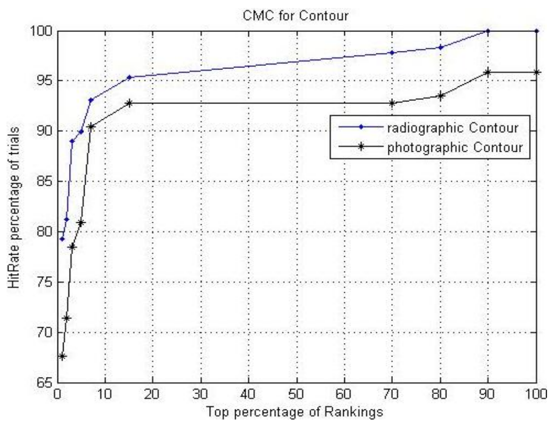

Fig. 7: Cumulative Matching Characteristic (CMC) curve

Among the 96 query images, 61 genuine images were ranked first with a hit rate of 0.65 for the similarity measure. In the remaining 35 images, 20 images were ranked second and the remaining 15 images were top-3 rankings.

Conclusion:

Developing an automated dental identification system is a demanding challenge at present. A novel focus of this algorithm is usage of dental photographs, if there is unavailability of dental radiographs. The analysis with photographic images will surely provide an aid for forensic law enforcement. The contour tracing is implemented using a level set method named ORACM method. This contour tracing algorithm is good for bitewing and periapical dental radiographic images. The experimental results clearly show that the algorithm it is well suited for photographic images with fewer computations.

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