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Research Article

DENTAL RADIOGRAPHS AS HUMAN BIOMETRIC IDENTIFIER: AN EIGEN VALUES/EIGEN VECTOR APPROACH

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ABSTRACT
From a pattern recognition and computer vision standpoint, the problem of person identification based on dental records can be cast as an image matching and retrieval problem: given a dental image. In the presented work, we propose to develop an Eigen values/Eigen vector based dental radiographs information data base that can be used as biometric identity of a person. The same may be combined with principal component analysis for further optimizing the feature data base.

Key Words: *Dental Biometrics, Dental Radiographs, Eigen Vector, Eigen Values*

INTRODUCTION
The goal of forensic dentistry is to identify people based on their dental records, mainly as radiograph images. In the proposed thesis work, dental radio graphs are attempted to be treated as one of the bio-metric information of human being, with the final goal of human identification. The dental radiographs are more permanent rather than finger prints, iris or facial features of a person. Also, the dental radiographs remains available even after several hours of expiry of a person. This enforces the forensic science experts to use dental radiographs to be as a very important technique in fool proof identification of a person. A ranking of matching scores is generated based on the distance between the ante-mortem (AM) and post-mortem (PM) tooth shapes. Initial experimental results on a small database of radiographs indicate that matching dental images based on tooth shapes and their relative positions is a feasible method for human identification.

From a pattern recognition and computer vision standpoint, the problem of person identification based on dental records can be cast as an image matching and retrieval problem: given a dental image. At a first glance, this problem seems more constrained than the generic object detection and object recognition problem. However, building a dental chart with distinctive features for each individual tooth (as human experts do) is extremely difficult, because the system must detect and classify each tooth before it can process them. One issue is the fact that the coarse shape of a tooth is not unique. For instance, all pre-molars have roughly the same shape, as do all molars and all incisors.

MATERIALS AND METHODS
Brief Literature Survey
This study describes different method used for dental biometrics. Dental biometrics is used in forensic science for human identification and requires ante mortem (AM) and postmortem (PM) radiographs for finding an unidentified subject. Dental radiographs are used for obtaining information related to teeth shape, teeth contour and relative position of neighboring teeth, also they gives information about dental work like crowns, fillings & bridges etc. Identification is done in three stages. Stage one includes preprocessing and segmentation of radiographs. Segmentation can be done by various methods that are mentioned in this paper. Stage two has Contour extraction or dental work extraction. Contour or shape of teeth and dental work can be extracted by using active contour model (ACM) or active shape model (ASM) methods. Stage three includes atlas registration and matching. Atlas registration is the method used for labeling teeth, which will help in the matching stage. Matching of AM radiograph with PM radiograph can be done by using algorithms (Shubhangi and Revati, 2012).

Dental biometrics is used in forensic dentistry to identify persons posthumously based on their dental radiographs. The proposed strategy consists of three main processing phases. The first phase is segmentation (feature extraction). In the segmentation step, seed points of the dental works are detected by thresholding. The final segmentation is obtained with a snake (active contour) algorithm. The second phase consists of creation of a dental code. The dental code is defined from the position (upper or lower), the size of the dental works, and distance between neighboring dental works. The third stage is matching which is performed with the Edit distance (Levenshtein distance). The method was tested on a real database consisting of 68 dental radiographs and the results were very satisfactory (Hofer and Marana, 2008).

This paper presents a method for human identification based on Dental biometrics. In this technique AM radiographs are matched with PM radiographs to verify the identity of a deceased individual. An algorithm is presented in this paper which consists of four stages. Stage one is preprocessing of dental radiograph. Stage two is segmentation used to extract single tooth and also for the dental work extraction. Next in stage three comes extraction of features like shape and size of tooth. Finally in stage four matching of AM and PM radiographs is done based on histogram properties, area of tooth and dental work and on this matching basis, individuals can be identified (Shubhangi and Revati, 2012).

Dental biometrics has been widely used for posthumous identification purposes. An automatic computer-aided dental identification system is necessary to process accurately a large number of cases in situations such as natural calamities. This study presents an automated scoring and ranking method that can be used to improve upon other text-based methods such as WinID. The postmortem (PM) radiograph with a marked region of interest (ROI) is matched with an ante mortem radiograph based on a database search, to retrieve a closest match. To express the degree of match between two radiographs, the weighted sum of squared differences (SSD) cost function is used. The method was experimentally verified on a database of 571 radiographs belonging to 41 different human beings. In 90% of the identification tests, this method isolated the correct match in the top 10%. In all other tests, the correct match was among the top 22% (Maja and Jeff, 2008).

Dental biometrics is used to identify victims of large scale disasters, where the conventional biometric features, e.g., face, fingerprint, iris, etc., have been destroyed. An unidentified individual's postmortem radiograph is matched against a set of identified ante mortem radiographs to get to the closest match. This paper presents an effective dental radiograph registration algorithm using phase-based image matching. The use of phase components in 2D (two dimensional) discrete Fourier transforms of dental radiograph images makes this method highly robust for image registration and recognition. This method was tested on a database of dental radiographs, the results of which indicates that the proposed algorithm is effective in correct recognition operation even for low-quality images (Akira *et al.,* 2006).

Image Acquisition and Preprocessing

The dental image source is the x-ray diagnostic centre. The presented work is primarily focuses on to the feature extraction from the dental radio graphs and not on how the x-rays are performed on dental part of the body. The dental images are in jpeg format and converted to gray scale format by using the rgb2gray command in matlab.

Dental Radiographs as Eigen Images

In mathematical terms, the principal components of the distribution of dental radiographs, or the eigenvectors of the covariance matrix of the set of face images, treating an image as point (or vector) in a very high dimensional space is sought. The eigenvectors are ordered, each one accounting for a different amount of the variation among the face images.

These eigenvectors can be thought of as a set of features that together characterize the variation between face images. Each image location contributes more or less to each eigenvector, so that it is possible to display these eigenvectors as a sort of ghostly face image which is called an "Eigen face". Each Eigen face deviates from uniform gray where some facial feature differs among the set of training faces. Eigen faces can be viewed as a sort of map of the variations between faces.

Each individual dental radiograph can be represented exactly in terms of a linear combination of the Eigen dental radiograph. Each dental radiograph can also be approximated using only the "best" Eigen dental radiograph, those that have the largest Eigen values, and which therefore account for the most variance within the set of face images. The best M Eigen dental radiographs span an M-dimensional subspace which we call the "dental radiograph space" of all possible images.

Eigen Values Computation

Let a dental radiograph image I(x, y) be a two-dimensional N x N array of 8-bit intensity values. An image may also be considered as a vector of dimension N^2, so that a typical image of size 256 x 256 becomes a vector of dimension 65,536, or equivalently a point in 65,536-dimensional space. An ensemble of images, then, maps to a collection of points in this huge space.

These vectors define the subspace of dental radiograph images, which we call “dental radiograph space". Each vector is of length N^2, describes an N x N image, and is a linear combination of the original dental radiograph images. Because these vectors are the eigenvectors of the covariance matrix corresponding to the original dental radiograph images, and because they are face-like in appearance, we refer to them as "Eigen dental radiograph".

An N x N matrix A is said to have an eigenvector X, and corresponding Eigen value λ if

$$AX=\lambda X. \qquad Eq^n. \quad 1$$

Evidently, eq^n. 1 can hold only if

$$Det|A-\lambda|I=0 \qquad Eq^n. \quad 2$$

Which, if expanded out, is an Nth degree polynomial in λ whose root are the Eigen values. This proves that there are always N (not necessarily distinct) Eigen values. Equal Eigen values coming from multiple roots are called "degenerate".

A matrix is called symmetric if it is equal to its transpose,

$$A=AT \qquad Eq^n. \quad 3$$

It is termed orthogonal if its transpose equals its inverse,

$A^TA = AA^T = I0$ Eq^n.4

Finally, a real matrix is called normal if it commutes with is transpose,

$$AA^T = A^TA.$$

Dental Radiograph Recognition based on Eigen Values

In the presented work, diagonal Eigen values are used for dental radiograph recognition score computation.

Diagonal Eigen Values

Standard Image				Test Image
E^1_1	E^2_1	E^3_1…	… E^N_1	T_1
E^1_2	E^2_2	E^3_2…	… E^N_2	T_2
E^1_3	E^2_3	E^3_3…	… E^N_3	T_3
E^1_4	E^2_4	E^3_4…	… E^N_4	T_4
…	…	… …	… …	…
…	…	… …	… …	…
…	…	… …	… …	…
E^1_M	E^2_M	E^3_M	… E^N_M	T_M

The average of the differential Eigen values i.e. difference of standard and test image is given by:

μ1 μ2 μ3 … μN μT

where $\mu i = \Sigma (Si - Ti)/N$, $i = 1,2,3 \ldots N$

The standard deviation is given by:

$\sigma i = \sqrt{\Sigma} (\mu i - Si)2/2xM2$, $i = 1,2,3 \ldots 1152$

μ1 μ2 μ3 …. μN

RESULTS AND DISCUSSION

In the proposed work, the dental radiograph images are analyzed for their similarity between the test and unknown image to that of the data base images. The algorithm has been implemented in matlab version 7.5. A text file containing information about the person in data base has been maintained. Once the image is identified, respective text file is opened up from the data base.

Conclusion

The proposed algorithm however shows a slow speed as the no. of dental images increases in data base due to recalculation of the differential Eigen values of query image to the data base images. But this problem may be overcome by optimizing the no. of Eigen values to a considerable level.

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