International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE) Vol 1, Issue 5, April 2015

# Age Estimation from Pulp/Tooth Ratio Using MATLAB

[1]Lia Ann Varughese,[2]Lismol Davis,[3]Malavika R,[4]Maria Salim,[5]Mrs. Ranjitha Rajan
Amal Jyothi College of Engineering, Koovappally P.O., Kanjirappally, Kottayam.

*Abstract:* **Accurate age estimation of human adult is an important problem in both anthropological and forensic fields. This paper proposes a method for the determination of pulp to tooth area ratio from dental radiographs of canine teeth, which is a non-invasive and feasible method for adult age prediction. With advancing age, the size of dental pulp cavity is reduced as a result of secondary dentine deposit. The aim of the study is to test the reliability and applicability of pulp/tooth area ratio (PTR) in canine teeth as an indicator of age.**

*Index Terms*— **Age estimation, Canine teeth, Pulp/tooth area ratio.**

## I. INTRODUCTION

Age estimation is an aspect of forensic human identification. In the last few years the scientific literature has provided several skeletal and dental methods to assess age, most of which apply many age indicators related to degenerative changes in skeleton such as modifications in the pubic symphysis in sternal rib ends, in auricular surface of the ilium, in endo-cranial and ecto-cranial sutures, while some utilize radiology of the proximal femur and clavicle. However, recent and more successful methods reported in the literature to assess age in adults are based on age related changes of teeth. They are considered as one of the reliable methods of identification of a person in forensic sciences. A variety of methods are used for dental age estimation, morphological, bio chemical and histological methods. However these methods are invasive and require tooth extraction, which is not possible in living individuals.

Teeth are the hardest part of the body and are least affected by the taphonomic process. Canines are the favored teeth as they are single rooted with largest pulp area for the ease of analysis. In addition they have less chance for wear when compared to anterior teeth. Non-invasive radiographic techniques have been developed from measurements of the reduction in the dental pulp cavity associated with advancing age due secondary canine deposition. After tooth eruption, the size of the pulp cavity gradually decreases with age due to deposition of secondary dentine in the pulp cavity wall. This reduction in pulp cavity wall is correlated with chronologic age and regression equation is derived to estimate the age.

## II. MATERIALS

A total of 100 dental radiographs of the mandibular canine teeth of Indian samples (56 females and 44 males), aged between 30 and 80 years are analyzed. The radiographs of teeth were taken from dental clinic.

The exposure parameters were set according to the patient's age and size. The patient's identification number, sex, age and date of radiographic taking were recorded.

The inclusion and exclusion of the subjects are based on certain criteria:

1) Subjects should be clinically free from any developmental endocrine or nutritional disorder and special dentine diseases.

2) The radiograph showing impacted teeth with root canal treatment, crown restoration, broken teeth, teeth with large areas of enamel overlap between neighboring teeth, unclear radiographs are excluded from the study samples.

## III. METHODS AND MEASUREMENTS

### A. *Image Production*

The radiograph of the mandibular canine teeth is stored as high quality JPEG files in the computer and it is imported to the MATLAB2014 version.

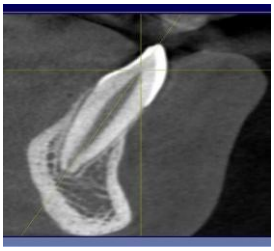


*Fig1: Dental canine radiograph*

*B. Image Analysis*

In the MATLAB2014 software the x-ray image of a tooth can be viewed as a matrix having r rows and c columns. The gray level of the input image varies from 0(black) to 1(white). In order to simplify or alter a digitized image to make it more readable or easier to analyze, it is segmented or partitioned into multiple segments or set of pixels in a process called segmentation. In radiographs the background initially has darker pixels than the portrayed objects. In the image segmentation, each pixel of the image must be classified into one of two classes: one corresponding to the object of interest, and another for all the other objects.

For the age estimation, we have to detect the tooth pixel and pulp pixel separately. In fact pulp pixel must be retrieved from the tooth pixels. Since these two segmentations are different, appropriate segmentation methods is used to detect the required regions efficiently. In particular, the main difference is that the intensity of the pixel is greater in the tooth than in the background, and so we can solve this problem through usual thresholding technique. However these techniques are usually inadequate for the second problem, the detection of the pulp pixels, because the gray level of the pulp pixel is not very different from those of the tooth pixel, even if, local and adaptive strategies are used.

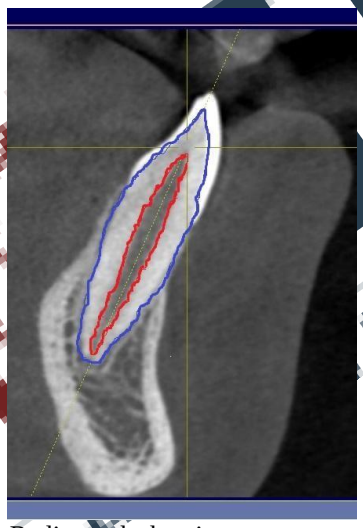


Fig2: Radiograph showing pulp and tooth area

*C. Detection of tooth and pulp pixels*

The algorithm consists of three stages:

1. High-pass filter

The image is given as an input to high pass filter. A high pass filter is the basis for most sharpening methods and image is sharpened when contrast is enhanced between adjoining areas with little variation in brightness or darkness. A high pass filter tends to retain the high frequency information within an image while reducing the low frequency information. The kernel of the high pass filter is designed to increase the brightness of the center pixel relating to neighboring pixels. The kernel array usually contains a single positive value at its center which is completely surrounded by negative values2. Edge detection using Sobel operator

Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities.

The sobel operator sometimes called sobel filter is used in image processing and computer vision, particularly within edge detection algorithm, and create an image which emphasis edges and transitions. Technically, it is a discrete differentiation operator computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the sobel operator is either the corresponding gradient vector of the norm of this vector. The sobel operator is based on convolving the image with a small, separable and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. On the other hand the gradient approximation that it produces is relatively crude, in particular for high frequency variation in the image.

3. Watershed Segmentation

Image segmentation refers to the process of portioning an image into groups of pixels which are homogeneous with respect to some criteria. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixel with same label share certain characteristic. The watershed transformation considers the gradient magnitude of an image as a topographic surface. A pixel having the highest gradient magnitude intensities (GMIs) corresponds to watershed lines, which represent the region boundaries. Water placed on any pixel enclosed by a common watershed line flows downhill to a common local intensity minimum (LIM). Pixels draining to a common minimum form a catch basin which represents a segment.

*D. Calculation of Pulp/tooth area ratio*

Using the previous segmentation technique the desired set of pixels is partitioned from the image, resulting in two separate regions. The separate regions obtained are pulp region and tooth region. For the calculation of the pulp to tooth area ratio, the count of the pixels in the two obtained regions need to be calculated. The number of pixels in both regions is calculated separately and the ratio is determined. Based on the calculated pulp/ tooth area ratio and the regression equation the age is estimated.

$$PTR\ ratio = \frac{\text{No. of pixels in the pulp region}}{\text{No. of pixels in the tooth region}}$$

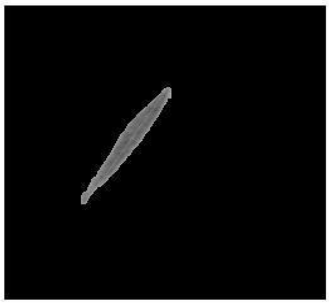


Fig3: Tooth Area

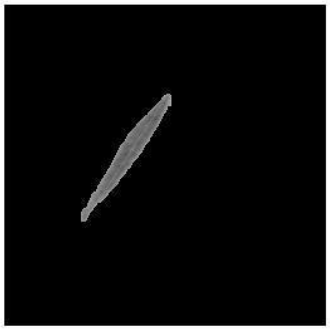


Fig4: Pulp Area

*E. Age estimation*

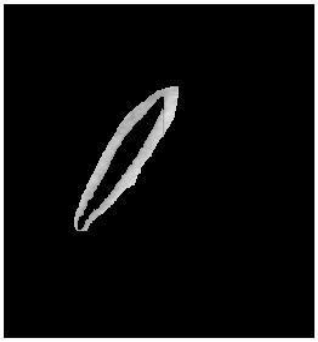
Age estimation by radiographic evaluation of secondary dentine deposition is an established non-invasive technique for adults. Assessment of the pulp/tooth area ratio is an indirect quantification of secondary dentine deposition. The ratio between pulp and tooth measurements was calculated and used in order to reduce the effect of any variation in the magnification or angulation of the radiographs. In addition, earlier studies have indicated that the amount of secondary dentine is correlated with chronological age and can be measured indirectly by radiographs.

In the study measurements of PTR show no statistically significant difference in male and female, this result run in parallel with the previous studies on single-root teeth which shown the sex has no significant influence on age estimation. The pulp/tooth area ratio and the age are related using the regression equation formulated.

## IV. RESULT

A MATLAB code was used for the implementation of the algorithm described in the previous section.

An output of separate pulp area and tooth area is obtained. Segmented pulp and tooth area is shown in fig3 and fig4 respectively. The PTR (pulp/tooth area ratio) is calculated. Dental age is calculated using the regression equation, DA=-69 + (332*PTR).



The various age group and sex distribution are listed in Table 1.The descriptive statistics of PTR of the canine teeth is listed in Table 2.

| Age groups | Males | Females | Total |
|---|---|---|---|
| 30-40 | 12 | 18 | 30 |
| 41-60 | 22 | 25 | 47 |
| 61-80 | 10 | 13 | 23 |
| TOTAL | 44 | 56 | 100 |

Table 1: Sample distribution across age groups and sexes

| Tooth | Maximum | Minimum | Mean | SD | No |
|---|---|---|---|---|---|
| Canine | .02 | .18 | .099 | .039 | 100 |

Table 2: Descriptive statistics of PTR of canine teeth

## V. STATISTICAL ANALYSIS

The accuracy and precision of the method can be evaluated by the distribution of PTR ratio with dental age

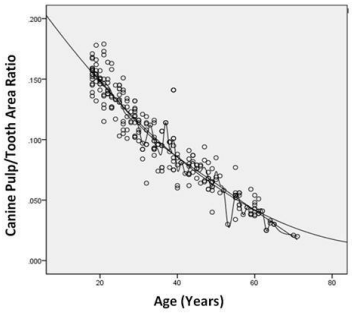



fig5: A Scattered spot curve showing a significant correlation between age and PTR.

## VI. DISCUSSION

Age estimation in adult subjects is one of the significant open problems in forensic medicine and anthropology. Several macroscopic techniques for age estimation have been developed, but their strong dependence on the operator and their poor precision in ages presents serious limitations to their reliability.

This work proposed a segmentation algorithm for use with radiograph images of canines, using MATLAB code for the automatic evaluation of the ratio of tooth and pulp areas, to assess age using regression equation. A sample of 100 radiograph images of canine belonging to a sample of individuals of known age and sex has been analyzed, with satisfactory results.

Two main advantages can be obtained by using our algorithm in place of manual procedure. First, we can be certain of always obtaining these same results when repeating age estimation using the same tooth. Second, our automatic procedure requires less than the manual procedure.

## CONCLUSION

The dental age is calculated with high rate of accuracy. Same result will obtained when repeating age estimations using the same tooth. This is an automatic procedure requires less time than the manual procedure. It is found to be more reliable method. Consequently this method showed promising results for dental age estimation by non-invasive technique using dental radiograph, which will be suited for forensic applications. Future research should aim at using several teeth together and are recommended to improve the precision and reduce standard error of age estimation.

## REFERENCES

[1] Afify M M, Zayet MK, Mahmoud NF, Ragab AR (2014) "Age Estimation from Pulp/Tooth Area Ratio in Three Mandibular Teeth by Panoramic Radiographs: Study of an Egyptian Sample." J Forensic Res 5:231.

[2] R. Cameriere, et al., Automatic age estimation in adults by analysis of canine pulp/tooth ratio:Preliminary results, Journal of Forensic Radiology and Imaging (2014).

[3] R. Cameriere, L. Ferrante, M.Cingolani, Variations in pulp/tooth area ratio as an indicator of age: a preliminary study, J. Forensic Sci. 49(2)(2004) 317-319.