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Research Paper / Makale

Determination Age and Gender with Edge Detection Algorithms Using Dental X-Ray Images

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Abstract: Age determination in forensic medicine is a very important issue in terms of criminal and law. In case of any disaster or unlawfulness, identification may be required. In such cases, the competent authorities ask the forensic medicine institution for determining the age. Forensic medicines must make the most accurate process of determining the age. In this study, a database was created manually with a total of 1313 teeth images to determine age and gender. Images in this database are pre-processed with image processing techniques. Numerical data were obtained according to the tanimoto similarity rates of images. This numerical data is saved in the XML file. Comparing is done with the data on this XML file. In addition to the age determination process, gender determination process was also carried out. Age determination was performed with + - 0 error. The application was developed in C # programming language.

Keywords: Age and gender determination, Image processing techniques, panoramic dental x-ray images.

Kenar Bulma Algoritmaları Kullanarak Diş Röntgen Görüntülerinden Yaş ve Cinsiyet Belirleme

Öz: Adli tıpta yaş tayini, ceza ve hukuk açılarından çok önemli bir konudur. Yaşanan herhangi bir felaket veya hukuksuzluk halinde kimlik tespiti yapmak gerekebilir. Böyle durumlarda yetkili birimler yaş belirleme işlemini adli tıp kurumundan ister. Adli birimlerin yaş belirleme işleminin en doğru bir şekilde yapmak zorundadır. Bu çalışmada yaş ve cinsiyet belirlemek için toplam 1313 panoramik diş görüntüsü ile bir veri tabanı manuel olarak oluşturulmuştur. Oluşturulan bu veri tabanındaki görüntüler, görüntü işleme teknikleri ile önişlemden geçirilmiştir. Ön işlemden geçirilen görüntülerin tanimoto benzerlik oranlarına göre sayısal verileri elde edildi. Bu sayısal veriler XML dosyasına kaydedilmiştir. Kıyaslama işlemleri bu XML dosyası üzerindeki veriler ile yapılmıştır. Yaş belirleme işleminin yanı sıra cinsiyet belirleme işlemi de gerçekleştirilmiştir. Yaş belirleme işlemi +- 0 hata ile gerçekleştirilmiştir. Uygulama C# programlama diliyle geliştirilmiştir.

Anahtar kelimeler: Yaş ve cinsiyet belirleme, Görüntü işleme teknikleri, Panoromik x-ray diş görüntüleri

1. Introduction

Forensic medicine is one of the most important factors in the identification of the age determination process for the person. The age determination process is done according to the individual physical characteristics of the person. Some of these are sex, height, body weight, hair, skin, eye color, fingerprints, bones and teeth [1]. Identity identification may be required in our lives for different reasons (earthquake, flood, fire etc.) [2]. Nowadays, the identification process for people has gained international status [3]. Therefore, identification should be done with the least error [4,5].

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Some events (disaster, suicide, murder, etc.) after the person's physical features may not provide any information to that person. In such cases, the most robust structure for identification is the teeth of the human. Because physical effects do not change the structure of the teeth too much. For the purpose of age estimation, atlases are used in dentistry and forensic sciences, where the developmental stages of the teeth are shown. This method is used in X-ray images taken from the teeth in living and dead bodies [6,7]. Different studies were done in the literature for age estimation. Some of these are as follows; In their study, they performed various segmentation and identification procedures on dental x-ray images [8,9]. In another study, they performed an age prediction using different methods via dental X-ray images [10,11]. Age estimation was performed by measuring different areas of the teeth [12], they performed an age prediction procedure in young and children [13,14], age estimation was made depending on the size of the skeleton [15,16], different studies were performed in different fields and age estimation was performed [17]. Image control system was designed with image processing techniques [18-19]. Emre et al. used image processing and artificial intelligence techniques to determine age and gender from dental images [20-23].

In this study, a dental database was created by removing the boundaries of panoramic dental x-ray images. Image processing techniques were applied to this database. These images were compared to the tanimoto similarity rates and the age determination process was performed. In addition to the age estimation process, gender estimation was also performed.

2. Experimental Methods

In this study, databases were first created. Used dental panoramic X-ray images were obtained from different cities in Turkey. The Universal Numbering System is used to enumerate the teeth and this system is shown in Figure 1.



Figure 1. Universal Numbering System

The images obtained by removing the boundary lines from the panoramic dental X-ray images are recorded in the database with the information of AGE_GENDER_TOOTHNUMBER_COUNT. Pre-process operations are performed on the teeth for better results. As in the general methodology shown in Figure 2 below, pre-process methods are applied first. Then apply the Otsu thresholding algorithm to the tooth image.

The images obtained as a result of these operations are kept in folders M1 and M2. For example, the second tooth number 19 of a 25-year-old male is recorded as: 25_M_19_2. A dental name of someone who is a female gender is kept as F instead of M.

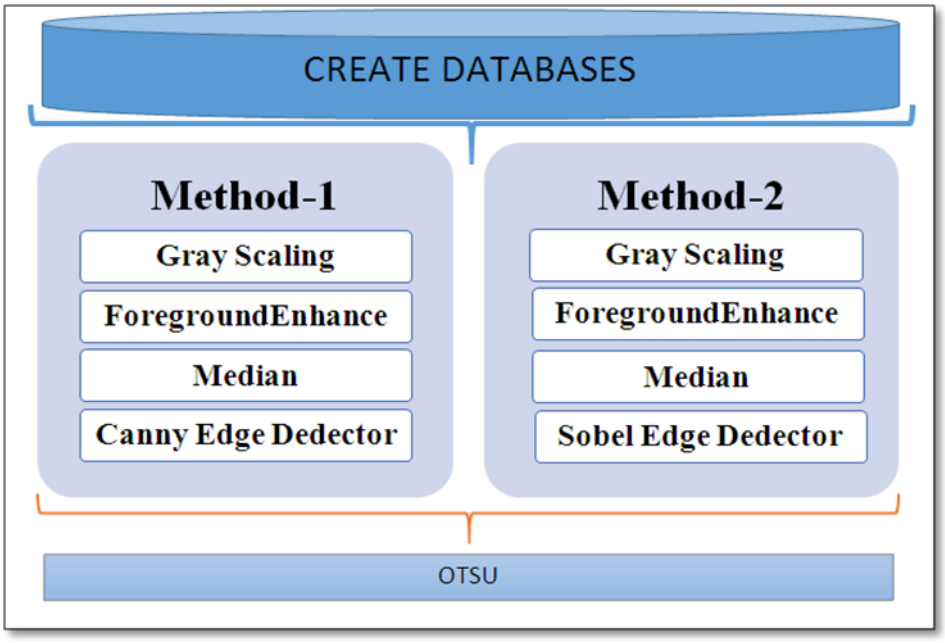


Figure 2. General Methodology

3. Application

In this study, dental x-ray images were pre-process to determine age and gender. Then, edge detection algorithms were applied to these images.

3.1. Pre-Process Operations

The input image is first applied to the GrayScaling process. Then, ForegroundEnhance method was developed with the foreground strengthening method in order to achieve higher success rate and the teeth with low image density were optimized. In this method, the procedure is as follows;

a) According to the image histogram (H_i) is obtained an average color (avg) of 0-255.

$$avg = \sum_{i=0}^{255} H_i \, i \Big/ \sum_{i=0}^{255} H_i \tag{1}$$

b) According to the image histogram (H_i) is obtained an average color (T) of avg -255.

$$T = \sum_{i=avg}^{255} H_i \, i \Big/ \sum_{i=avg}^{255} H_i \tag{2}$$

c) For each pixel in the image, a comparison is made according to the T threshold. Thus, the dental images are made clearer.

$$F[x,y] = \begin{cases} 0 & if\ F[x,y] > T \\ F[x,y] & otherwise \end{cases} \tag{3}$$

However, as a result of the color reduction process, some undesirable noise may occur on the new image. To eliminate this, the formula of the median filter in equation 4 is used;

$$F[x,y] = \text{median}\{g[p,q]\} \tag{4}$$

Where g [p, q] refers to convolution kernel.

After these operations, the canny edge detection algorithm is applied to the images. Then, the database image is displayed as shown in Figure 3 (a part is shown).



Figure 3. Result of Canny algorithm

Similarly, sobel edge detection algorithm is applied to images. Then, the database view is shown as shown in Figure 4. (A part is shown).



Figure 4. Result of Sobel algorithm

3.2. Comparison Method

The comparison process continues with special operations applied to the binary image obtained from the M1, M2, folders.

The Tanimoto similarity function (T_s) is applied in the calculation process according to the similarity ratio. For two images, bits in the same coordinate are compared with logical "AND" and "OR" bit operators. In the two pictures *A* and *B*, A_i, B_i shows the i^{th} bit of both images. Accordingly, the similarity of Tanimoto can be written as the equation in the following equation 5-a or 5-b:

$$T_s(A,B) = \text{cmpAND}sum_i(A_i = B_i \; and \; A_i = 255\;),$$
$$\text{cmpOR}sum_i(A_i = 255_i \; or \; B_i = 255\;),$$
$$Then \;\; T_s(A,B) = \text{cmpAND} \;/\; \text{cmpOR} \tag{5-a}$$

$$T_s\;(A,B) = \sum_i A_i \wedge B_i \;/ \sum_i A_i \vee B_i \tag{5-b}$$

4. Conclusion

Figure 5 shows the graph of the distance to the test tooth at the similarity ratio of the teeth. Black zigzag lines indicate the distance of each tooth to the test tooth. Blue straight line is the result of measurement made for test tooth. The tooth closest to this line is determined by the red round region and is shown on the chart with the label name.

As can be seen from Figure 5, the exact result is obtained by comparison with similarity ratio. It is seen that only the teeth of their age group are close to the blue line. The other 1308 teeth are too far for the sought tooth.

In this study, computer environment was used instead of dental atlases used in forensic medicine to estimation age. A multi-disciplinary study was conducted to determine age and gender from dental X-ray images. The data base of 1313 dental images obtained from panoramic images were created manually.

First of all, image enhancement was performed by applying 2 methods. The image of the teeth to be tested from outside, the results of the images obtained from these 2 methods (M1, M2) were compared according to similarity rates and both age and gender were estimated.

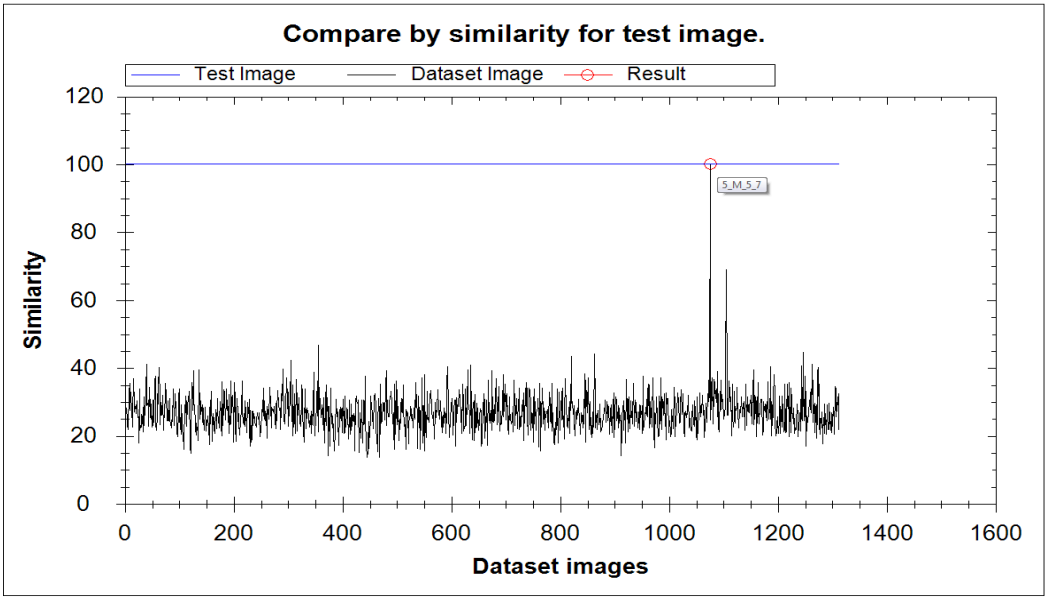


Figure 5. Result according to similarity

Comparisons were made with samples from different ages. The results are compared with those of other age estimation studies in the literature and are shown in Table 1.

Table 1. Comparison with other methods

Method	**Error**	**Number of tooth used**
Kvaal Method [24]	±9.8 **Standard Error**, ± 0.5-2.5 yıl	100
Cameriere Method [25]	± 5 **Standard Error**	100
Yang et al. Method [26]	± 8.3 **Standard Error**	28
Star et al. Method [27]	± 8.44 **Standard Error**	111

Proposed Method Results (RG:Real Gender EG: Estimation Gender, Y:Year, E:Error)

	4-9 years				**9.5-22 years**				**22.5-63 years**			
	M1		**M2**		**M1**		**M2**		**M1**		**M2**	
Comparing by	**RG**	**EG**	**RG**	**EG**	**RG**	**EG**	**RG**	**EG**	**RG**	**EG**	**RG**	**EG**
Similarity Ratio	F	F	F	M	F	F	F	F	M	F	M	M
	+-0 Y E		+-0.5 Y E		+-0.5Y E		+-0.5Y E		+-1. E		1.5 Y E	

In our study, test procedures were performed on some dental images. According to the data obtained from these tests, better results are obtained from the studies in the literature. Looking at Table 1 above, the best results were obtained according to M1. Since the morphological characteristics of the teeth do not change as the age progresses, it is seen that the correct prediction success decreases.

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