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Supraorbital Margins for Identification of Sexual Dimorphism and Age Detection from Human Skull Using Wavelets

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ABSTRACT

The accurate determination of the sex and age of human skull is a critical challenge in skeleton anthropology and crime department. In the forensic laboratory they determine both the sex and age of skeleton using carbon content of the bones. The teeth, pelvis and skull are the most widely used sites for determination of sex and age of the skeleton. This paper introduces a technique for objective qualification of age and sexual dimorphic features using wavelet transformation, it is a multiscale mathematical technique that allows determination of shape variation that are hide at various scale of resolution. We use a 2D discrete wavelet transform in the proposed method. In the skull the supraorbital margin is consider to determine sex of skull and the area occupation of upper part of skull is used to estimate the age of the skull. SVM is a classifier used for classification. We used both supervised and unsupervised SVM for both sex and age detection of the skull.

Keywords: Supraorbital margin, age and sex determination, 2D wavelet transformation and forensic laboratory.

1. INTRODUCTION

Sex and age determination of unidentified skeleton is a very important part of skeleton anthropology and forensic lab analysis. In the context of forensic analysis, sex and age determination together with assessment of racism, population affinity and stature is important for the process of person identification. The sex determination based on skeletal remains is based on sexual dimorphism, which is generally present to varying degrees in bones of human skeleton.

The anthropology sites of the skeleton that are commonly used for sexing are the skull and pelevis. In the traditional method for sex diagnosis of human skulls are classified as morphoscopic and morphometric. In the morphoscopic method, a set of skulls is either as a robustness or based on comparison of specific cranial traits etc. In the morphometric method, measurements of the cranial size and shape are obtained, usually focusing on the same set of sexually dimorphic cranial traits.

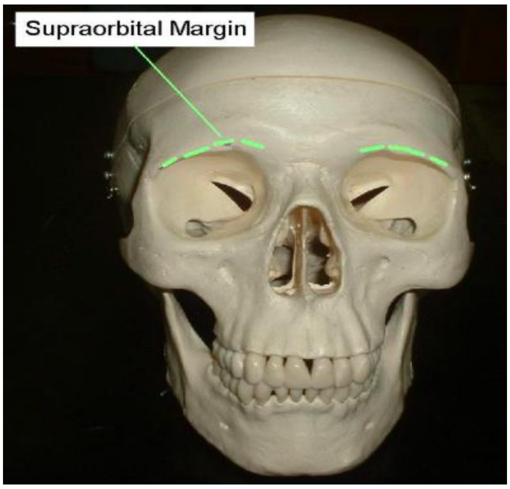

Fig.1. Supraorbital margin in skull

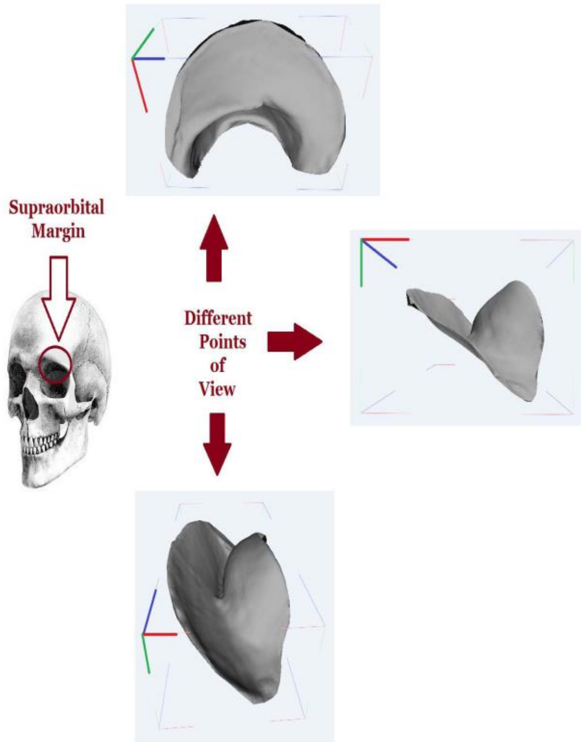

Fig. 2.Supraorbital margin for different point of view

In the supraorbital margin analysis for sex determination, male skulls are characterized by a wider, semi-circle, rounded and blunt supraorbital margin. For female have a sharp, edge of dulled knife supraorbital margin are shown in fig.3.

Many anthropologists have studied the age systems, where age is often a major organizing principle. Age determination will be based on the area occupation of the upper region of the skull. By comparing the area occupation of skull with the database we can obtain the age of the skull. We proposed a new technique for sex determination based on our exploration of a data set of two dimensional digital surfaces of supraorbital margins. The proposed method investigate a specific morphological region of the cranium, i.e., the valley region or the negative of the supraorbital surface.

2. DATA SET

The studied sample was obtained while studying the skeleton anthropology of a European report skeleton analysis shown in table 1. For all the tested specimens, the particular individual sex, age during death and birth date was recorded. From that the superior and partial portions of the orbital rim we can made the analysis.

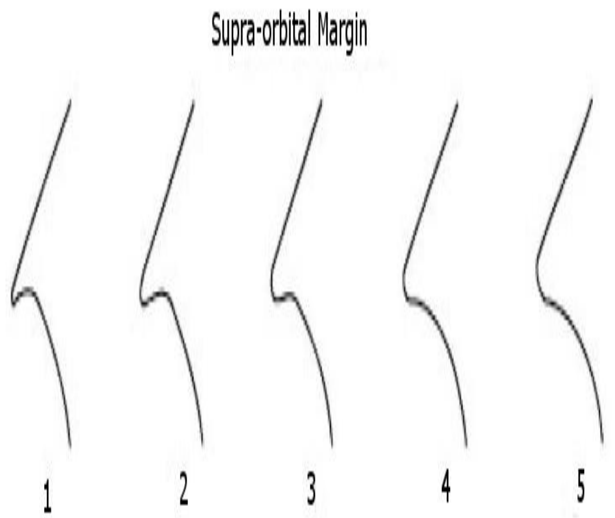

Fig.3.The extreme supraorbital margin on the left (1) characterize a sharp edge, which is a feature of female skull, while the extreme supraorbital margin on the right(5) shows the wide rounded blunt shape which is a feature for male skull.

Table 1. Sex, age and death of subject (skull)

	ID	AGE	BIRTH	DEATH
Females(7)	42	56	1902	1958
	264	70	1887	1957
	276	27	1918	1945
	333	39	1914	1953
	343	53	1904	1957
	361	21	1927	1948
	475	77	1881	1958
Males(5)	53	77	1878	1955
	69	40	1906	1946
	91	55	1904	1956
	97	81	1886	1967
	201	63	1896	1959

3. METHODOLOGY

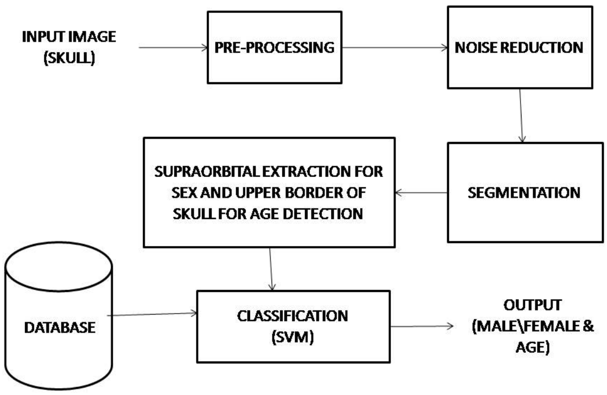

Fig.4. Block diagram for the proposed system

3.1 Input Image

The input image will be a skull image of the completely decomposed skeleton can be obtained by image acquisition through a digital camera shown in fig.5. For determination of sexual dimorphism we can only give the supraorbital region only.

Fig.5. Input image of the skull

3.2 Pre-Processing

In pre-processing there will be two main process are being carried out. They are RGB to gray image conversion and resizing. For all the image processing operations are being carried out only RGB to gray conversion. Resizing means an increasing or decreasing the image size.

Fig.6. Gray scale image

In this sex determination we can be able to increase the image pixel rate, so this process is also called as zooming the image.

3.3 Noise Reduction

Noise reduction is done by filtering. In this method we use a median filter. Median filter is also a type of order static filter used to replace the value of a pixel by the median intensity levels in the neighborhood of that pixel.

Median filter generally performs the operation of smoothing the image. Smoothing will be used to bring the blurring effect. This blurring effect will be used to increase the clarity i.e., appearance of the image. The main reason behind to increase the clarity of the image will be clearly able to identify the shape of the supraorbital region for sex determination of the skull.

Fig.7. Filtered image

Fig.8. First threshold binarization of image

3.4 Segmentation

Segmentation is the process of extraction of required part of the image. We can clearly extract the supraorbital region for determination of sex of the skull and extract the upper area of the skull to determine the age of the skull.

The result of image segmentation is a set of segments that will cover the entire image, or a set of contours extracted from the image.

Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristics.

Fig.9. Fuzzy Segmented image

We use an FCM (fuzzy c means) clustering being done in segmentation. In FCM we can generate the GLCM (gray level co-occurrence matrix). Let $\boldsymbol{x} = (x, y) \in$ R2 be the vectorial notation of a 2D point(x, y). The continuous wavelet transform of a 2D signal $f(\mathbf{x})$.

$$W\psi(\mathbf{b}, a) = 1\sqrt{}\, a\ \psi*(\mathbf{x} - \mathbf{b}a)\ f(\mathbf{x})d2\mathbf{x}$$

Where $\psi*$, b and a represent the complex conjugate of the analyzed wavelet ψ (or "mother wavelet"), the shifting parameter, and the dilation parameter (related to analyzed scale), respectively.

$$W\psi[f]\ (\mathbf{b}, a) = W\psi x\ [f] = a{-}2\ f(\mathbf{x})\psi x\ (a{-}1(\mathbf{x} - \mathbf{b}))d2\mathbf{x}$$

$$W\psi y\ [f] = a{-}2\ f(\mathbf{x})\psi y\ (a{-}1(\mathbf{x} - \mathbf{b}))d2\mathbf{x}$$

Then, after integrating by parts we get, which can be rewritten as:

$$W\psi[f]\ (\mathbf{b}, a) = a{-}2\nabla\ g(a{-}1(\mathbf{x} - \mathbf{b}))\ f(\mathbf{x})d2\mathbf{x}$$

$$= \nabla\{Wg[f](\mathbf{b}, a)\}$$

$$= \nabla\{g\mathbf{b},a * f\}$$

General discrete wavelet transform for a particular dilation a and translation, the wavelet coefficient W_f (a, b) for a signal can be calculated as

$$W_f\,(a,b) = \langle f, \psi_{a,b} \rangle = \int f(x)\ \psi_{a,b}(x)\ dx$$

f(x) is given as,

$$f(x) = 1/C_w \int_{-\alpha}^{\alpha} \int_{-\alpha}^{\alpha} W_f(a,b)\ \psi_{a,b}(x)\ db\ da/a^2$$

Where C_w is the normalization factor of the mother wavelet. Although the continuous wavelet transform is simple to describe, mathematically both the signal and the wavelet function must have closed forms, making it difficult or impractical to apply.

The discrete wavelet is used instead. The term Discrete Wavelet Transform (DWT) is a general term, encompassing several different methods. It must be noted that the signal itself is continuous; discrete refers to discrete sets of dilation and translation factors and discrete sampling of the signal. For simplicity, it will be assumed that the dilation and translation factors are chosen so as to have dynamic sampling, but the concepts can be extended to other choices of factors. At a given scale, a finite number of translations are used in applying multi resolution analysis to obtain a finite number of scaling and wavelet coefficients.

The signal is represented in terms of its coefficients as shown below

$$f(x) = \sum_{k} C_{jk} \psi_{jk}(x) + \sum_{j=1} \sum_{k} d_{jk} \psi_{jk}(x)$$

Where C_{jk} are the scaling coefficients and d_{jk} are the wavelet coefficients.

3.5 Classification

In the classification we can use the SVM (support vector machine). It will be able to compare the input image with the database to determine the sex and age of the given input image. SVC (support vector clustering) is a similar method that also builds on kernel functions but is appropriate for unsupervised learning and data-mining. It is considered a fundamental method in data science.

3.6 Database

The database consist of text images for various skulls. For comparison with the input image for identification of sex and age it will be very important.

3.7 Output

The output will be a general data that will give the sex and age of the given input image.

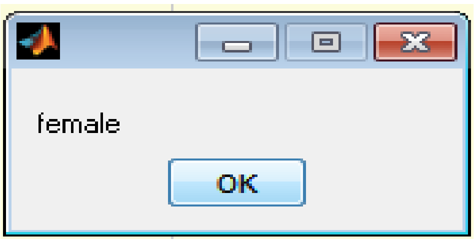

Fig.10. Output to display sex of the skull

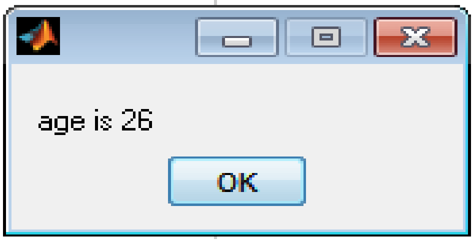

Fig.11. Output to display age of the skull

4. RESULTS AND DISCUSSION

The proposed model will generally give the information about the sex and age of the given skeleton from the identification are generally from the skull itself. For any investigation regarding the skeleton this model will be very useful for the determination of the sex and age of the skull by using a 2D wavelet transform. Once the novel approach is incorporates with a user-friendly software, it will be used for all the community of the people. The proposed system is also suitable to 3D models generated by any devices whose the capturing system also incorporates with the 3D point cloud such as CT-images, volume meshes and photogrammetric based images also. This model will be also extended to other parts of the skeletons regions for morphologic differences related to disease or racisms of the skull.

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