Multi Variant Analysis And Validation Study On Mastoid Triangle Process For Sex Determination

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Abstract— **The major objectives of this paper are (1) address the factors influencing sexing the human skull through a review of the literature (2) list the general techniques and methods used for sex determination (3) address the mastoid process method in determining sex (4) address the relevance of this information to computational forensic science research and applications. This paper is a summary of findings of Mastoid process sex determination that will give the knowledge that how far skull biometric is useful in determination of sex for unique identification and verification of human. From the available literature in this topic, analysis was done and most relevant accurate method for sex determination was identified. The existing techniques in sex determination are comprehensively reviewed and discussed. Validation of mastoid process approach is done with Matlab (2007) and sex determination was performed with sample database. Experimental results show the effectiveness of this approach in performance.**

Keywords- Skull Biometrics, Anthropometry, Computational forensics, Mastoid Process, Discriminant function analysis

I. INTRODUCTION

Historically, human identification is one of the most challenging subjects that man has confronted. The concept of identity is a set of physical characteristics, functional or psychic, normal or pathological, that defines an individual. No two individuals are exactly alike in all their measurable traits, even genetically identical twins (monozygotic) differ in some respects. The determination of the sex of skeletons represents an important stage in the execution of the forensic anthropological examination [9]. The studies for sex determination are based on the dimorphism between the sexes that is present in the majority of human bones. Computer based methods have become important in forensic science for crime investigation, prosecution and the law. Biometrics is playing a vital role in this area.

II. COMPUTATIONAL FORENSIC

Computational Forensics (CF) is an emerging research domain. It concerns the investigation of forensic problems using computational methods. The primary goal is the discovery and the advancement of forensic knowledge. CF involves modeling, computer simulation, computer-based analysis and recognition in studying and solving forensic problems [9]. Computer forensics (also referred to as digital forensics or forensic information technology) is one specific discipline that could use computational science to study digital evidence.

Computational methods find a place in the forensic sciences in several ways, as for example:

- rigorous quantification of individuality
- definition and establishment of likelihood ratio

In recent years, computational forensic has a rapid growth .In this field; algorithms implemented are from the fields of signal and image processing, computer vision, computer graphics, data visualization, statistical pattern recognition, data mining, machine learning, and robotics.

III. ANTHROPOMETRY

Anthropometry is the study of measurements or proportions of the human body such as dimensions of bones, muscles, and adipose (fat) tissues according to sex, age, etc. for identification purposes.

Cranial Anthropometry also known, as craniometry, is the measurement of the skull and face.3 ways to categorize the skull are

- Dolichocephalic: long and thin
- Brach cephalic: short and broad
- Monocephalic: intermediate length and breadth

Forensic anthropology is the application of the science of physical anthropology and human osteology, the study of the human skeleton [17]. Forensic anthropological techniques can be used to assist in the recovery of assess age, sex and race.

IV. SKULL BIOMETRIC

The skull appears to be the main reliable bone apart from the pelvis exhibility sexually dimorphic features. The human skull also includes 14 facial bones that form the lower front of the skull and provide the framework for most of the face.

V. SEX DETERMINATION

Sex can be determined by studying the size and shape of the skull bones by comparing with already established male and female skull databases. Temporal bone plays a vital role in sex determination. For example, the posterior part of the right and left temporal skull bones is large in males than the males.

The published literature on adult head and face, sexing is diverse, spanning topics related to anthropology and biology, medicine and pathology, and computer and forensic science.

VI. MATERIALS AND METHODS STUDIED

A. *Masato, Yasuhiro, Toshiyuki and Kaoru (1986)*

They were studied the shape of skull from roentgen cephalogram based on line drawing technique. They used cephalogram of 50 male skulls and 50 female skulls to analyse. Eminence of Glabella and Nasal root (Figure 1) were picked up as reference points to analyse. The mean radius of circular arc corresponding to the eminence of glabella and nasal root were calculated. They found that the difference was demonstrated to be significant at both the places ($p<0.01$) with smaller radius in male than in female [7].

Similarly the SD of radii at the eminence of glabella in female is 3 times larger than in males. The difference was especially clear at the eminence of glabella where sex could be determined with an accuracy of more than 90%.

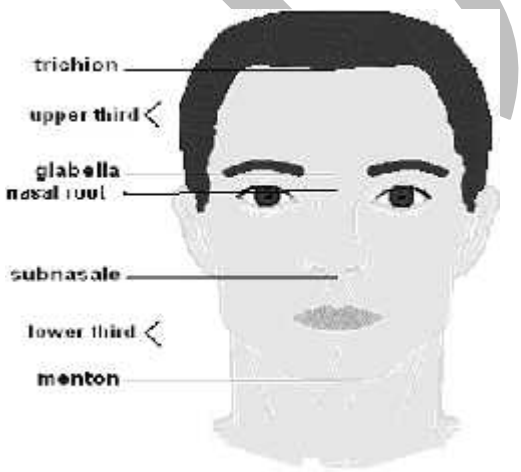

Figure 1 : Human Face

B. *Day and Tschabitscher (1998)*

They analysed 197 skulls and reported that the mastoid triangle area was a complimentary indicator for the sex determination [6].By the use of Discriminant function analysis; they concluded that Mastoid triangle was superior indicator in skull for sex determination.

C. *De Paiva and Sagre (2003)*

De Paiva & Sagre analysed 60 skulls (30 male & 30 female) and they used xerographic copy and they marked three landmark points namely Porion, Asterion and Mastoid ale

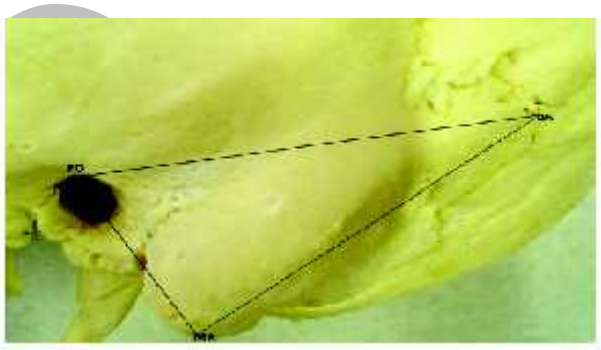

Figure 1: Mastoid Triangle

By using the three points in Figure 2, the demarcated triangle was formed.

Po --- the uppermost lateral point of the external auditory meatus

Ms --- The lowest point Mastoid ale

As --- the meeting point of the lamboid, occipitomastoid and pareitomastoid

The area of demarcated triangle for each side of the skull (Left and right) was determined and the total value of these measures was calculated. This study demonstrated the result in three areas that are left area, right area and total area. They concluded that the total area (left & right) could be used of sexing the human skull better than the isolated left area and right area. This result has given 95% accuracy in both the sexes [16].

D. *S.S.Adebesi (2003)*

Same like Mastoid triangle some other measurements were also used for determining the sex. S.S.Adebesi studied 350plain radiographs in which 185 are male skulls and 165 are female skulls [5]. He measured the following dimensions

- Cranial length &cranial breadth
- Nasal height &Nasal breadth
- Orbital height & Orbital breadth
- Mandibular length & Mandibular breadth
- Facial height.

Figure 2: Lateral view of the human skull

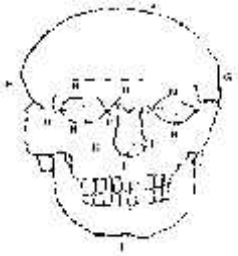

Figure 3: Frontal view of the human skull

Range and mean values were worked out for each parameter in Figure 3 and Figure 4 in both the sexes. T-test ($p<0.05$) was used to compare the values. Indices according to Najjar and McWilliams were calculated [15]. This study became the extended study of Najjar and McWilliams. In this study almost all dimensions recorded higher values in the male skull than in the female skull.

E. Suazo, Zavando & smith (2008)

Based on the study of Pavia &Segre (2003), mastoid triangle and lineal dimensions with Fischer's lineal discriminant functions were analysed. They used 81 human skulls (50 male & 31 female). Among the lineal dimensions, higher values were obtained only in Po-Ma in female groups [7].

In the first work of De Paiva and Sagre, they used 2D plane image by means of Xerographs to measure the dimensions. But Suazo, Zayando & smith used direct measurements by using callipers from the skull. So accuracy in lineal dimensions is more in the later.

VII. EXPERIMENTAL RESULTS

Based on Paiva and Sagre, to evaluate the effectiveness, database of 15 landmark data from 23 skulls (10 Female, 13 Male) were collected from the Department of Forensic science, Trichirapalli, TN. From the database, only three landmarks were chosen to investigate and evaluate the performance of Mastoid triangle.

The chosen landmarks are

- Porion (Po)
- Mastoid ale (Ms)
- Asterion (As

In order to identify statistical measurements, Matlab 2007, was used. According to Paiva & Sagre, three distances Po-Ms, Ms-As and As-Po is calculated. The triangle area is calculated using the formula with the sides of length l, b, and h:

$$\text{Area} = \sqrt{(S\,(S-l)\,(S-b)\,(S-h))} \qquad (1)$$

Where $S = (l + b + h)/2$

Mean and Standard Deviation were calculated for the 23 samples and summary statistics are given in Table 1.

According to Paiva & Sagre, the Total area of left and Right Mastoid Triangle >= 1447mm^2 and <= 1260 mm^2 characteristics male and female sex respectively.

TABLE I. STATISTICAL MEASUREMENTS FROM MALE AND FEMALE SAMPLES

Measurements from Forensic Samples (Right side)	Mean		Standard Deviation	
	Male	Female	Male	Female
Po-Ms	31.2	28.65	3.4	3.1
Ms-As	50.0	47.6	5.0	5.1
As-Po	48.15	45.7	3.6	3.3
Area	718.25	632.7	106.4	107.4

From the laboratory results, Mastoid process triangle approach has significant, positive performance results in both Male samples (93% confidence) and female samples (95 % confidence). The results show that our approach has an encouraging performance.

Also Table 2 summarizes T-test evaluation performance to add strength to the mastoid process

TABLE II. T - TEST: SIDE DIFFERENCES BY MALE AND FEMALE

Measurements from Forensic Samples (Right side)	T-test	
	Male	Female
Po-Ms	0.291	0.693
Ms-As	-0.613	-0.113
As-Po	-0.558	-0.152
Area	-0.111	0.295

Overall performance of this approach has given improvements in performance and useful for further research in the same.

VIII. DISCUSSION

The objective of this study is to demonstrate through practical method that triangle area (based on anthropometric techniques) of Mastoid process is useful in gender identification. From these practical measurements and several literatures reviewed, we can conclude the following

- ✓ Skull is the major biometric to determine the gender

- ✓ Importance of Mastoid process for the purpose of gender identification
- ✓ Mastoid triangle area is significantly more in males than in females
- ✓ The related statistical values to the mastoid process obtained by anthropometric techniques that better demonstrate dimorphism between the genders.
- ✓ Multiple measurements will give effective evolution rather than isolated measurements
- ✓ Accuracy of gender classification obtained from mastoid process is better than previous works
- ✓ Easy to execute, gives fast results and confidence up to 90%

Meets the needs of forensic science department especially in Computational Forensic Science

IX. FUTURE WORK

Based on the success in this practical implementation, in future, we aim to determine the gender from the human skull image (CR X-Ray) for the forensic science applications. In our research work, four main areas need to be analyzed to reach the final goal. Firstly, the image needs to be enhanced to get a better visual quality for further work. Secondly, from the enhanced image, feature extraction needs to be done. Thirdly, identifying landmark locations from the extracted features of skull image needs to be achieved. By using the hybrid method of Mastoid Process, gender identification is the final goal of our research work

X. CONCLUSION

In this paper, the impact of Mastoid Process Triangle approach for sex determination is analyzed and discussed. Among various techniques, which were developed for sex determination, Mastoid process shows effective results. With my experimental results I conclude that mastoid process will give improvements in performance. Therefore, In future, Digitalization of 3D- skull and creating the database for different orientations like scaling, rotating could be done to achieve greater results in sex determination.

The objective of this study was to demonstrate the different methodologies through a complete readily available literature review. Therefore, compared with the most important historical studies dealing with sex determination of skulls, the present literature review shows that mastoid process with lineal dimensions is an improved method. This paper (1) provided an up-to-date summary of examples from the literature on sex determination with a discussion detailing particular methods, and (2) obviated the benefits of an interdisciplinary approach to literature reviews; specifically in sex determination is meaningful to computer science research and forensic science applications.

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