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# Gender Detection from the Human Skull on the Basis of Frontal Bone

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**Abstract** - The need of determining gender of a human turn up regularly in the field of forensics. Due to the huge technological advancements in forensics as well as healthcare determining the gender is easy with X-Rays, Computed Tomography (CT) scan, Magnetic Resonance Imaging (MRI) etc. However conclusions are drawn based upon the prediction made by doctors manually. However a second opinion from a computerized system will be advantageous. Determination of gender can be concluded based upon many factors like shape of the forehead, wrist bone, shape of chin etc. However, determination based upon the shape of the frontal bone has been used in forensics from a long time. The major challenge is to effectively excerpt, evaluate and understand the information from the image by using proper techniques and then interpreting the results by making effective use of the various image processing tools.

**Index Terms** -Forehead, Frontal bone, Image processing.



## 1 Introduction

One of the major applications of computers is to use them in the field of medical image processing as well as forensics for quantitative analysis of medical images like x-rays, MRI, and C.T. Scan etc. It is a known fact that medical images are ocular in constitution. As these images are perceived manually to detect the problems there are usually some loopholes associated which may be related to limited knowledge or experience, distraction, frustration etc of the observer and may lead to many problems. Here if computer is used as an active element in detecting the related issues then it will surely be a perk on the interpretation of the observer and thus improve the diagnostic veracity of even an experienced observer. In forensics determining the various factors such as the age and gender determination are encountered almost on a daily basis. Forensic anthropologists are skilled in examining skulls and deriving conclusions based on it. But when an anthropologist has a skull the first step when starting from scratch is to determine the gender. Based upon experience depending on certain factors such as the shape of the forehead , wrist bone ,shape of chin, pelvic outlet certain conclusions can be reached .However the most commonplace method used is to look at the shape of the frontal bone and then trying to reach conclusion if it may be a male or female before moving forward.As mentioned by by Natalie R. Shirley in Forensic Anthropology: An Introduction There are two parts of the skull namely

1. The neurocranium (the case of the braina fea)
2. The splanchnocranium (face)

The frontal bone is a curved arc that is more protuberant in males than in women. The parietal bones form the top and sides of the skull structure.The occipital bone form the base and back of the skull structure. Temporal bones form the sides of the cranium. However when an image is entered into the system for processing the preeminent point in question is to first analyze if the entered image is definitely a skull and not any other curved image like say an orange or egg before detecting the frontal bone. The further processing of the Image will be performed only if there is a probability that the image is a human skull. After determining that there is a probability that the image is a human skull the next step is to detect the frontal bone fragment from the image. If the frontal bone is more gracile and less sloped then the probability is high that the skull may be of a female. On the contrary if the frontal bone is sloped then it may be of a male.

## 2 Motivation

The gender identification from the skeleton is useful in many domains such as criminal investigation, archaeologi-

cal discovery. When a skeleton is found, the pathologist and the forensic anthropologist are the one who are responsible for determining whether the skeleton is of the male or female. For determining the gender the skeleton must be of adult because it is difficult to determine the gender of a child. Currently the sex determination is done by the experts considering the number of features of the skeleton of the human body. But still as it done manually it needs an experience specialist to determine the sex. Moreover the manual examination cannot be 100% accurate so an automated system or tool is needed which can help in determining the gender. The gender can be determined based on the different feature of the human skeleton but the most commonly used with a high accuracy rate is the method in which the curve of the frontal bone helps in determining the sex. In male the forehead is slightly sloping whereas in case of female it is more of a vertical. Thus if we can classify the range for the slope for male and female, we would be able to identify whether the skull is of male or female.

## 3 Statement of the Problem

### 3.1 Scope

This Gender detection paper focuses on detecting the gender by analysing the skull of the human body. It identifies whether the given object is human skull or not (given only right side view of the skull). It identifies the gender based on the shape of the frontal bone so the image must have a clear view of the frontal bone. It can be used as a tool by the anthropologist and pathologist for helping them in determining the gender of the skeleton. Thus its application lies in criminal investigation and archaeology for increasing the accuracy of the specialist and speeding up the process of gender detection.

Block Diagram

The basic block diagram of the proposed system consists of following components:

1. Input File: It is the input to the proposed system. The input file is the image of the skull whose gender is to be determined. There are certain constraints that the input image must satisfy before giving input to the systm. These constraints would be discussed in the implementation section.

2. Human Skull Determination: This module accepts the input file and checks whether the given image is of the human skull as determined by the system requirements. The image is said to contain the human skull only when the human skull in the image satisfy the prerequisite set by the system.

3. Gender Determination: The gender determination module analyses the skull and determine whether the skull is of male or female using the slope of the frontal bone of the skull. This module is sub dived to sub modules which performs various actions such as cropping frontal bone, Average Calculation, ThresholdComparision,etc

4. Output: The output states whether the given image contains the skull of male or female or is invalid image. The output may be given to other systems as an aid for determining the gender of the skull. This tool can be combine with multiple gender detection tools to get the results with highest accuracy.

## 4 Edge Detection

Edge detection means discovering the abrupt changes in pixels of an image and thus determining the boundries of the image. The boundries of an image are defined by edges and so if the edges are detected then the unrelated information is eliminated and so we can easily focus on the important properties of the image to get essential information .there are many edge detection techniques that are available that may be used to detect edges based upon the needs. Canny or sobel edge detector may be used to detect the edge of the human skull. A. Sobel Edge Detector can be used to determine the edges of the human skull. The sobel operator consists of a pair of 33 convolution kernels. One kernel is simply the other rotated by 90. One mask estimates the gradient in horizontal direction and the other on y direction. This mask is then run over the image. The approximate magnitude is given by : |G| = |Gx|+|Gy| B.Canny Edge Detector The Canny edge detector is considered as an ideal edge detector.The different steps followed by canny edge detector to detect edges are: 1) Smoothing of image using a Gaussian filter 2) Compute the magnitude of the gradient as well as orientation 3) Apply non maxima suppression to the magnitude of gradient and then using double thresholding algorithm to detect and link edges. 4) Finally, if the pixel gradient is between the two thresholds, only then the pixel that is connected above the upper threshold is marked as an edge. Otherwise the pixel will be eliminated.

Reasons to choose sobel operator

The fundamental advantage of using sobel operator is its simplicity. The sobel method provides an approximation of the magnitude of the gradient as well as detects not only the edges but also the orientation of the edges in the image. However the sobel operator is sensitive to noise. As the level of noise in image increases the performance of sobel operator degrades. By using the Gaussian filter in canny edge detector

The noise inimage can be easily eliminated and also the edges can be detected in spite of noise due to thresholding .However the canny edge detector is complex and so it is

time consuming. So we preferred sobel edge detector.

## 5 Mahematical Background

For the feature extraction and in the process of human skull detection as well as gender detection, We just need to know single formula of the straight line. As the slope between two points has been considered for the computation, We will look into that particular formula in this section. Suppose A(X1,Y1) and B(X2,Y2) are two points and we need to find out the slope between these two points. Let S be the slope between these two points which can be calculated by using formula given below:

$$S = Y2 - Y1/X2 - X1$$

Lets take an example, A (1,-4) and B(-4,2) are two points and we need to find slope between these two points assuming straight line between them.

So here X1 = 1, X2 = −4 and Y1 = −4, Y2 = 2. So by using slope formula:

$$S = 2-(-4)/-4-1$$
$$S = 2 + 4/-4-1$$
$$S = 6/-5$$
$$S = -1.2$$

## 6 Assumptions

There are a few assumptions that are considered when the image is to be processed. It is required that the background of the image is plain and clear in texture. There is nothing written at the background or decorated background as such. This is because the sobel operator will also detect the edges of the background which may lead to erroneous results. The image must contain a single object only. The system cannot recognize and process multiple objects in a single image. The current system design is such that the nose of the human skull should be pointing at right direction in the image and also the color of the skull must be distinguished from the background clearly. As in an ordinary human skull the height and width of the skull must be one third or more of the height and width of the entire length of the skull. The image must contain only the skull and the portion beyond the skull should not be present though a minimal portion may be accepted by the system.

## 7 Human Skull Detection

In this section, the process of detecting the human skull is explained. First task in this process is to extract five pixels or points from the image for the further computation. Let the pixels in the rows of the image be denoted by xi where values of i belongs to the set 1,2,3,...,n and the columns be denoted by yj where values of j belongs to the set 1,2,3, . . . , n . Let the first point on the edge detected on the image be denoted by P(xi,yj), such that yj will be the minimum

for a particular point when image is traversed through xn/3 to (xn − xn/3) and y1 to yn/3. Now the second point Q(xi,yj) will be on the outer edge, such that the value of xi will be minimum and ranges from x1 to xn/3 and yn/3 to (yn − yn/3). The third and fourth point will be on the right side of the image such that yj will be maximum for the third point R(xi,yj) when the image is traversed from yn to (yn−yn/3) in the decreasing order and from x-coordinate of point Q(xi,yj) to (xnxn/3). For the fourth point S(xi,yj), yj will be such that yj < y-coordinate value of point R(xi,yj) and greater than any other boundary point in the image while traversing from R(xi(+30),yj) to (xnxn/6) and yn to (ynyn/3). The fifth point T(xi,yj) will be obtained such that the value of xi will be maximum through x-coodinate of point S(xi,yj) to (xnxn/6) and y-coordinate of point R(xi,yj) to (y-coodinate of Q(xi,yj)+(y-coordinate of R(xi,yj) y-coordinate of Q(xi,yj))).

FIG. 1. P(XI,YJ)

FIG. 3. P(XI,YJ)

FIG. 2. Q(XI,YJ)

FIG. 4. Q(XI,YJ)

The basic idea of the point's extraction from the image is also shown in table I. After extracting five points from the image, We will compute the slopes between those five points as given below in table II. The average slope value is calculated from five slope values we get using two-point formulas discussed in section III. If we don't get five points on the particular image, then that image is directly considered as invalid or not human skull. In case, we get the five points then as per the average slope value of the image, We consider it as valid or invalid.

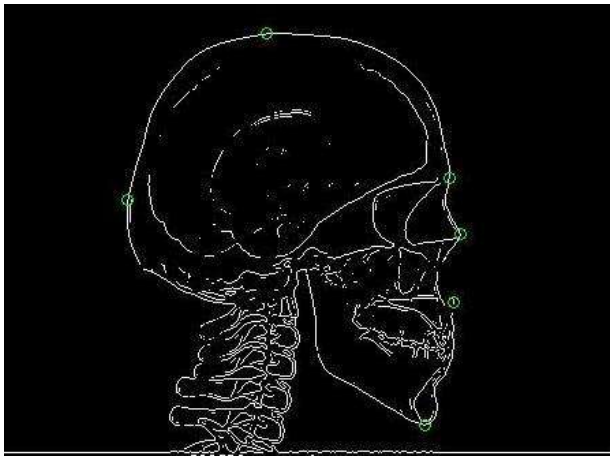
## 8 Gender Detection

As per section V, five points are extracted from the image. Few points among them are used in the next phase of Gender Detection. In this process, Frontal bone of the human skull is extracted from the image as shown in figure. For that purpose, point Q and point R are selected and a cut is made in rectangular shape considering those two points as the diagonal end points of the rectangle. Thus the frontal bone part of the image is obtained. The next task is to find the slope of frontal bone to determine whether its of a male or female. So five equidistance points are selected on the curve. The slopes between these five points are computed using Two-Point Formula as mentioned in section III. Average slope is taken into consideration for the gender determination.

## 9 Performance and Results

Implementation is done in matlab making use of its huge functionality. Sample results in both the important phases of the system are described with the help of screenshots of the output.

The five points extracted during the phase of human skull detection are shown. We can take few sample images as an input considering some valid and invalid input to the system. This system detects human skull correctly more than average. In statistical words, this system is 90% accurate in case of detecting human skull. We can also include some invalid input images like watermelon, skull of the monkey, balls, eggs and so on.



Extracted Five points during human skull detection phase

| Point | Condition | Image Traversal | | | |
|---|---|---|---|---|---|
| | | Rowwise | | Columnwise | |
| | | From | To | From | To |
| P ($X_i$; $Y_j$) | Min($Y_j$) | $X_n$=3 | Xn<br>$X_n$=3 | $Y_j$ | $Y_n$=3 |
| Q($X_i$; $Y_j$) | Min($X_i$) | $X_i$ | $X_n$=3 | $Y_n$=3 | $Y_n$<br>$Y_n$=3 |
| R($X_i$; $Y_j$) | Max($Y_j$) | Q($X_i$) | $X_n$<br>$X_n$=3 | $Y_n$ | $Y_n$<br>$Y_n$=3 |
| S($X_i$; $Y_j$) | Max($Y_j$) and < R($Y_j$) | R($X_i$ + 30) | Xn<br>$X_n$=6 | Yn | Yn<br>$Y_n$=3 |
| T ($X_i$; $Y_j$) | Max($X_i$) | S($X_i$) | Xn<br>$X_n$=6 | R($Y_j$) | Q($Y_j$) + (R($Y_j$) Q($Y_j$)) |

## 10 Conclusion

In this paper a system for the gender detection using image processing is presented. Based on the human skeletal remains different conclusions about age , gender etc. can be drawn from the skull, pelvis, wrist, chin bone etc. However this system uses the frontal bone for gender recognition because it is the first step used by the forensics department for making predictions till date. By using the image of the human skull which can be sought through X-ray , CT scan or MRI prediction of gender can be made by making several operations on the image which have been mentioned in the paper. The use of this system serves as a form

of second opinion to the medical practitioner and thus is an approach by which more precision may be acquired.

The determination of the gender can be done using the system however to get more accurate results other parameters such as the chin bone, pelvis and more can be considered along with the frontal bone. By improving the system deformities can be also detected such as the thin line fractures using edge detection techniques.

## 11 Future Work

The last few years several authors reported successful gender recognition methods that produce performances comparable with the abilities of humans in the gender detection task. However, one of the main reasons that dictate the need for developing automatic gender detection systems is the failure of humans to perform the gender detection task precisely thus in the future it is necessary to develop systems that convincingly outperform the gender detection performance achieved by humans. Ideally gender detection should operate on unconstrained skull images in order to support the use of this technology in real life applications. For example gender detection based on skull images captured by surveillance cameras or based on images captured by low resolution web cameras or an X-ray need to be investigated. Such scenarios support the application of non-invasive gender detection for access control. So far experimentation in facial gender detection was limited to static images. The possibility of using temporal features for gender detection is an area for possible future research. This approach falls in the general area of behavioral bio metrics where human actions are used for identity verification tasks. A key issue pertaining to the future development of facial gender detection using skull images is the availability of suitable publicly available datasets. Future research efforts in gender detection should include efforts for generating suitable datasets to support both the training and comparative evaluation of different gender detection approaches reported in the literature. The determination of the gender can be done using the system however to get more accurate results other parameters such as the chin bone, pelvis and more can be considered along with the frontal bone. By improving the system deformities can be also detected such as the thin line fractures using edge detection techniques.

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