

Theta Graphs Based 3D Facial Reconstruction for Forensic Identification and Face Detection

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Abstract

Powerful techniques for modeling and rendering three dimensional organic shapes, like human face, body are today available for applications in many fields such as special effects, ergonomic simulation or medical visualization, just to name a few. These techniques, combined with theta graph and Content Based Image Retrieval, are proving to be very useful also to archaeologists and anthropologists committed to reconstruct. This paper presents an integrations with theta graph and facial reconstruction is proposed to reconstruct face even from the skull which can be used for both forensic and recognition. A generalized theta graph is proposed for n internal disjoint paths for human face, in which each path contains m vertices and path end vertices are merged with the vertices v_1 and v_2 respectively. This graph is denoted as $\theta(nP_m)$. It is proved $\theta(nP_m)$ is graceful for $m = 2j + 1$ and $j = 1, 2, \dots, n$.

Keywords: Facial reconstruction, Forensic, graceful labeling, theta graph.

Mathematics Subject Classification (2000) MSC 05C78

1 Introduction

In the last years computer generated imaging has been often used for forensic reconstruction [3], as an aid for the identification of faces, as well as for medical visualization [4,5]. In fact, 3D modeling, rendering and animation environments today available have greatly increased their power to quickly and effectively produce realistic images of humans [7]. Nevertheless the typical approach usually adopted for modeling a face is often still too much artistic and it mainly relies on the anatomic and physiognomic knowledge of the modeler.

Graphs considered in this paper are simple, finite and indirect. In general $G(V, E)$ denotes the graph G with vertex set $V(G)$ and edge set $E(G)$, such that $|V(G)| = p$, $|E(G)| = q$. If ϕ is an injection from the vertices of G to the set $\{0, 1, \dots, q\}$ such that, when each edge xy is assigned by the label $|\phi(x) - \phi(y)|$, the resulting edge labels are distinct. The concept of graceful labeling was introduced Rosa [1] with the name β -valuation. Gallian [2] given the extensive survey of contributions to graceful labeling of variety of graphs.

Definition: A theta graph consists of a pair of vertices u, v with three internally disjoint paths joining u to v . A generalized theta graph consisting of n internal disjoint paths, in

which each path contains m vertices and path end vertices are merged with the vertices v_1 and v_2 respectively. The internal vertices of the i^{th} path denoted by $(\varphi(c_i^1), \varphi(c_i^2), \dots, \varphi(c_i^{m-2}))$, $1 \leq i \leq n$. This graph denoted as $\theta(nP_m)$, $m = 2j + 1$ and $j = 1, 2, \dots, n$. For $j = 1, 2$ $n \geq 2$ and for $j = 3, 4, \dots, n$ the number of paths must be odd.

2 Methodology

In general the forensic skull reconstruction and image based face recognition has a simple basic difference that uses skull to reconstruct and skull with skin uses the face recognition, but the theta graph based rendering has a vital advantage on both the area. In identification of face using skull they uses various points like LEyebrowMid, LEyebrowEnd, NoseBridge, NoseTip, LNoetriBulge, LEar, LEyeidUpper, LEyelidLower, LipUpper, LLipUpperBend, LMouthCorner, LLipLowerBend, LipLower, Chin, LJawEnd, etc., were used and L denotes Left side of the face and right side of the face has the same parameter used for forensic identification, but the face recognition has feature and these were extracted and then it has been recognized.

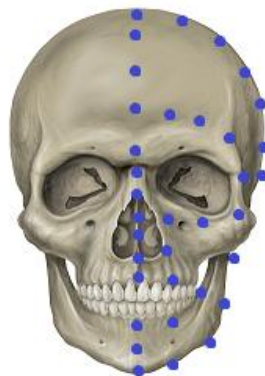


Fig. 1 Skull applied with theta graph for forensic reconstruction.

Difference between male and female skull is major issue in both forensic and face recognition system. Male skull should be heavier, larger, thicker and forehead is slightly receding when compared with female skull. Here male skull is considered for Fig.1 and the points were applied.

The nose is built up of the nasal bones and cartilage. There are different suggestions on how to predict the shape of the nose of a person. [7] involves calculation of the shape of the nose based on the angle of the nasal bone. This gives a hint of the shape of the nose, but the amount and shape of cartilage is still very hard to predict by just considering these facts. Different studies performed on the correlation between the nasal bone structure and the actual nose show different results. In addition to this the nose changes its shape with time which makes the reconstruction of the nose based on the skull very hard. We have taken the input image of Fig 3 a-c and by determining the depth map using stereoscopic image construction, the 3D wireframe outputs for sample image 1 with front wireframe. Left side and right side wireframe are given in following fig respectively.

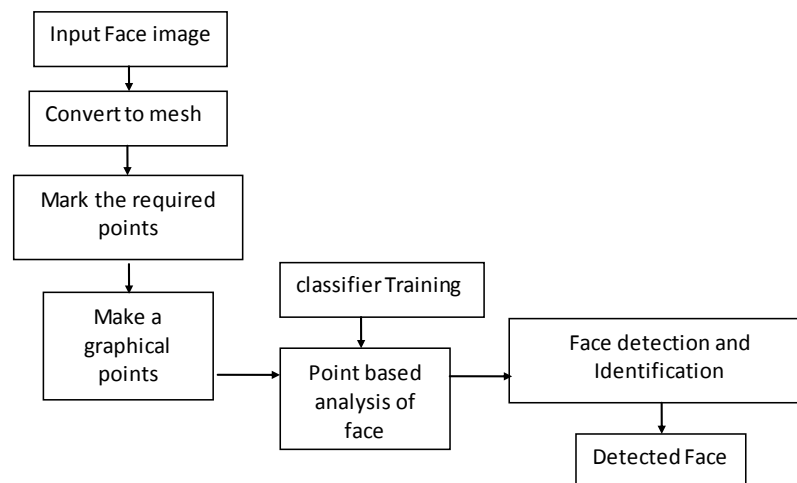


Fig. 2 Flow of the proposed algorithm

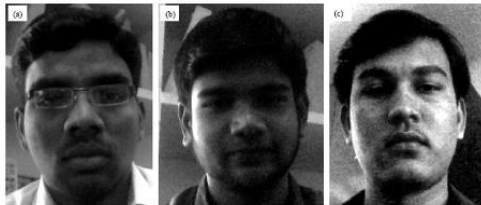


Fig. 3 Normal face is collected

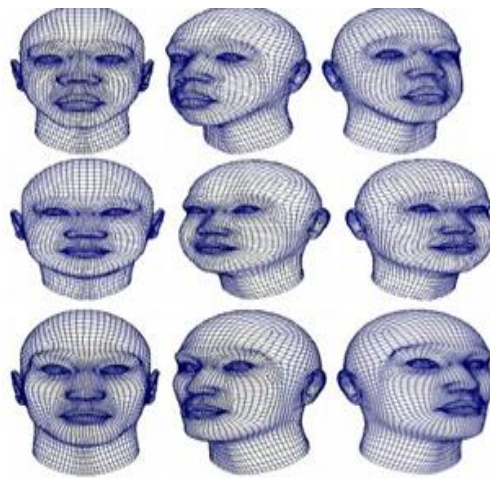


Fig. 4 Mesh applied on face

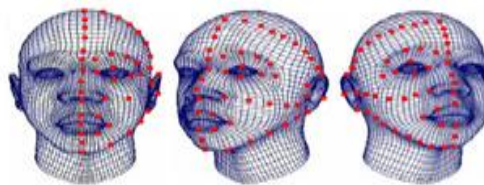


Fig. 5 General form of theta graph

Many invasive techniques are available for face detection and recognition. After the development of technology for image and video processing, better algorithms and image processing tools paved the way for non-invasive techniques. Even then unmasked face, permanent markers on skull, materials embedded in face / skull are used for recognizing skull

based on face. Our technique gives a robust result without employing any of the above invasive methods. Graph theory (theta) based detection of face from skull is being analyzed. Our method uses just web cam with optimum illumination to detect the face from skull like broken, partial skull, etc. Our approach is to have a reliable, faster recognition system for real time applications.



Fig.6 Non Oscillating images



Fig.7 Skull



Fig.8 Disparity images

3 Mathematical approach for the algorithm

3.1 The Generalized theta graph is graceful for skull analysis

Theorem: $\theta(nP_m)$, $m = 2j + 1$ and $j = 1, 2, \dots, n \geq 2$ is graceful.

Proof: The general form of theta graph is shown in the following Figure 6.

The labeling of vertices are as follows:-

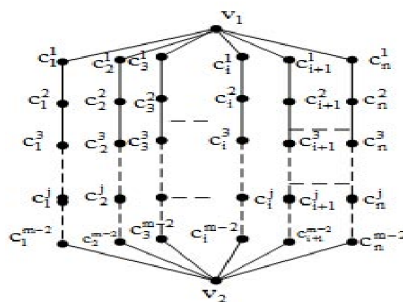
$$R(1): \varphi(v_1) = q, \varphi(v_2) = \frac{q}{2}.$$

$$R(2): \varphi(c_1^1) = 0, \varphi(c_i^1) = i - 1, 2 \leq i \leq n.$$

$$R(3): \varphi(c_n^2) = q - 1, \varphi(c_{n-j}^2) = \varphi(c_{n+1-j}^2) - 2, 1 \leq j \leq n - 1.$$

$$R(4): \varphi(c_1^{2j+1}) = nj, 1 \leq j \leq \frac{m-3}{2}.$$

$$R(5): \varphi(c_i^{2j+1}) = \varphi(c_{i-1}^{2j+1}) + 1, 2 \leq i \leq n, 1 \leq j \leq \frac{m-3}{2}.$$



$$R(6): \varphi(c_n^{2j+2}) = q - 1 - nj, 1 \leq j \leq \frac{m-5}{2}.$$

$$R(7): \varphi(c_{n-i}^{2j+2}) = \varphi(c_{n+1-i}^{2j+2}) - 2, 2 \leq i \leq n-1, 1 \leq j \leq \frac{m-5}{2}.$$

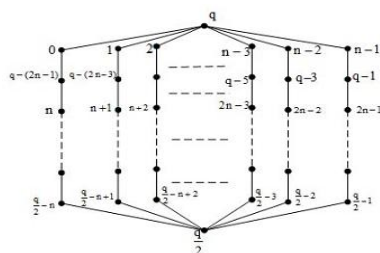


Fig. 5 Graceful labeling of theta graph

Now, the induced edge labeling of theta graph are as follows:-

- R (1): $\varphi(v_1 c_i^1) = q + 1 - i, 1 \leq i \leq n$. R (2): $\varphi(c_{n+1-i}^j c_{n+1-i}^{j+1}) = q + 1 - j n - i, 1 \leq i \leq n, 1 \leq j \leq m - 3$. R (3): $\varphi(v_2 c_i^{m-2}) = q + 1 - (m - 2) n - i, 1 \leq i \leq n$.

3.2 Conclusion

The above procedure results $\theta(nP_m)$, $m = 2j + 1$ and $j = 1, 2, \dots, n \geq 2$ is graceful. Using this planer graph, the face drawn as a theta graph with longitude lines as paths, in which latitude lines are vertices. By above generalized procedure, it has been proved that

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