BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LIX (LXIII), Fasc. 2, 2013
Secția
CONSTRUCȚII DE MAŞINI

CAD – TECHNIQUES USED IN OPTIMIZATION OF FACIAL RECONSTRUCTION

BY

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Received: September 2, 2013
Accepted for publication: September 19, 2013

Abstract. Facial reconstruction term is developed in two directions: forensic and surgery. The aim of forensic facial reconstruction is to create the appearance of the individual at the time of his/her death. Reconstructive surgery is performed on abnormal structures of the face, head, and neck, caused by birth defects, developmental abnormalities, trauma or injury, infection, tumours, or disease. It is generally performed to improve function and quality of life for a patient, but may also be done to approximate a normal appearance. In this paper it is presented a new method to obtain a 3 – dimensional model used in reconstructive surgery which is used to optimize the surgery process by minimizing the costs and maximizing the benefits. This method considers general purpose CAD software.

Key words: modelling, optimization, reconstructive surgery.

1. Introduction

Three-dimensional (3D) cranio-facial reconstruction can be useful in the identification of an unknown body (Verze, 2009). The progress in computer science and the improvement of medical imaging technologies during recent years had significant repercussions on this domain. New facial soft tissue depth

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data for children and adults have been obtained using ultrasound, CT-scans and radiographies. New guidelines for facial feature properties such as nose projection, eye protrusion or mouth width, have been suggested, but also older theories and "rules of thumbs" have been critically evaluated based on digital technology. New fast, flexible and objective 3D reconstruction computer programs are in full development (De Greef & Willems, 2005).

Facial reconstruction term is developed in two directions: forensic and surgery. The aim of forensic facial reconstruction is to create the appearance of the individual at the time of his/her death (Vanezis *et al.,* 2000). Reconstructive surgery is performed on abnormal structures of the face, head, and neck, caused by birth defects, developmental abnormalities, trauma or injury (Chukwudi *et al.,* 2013),, infection, tumours, or disease. It is generally performed to improve function and quality of life for a patient, but may also be done to approximate a normal appearance (Widanagamaachchi & Dharmaratne, 2008).

There are several types of reconstruction (Helmer *et al.*, 1993):

− *Two-dimensional facial reconstructions* are based on ante mortem photographs, and the skull. Occasionally skull radiographs are used but this is not ideal since many cranial structures are not visible or at the correct scale. This method usually requires the collaboration of an artist and a forensic anthropologist. A commonly used method of 2D facial reconstruction was pioneered by Karen T. Taylor of Austin, Texas during the 1980. Taylor's method involves adhering tissue depth markers on an unidentified skull at various anthropological landmarks, then photographing the skull. Life-size or one-to-one frontal and lateral photographic prints are then used as a foundation for facial drawings done on transparent vellum. Recently developed, the F.A.C.E. and C.A.R.E.S. computer software programs quickly produce two-dimensional facial approximations that can be edited and manipulated with relative ease. These programs may help speed the reconstruction process and allow subtle variations to be applied to the drawing, though they may produce more generic images than hand-drawn artwork.

− *Three-dimensional facial reconstructions* are either: 1) sculptures (made from casts of cranial remains) created with modeling clay and other materials or 2) high-resolution, three-dimensional computer images. Like two-dimensional reconstructions, three-dimensional reconstructions usually require both an artist and a forensic anthropologist. Computer programs create three-dimensional reconstructions by manipulating scanned photographs of the unidentified cranial remains, stock photographs of facial features, and other available reconstructions. These computer approximations are usually most effective in victim identification because they do not appear too artificial (Cavanagh & Steyn, 2011).

− *Superimposition* is a technique that is sometimes included among the methods of forensic facial reconstruction. It is not always included as a technique because investigators must already have some kind of knowledge

about the identity of the skeletal remains with which they are dealing (as opposed to 2D and 3D reconstructions, when the identity of the skeletal remains is generally completely unknown) (Choi *et al.*, 2010). Forensic superimpositions are created by superimposing a photograph of an individual suspected of belonging to the unidentified skeletal remains over an X-ray of the unidentified skull. If the skull and the photograph are of the same individual, then the anatomical features of the face should align accurately.

According to the technical literature, there are several problems with facial reconstruction, namely (Rhine, 1998):

− *Insufficient tissue thickness data* - there are multiple outstanding problems associated with forensic facial reconstruction. The most pressing issue relates to the data used to average facial tissue thickness. The data available to forensic artists are still very limited in ranges of ages, sexes, and body builds. This disparity greatly affects the accuracy of reconstructions. Until this data is expanded, the likelihood of producing the most accurate reconstruction possible is largely limited.

− *Lack of methodological standardization* - a second problem is the lack of a methodological standardization in approximating facial features. A single, official method for reconstructing the face has yet to be recognized. This also presents major setback in facial approximation because facial features like the eyes and nose and individuating characteristics like hairstyle - the features most likely to be recalled by witnesses - lack a standard way of being reconstructed. Recent research on computer-assisted methods, which take advantage of digital image processing, pattern recognition, promises to overcome current limitations in facial reconstruction and linkage.

− *Subjectivity* - reconstructions only reveal the type of face a person may have exhibited because of artistic subjectivity. The position and general shape of the main facial features are mostly accurate because they are greatly determined by the skull.

− *Costs* - 3D facial reconstruction images needs special software which is expensive a need time to acquire and process data.

Having in view the above mention problems one develop a new methodology of obtaining 3-dimensional models based on a computer tomography images and the use of common CAD software thus minimizing the costs of the process. The models will be further process using rapid prototyping systems. The information will be use in surgery process knowing exactly the amount and the shape of flash that must be extract from the patient. In the following one presents the methodology.

2. Material and Used Method

In the following one present the methodology that one develop in order to use common CAD-type software such as AutoCAD, Mechanical Desktop by

Autodesk and DELCAM. The usage of such software leads to a minimum cost of obtaining a 3D model. In order to present the methodology one considers the computer tomography of a male age 66. The model is based computer tomography images (Fig. 1). The *.bmp saved image is then open in a CAD software and the shape of the section is formatted with the help of the B-spline curves (Fig.2).

Fig. 1 − Computer tomography image, section 104.

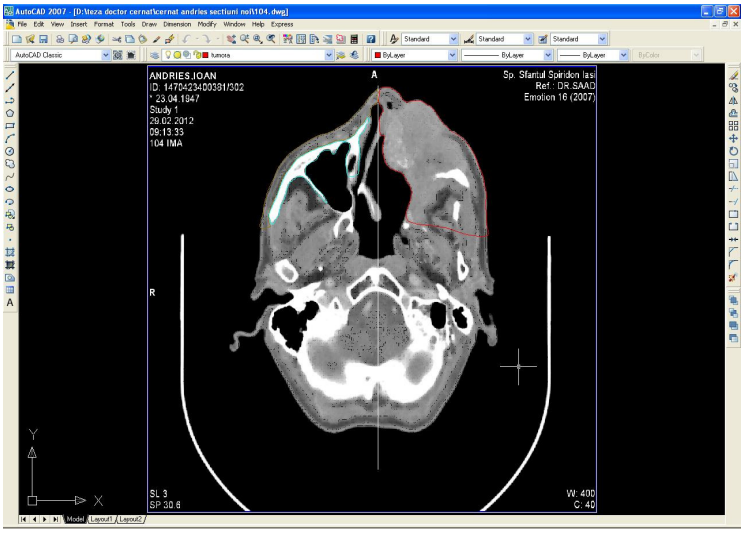

Fig. 2 − The *.bmp type image prepared in CAD software.

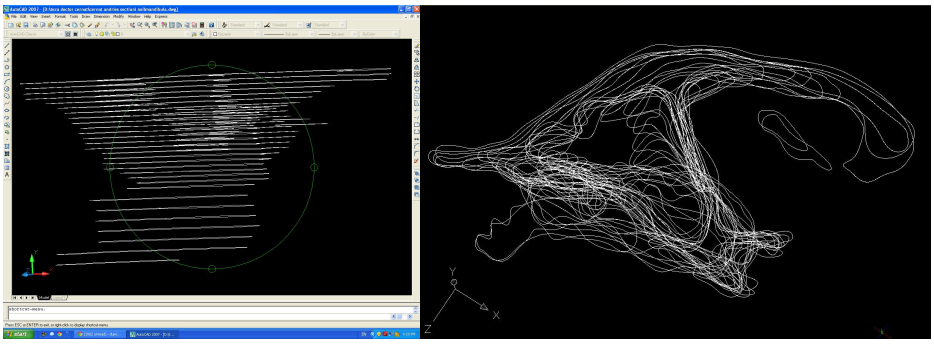

Fig. 3 − The 3-dimensional shape of the model of mandible
based on the merge sections.

The images obtain from computer tomography is processed one by one and the resulting shapes are merge into one 3-dimensional shape of the considered part of the body (Figs. 3 and 4). The merging operation is carried out in Mechanical Desktop software.

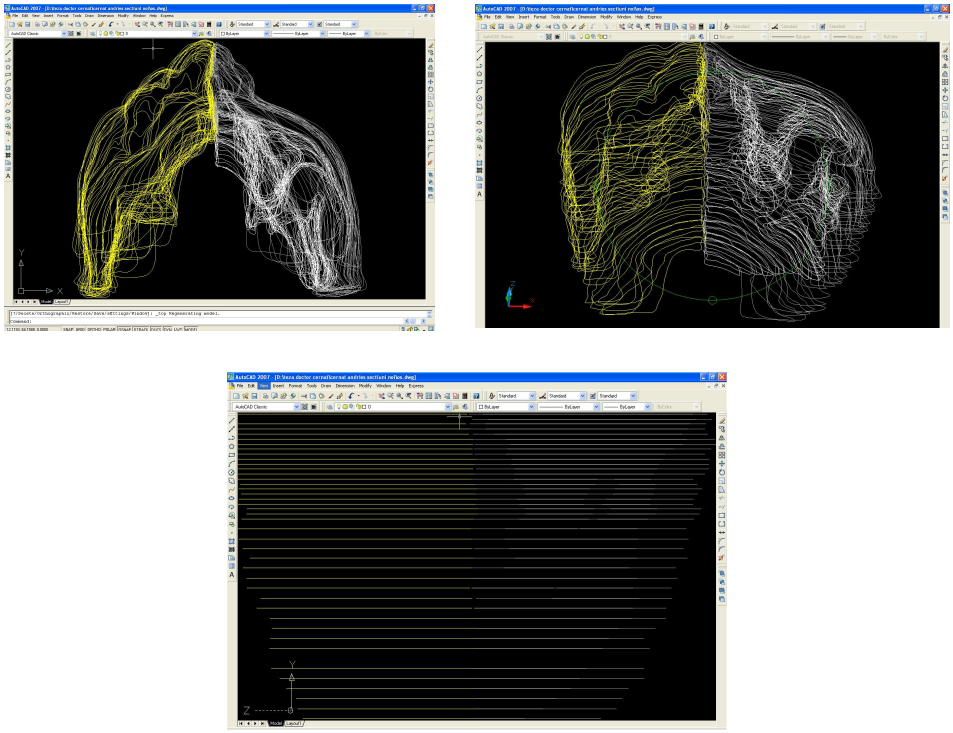

Fig. 4 − The 3-dimensional shape of the model based on the merge sections.

The next step in creating the 3-dimensional model needed in facial reconstruction is to give a volume to the shape obtained from computer tomography. This is obtain in CAD software with the help of "loft" command Fig. 5.

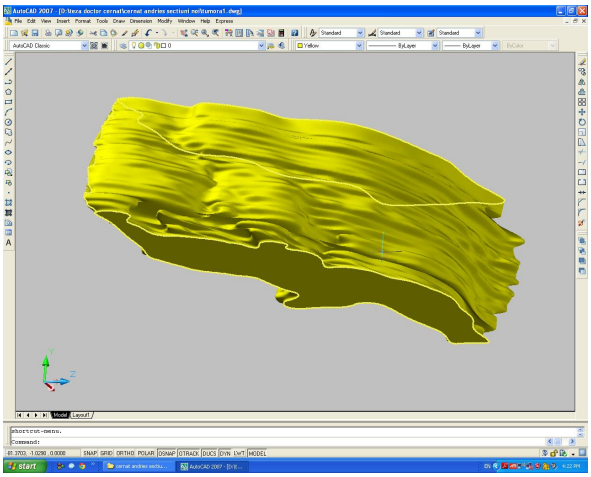

Fig. 5 − The volumetric shape of a section from computer tomography.

In order to obtain the necessary information for printing using rapid prototype process one transfer the in other format of the file with the help of DELCAM software.

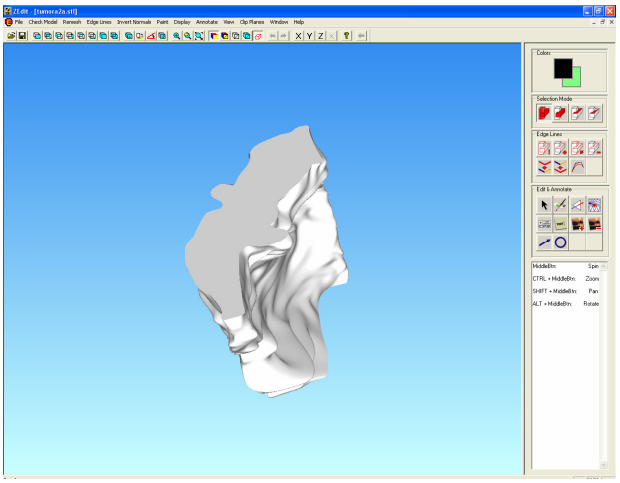

Fig. 6 − 3-dimensional model transferred in DELCAM software.

The last step is to process the information obtaining the hole data as in Fig. 7.

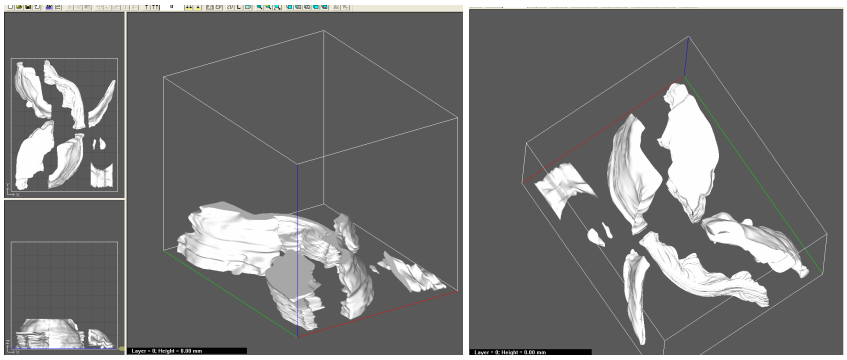

Fig. 7 − 3-dimensional models prepared for rapid prototyping.

The 3-dimensional model is materialize using a 3-D printer through a process called rapid prototyping (Fig. 8).

Fig. 8 − 3-dimensional printer.

3. Results and Discussions

The rapid prototype product is presented in Fig. 9. Based on the data obtained from rapid prototype models one can determine the shape and dimensions of the tumour that is extracted through the surgery operations. Also one can determine the exact size of the flash that must be extracting from the patient thus reducing the time of surgery operation and maximizing the benefits.

Fig. 9 − A rapid prototype obtained model.

4. Conclusions

1. One creates an new methodology which optimize the costs of obtaining 3-dimensional models by using common CAD software.

2. One can create through rapid prototyping process detailed models which give vital information needed in facial reconstruction surgery.

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TEHNICI CAD UTILIZATE ÎN OPTIMIZAREA RECONSTRUCȚIILOR FACIALE

(Rezumat)

Reconstrucția facială a fost dezovltată pe două direcții: criminalistică şi chirurgie. Scopul reconstrucției faciale în domeniul criminalistic este de a crea o înfățișare a unei persoane după moartea acesteia. Chirurgia reconstructivă se realizează

pentru îndepărtarea unor structuri anormale de pe față, gât sau cap cauzate de defecte de naştere, traume, infecții, tumori sau boli. Ea este în general realizată pentru a îmbunătăți funcțiile sau calitatea vieții pacientului dar poate fi realizată şi pentru a asigura o expresie facială aproximativ normală. În lucrare se prezintă o metodă proprie de obținere a unui model tridimensional utilizat în chirurgia reconstructivă care asigură optimizarea acestui proces atât prin minimizarea costurilor cât şi prim maximizarea beneficiilor. Metoda utilizează software de tip CAD.