Geometry acquisition of a car occupant anatomy

SERRE T., BASILE F., BEHR M., DURAND F., BIDAL S., BRUNET C.

INRETS-LBA (Laboratory of Applied Biomechanics)
Director : Pr. J. BONNOIT
Faculté de Médecine, Boulevard P. Dramard
13916 Marseille Cedex 20, France

INTRODUCTION

The aim of this research was an anatomic study of the seated position in order to reply, in particular, to various questions raised in industry as how to predict the threshold of the main injuries that can be encountered in car accidents. It shall also produce a basis for further injury mechanism models. This methodology is based on obtaining reference serial sections from an entire subject frozen in the driving position, as well as on computerised three-dimensional visualisation allowing the validation of the anatomic analysis. The Laboratory of Applied Biomechanics was working on this subject for many years[(1)(2)] and this technology was used in the framework of the HUMOS (Human Model for Safety) European project.

METHODOLOGY

The data acquisition process can be divided into three main stages, ie the anatomical subject selection and slicing, the anatomic acquisition (organs identification on the slices) and a final stage of three-dimension reconstruction.

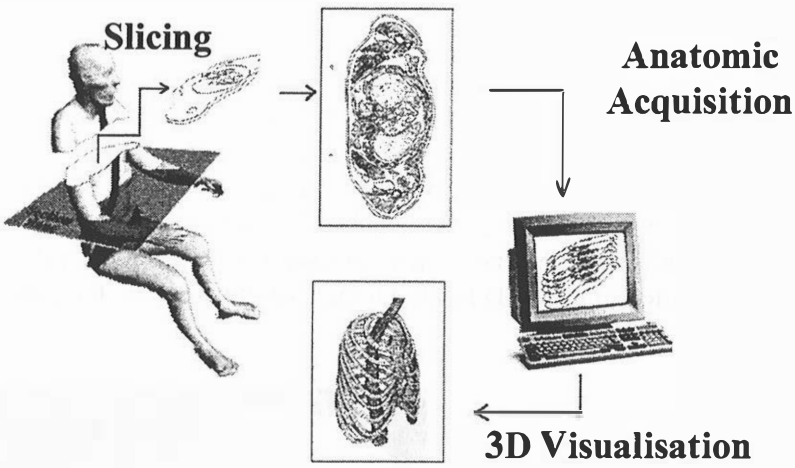


Figure 1 : General process define by [(3)]

Subject selection and slicing

The selected cadaver, close to the "50th percentile European male subject", was placed into the cockpit of a car in driving position (in collaboration with ECIA). Then the body was frozen in this position and placed into a foam-filled sarcophagus. In order to have the direction of the section plane as close as possible to conventional anatomic descriptions (ie sagittal, coronal or transversal), the entire body was divided into 5 different blocks (thorax-head, pelvis-abdomen, hands-arms, knees and foot-ankle). Reference slabs were attached to each block in order to ensure the integrity of the blocks and to define a reference system for the data acquisition. Blocks were sectioned each 7.5mm with a 2.5mm thick saw. Each slice were cleaned and photographed.

Anatomic acquisition

Pictures of the slices are then scanned for a computer assisted anatomic analysis. A new software tool, developed in the Matlab environment, has been used by anatomists to identify any visible item on the slices. This software platform displays an image of a selected slice (with the reference slabs appearing) and offers displaying possibilities such as zooming to identify and name any anatomic entity. The anatomist can therefore identify, name and define contours with the help of a graphic table. The result is an ascii file with the name of the anatomic entity and the 3D-coordinates of the contour in the reference space. A validation tool also enables the anatomists to visualise the piling up of all the contours of one same organ and eventually to proceed to contour corrections.

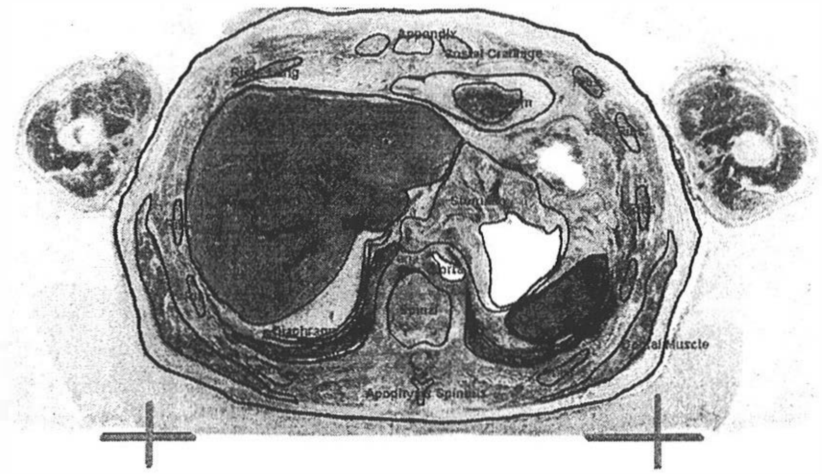
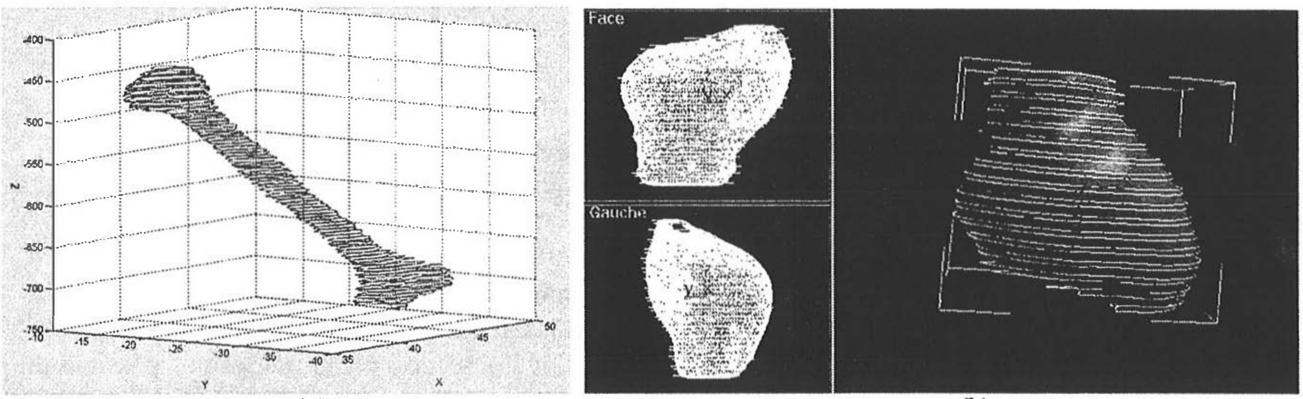


Figure 2 : Example of an anatomic slice identification with references slabs

3D Visualisation

The reconstruction of the contour pile offers a first means of validation for the anatomists (Fig. 3a). However, this appears not to be sufficient, especially in cases of complex-shaped organs (ie scapula, pancreas...). So a software tool has been developed to generate 3D objects from the raw contour files (Fig. 3b). Several methods (simplex meshes[4], marching cubes[5], ...) have been compared, and the one based on the "marching cubes"[5] algorithm gave very interesting results (except for ultra-thin organs). The output file (".dxf" format) can be imported to most 3D Finite Elements software tools for meshing modelisation.



(a) (b)

Figure 3 : Pilling up of the contours of a humerus (a) and 3D reconstruction of the heart (b)

RESULTS

The results of this work is a complete anatomic and geometric database of a seated human body in driving position. The division of the cadaver into 7.5mm thick slices allowed a software reconstruction of bones and organs with a particularly high resolution. Some anatomic details such as the transverse and spinous processes (Figure 5) can be underlined. However, the reconstruction tool, based on "marching cube" algorithm, is not well adapted for thin organs like diaphragm. This database allows to improve knowledge on the spatial arrangement of organs and interaction between them in this particular position. From an anatomic point of view, it is obvious that the lack of pressurisation of the cadaver and his passive musculature induce a decrease of some particular organs dimensions (cardiovascular and pulmonary system, muscles, ...). However, it seems that this deficiency has no effect on orientation and position.

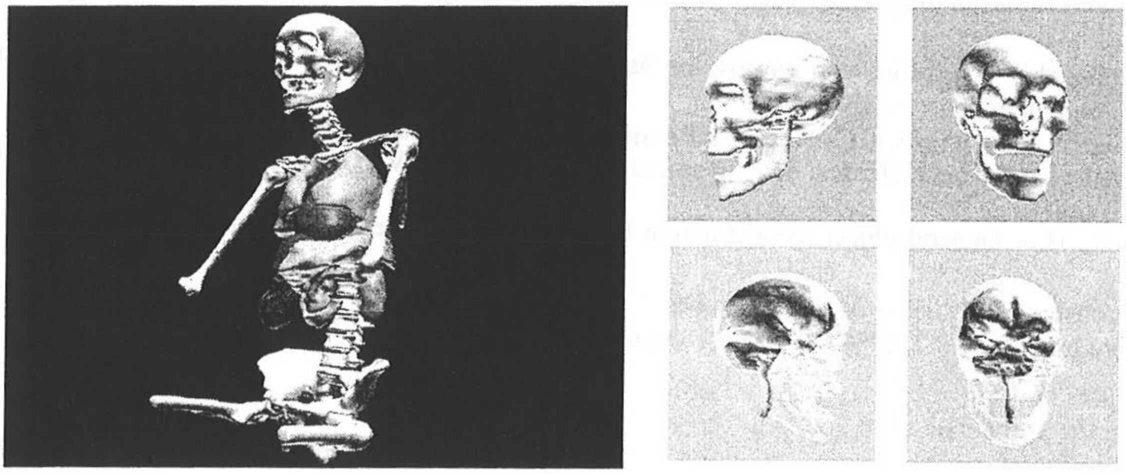


Figure 4: Visualisation of thoracic and abdominal organs, and head with cerebellum ,cerebrum and the brain stem.

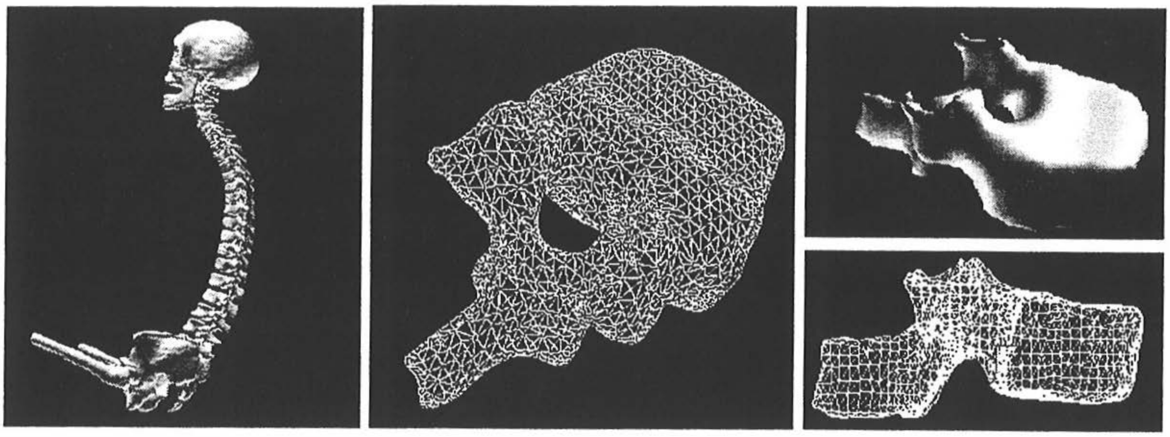


Figure 5: General curve of the spinal column and in detail the 12th thoracic vertebra.

CONCLUSION

The creation of a geometric database of the human anatomy in the seated position opened up new possibilities in the fields of anatomy teaching and transports security, especially in terms of bio-mechanics. This methodology is used in the framework of the HUMOS European project and contributes to the elaboration of more accurate numeric models.

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