3D RECONSTRUCTION OF OBJECTS FROM ULTRASOUND IMAGES

prof.dr.ing. Stefan Holban
ing. Gabriel-Miro Muntean, ing.Calin Rotaru,
ing. Daniela Crivianu-Gaita
Computer Science Department
"Politehnica" University

1. Introduction

Developments in tools based on information technologies are assumed to have a fundamental impact on medicine. Computer assistance may be employed in surgical therapy for preoperative planning, intraoperative guidance and postoperative assessment (for example: in cranio-facial surgery, neurosurgery, orthopaedic surgery etc.). In this way, image and signal processing techniques abstract and interpret data for diagnostic, therapeutic, and monitoring purposes.

Though it comprises dedicated hardware and software, in practice, the recognition and reconstruction of objects from their 2D projections has proved to be of use, with excellent results regarding the precise knowledge of the human body.

The purpose of the paper is to present an approach on the reconstruction of 3D objects from their 2D projections and calculation of their volumes. We will discuss the possibilities and limits in 3D reconstruction of objects from ultrasound images.

2. A program for 3D reconstruction

The primary information, obtained from the echograph, is composed of 2D digital images. These images are obtained by digitising the frames acquired from the 3,5 MHz ultrasound equipment, and transformed into a 640x480 bitmap array quantified on 256 grey levels. The format used is that of Windows Compatible Bitmaps.

The echographical images are stored into bitmap files. They are interactively loaded by the user. Using the mouse the user has to specify a clipping rectangular region .The rectangle must be chosen so that its centre corresponds to the supposed centre of the internal organ. After making the selection, this region is clipped and a new, smaller, bitmap is created. This bitmap will be the source for the next processing.

The clipped bitmap obtained is processed for the best rejection of the noise and for getting the most realistic image of the organ. First a circular filter is applied in order to emphasize the organ. This filter uniformly illuminates the chosen region. The highest intensity is added to the centre and it decreases with the distance to the centre. The circular filter used by us combines two criteria: the distance of a pixel from the centre of the chosen region and the initial intensity of pixels. The value of the constant which multiplies the initial intensity of the pixels was chosen by trial and error.

The authors have tried different types of filters [6], finally choosing the circular filter which is best suited for the purpose of our work. The idea was to increase the grey level differences in order to better indicate the organ of interest - in our case the prostate.

Different levels of grey are selected from the filtered bitmap in order to obtain some "depth curves" [7]. These curves contain depth information which will be used for building the 3D image.

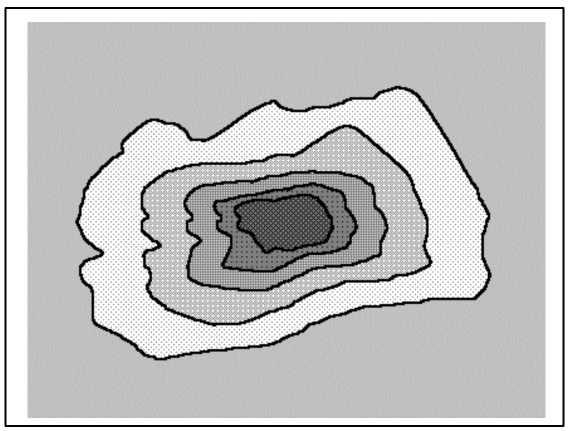

Fig1. Representation of prostata using "depth curves"

Taking into account the fact that the object of our analysis - the prostate - is an irregular and asymmetric object whose shape and dimension varies from one subject to another, it would seem absolutely necessary to acquisite many echographic images from determined positions [1], [8]. In the County Hospital of Timisoara, it was impossible to apply such methods, because there was no endorectal transducer.

As the examiner usually has only 2-3 images, we designed a method of reconstruction of the objects using 2 sections: P and Q. The 3D object is composed of surfaces having the shape identical to the P surface and scaled according to the local dimension (on the Q section).

At the beginning we thought that the only possibility of representing the 3D object would be to use a ray-tracing algorithm [9]. This algorithm has the advantage of a realistic representation of objects. The disadvantage is the long time necessary for a prostate representation. This is a major disadvantage, since the software is designed for interactive work, within the time of a consultation.

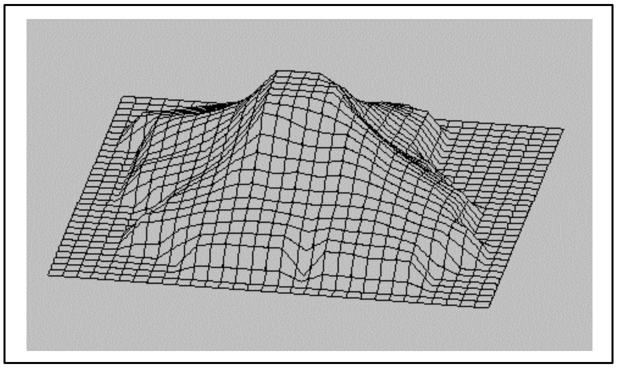

Fig. 2. A 3D representation using “wireframe”

The optimal solution turned out to be a depth algorithm, thus providing a realistic image quickly. The pixels corresponding to points closer to the observer are coded with brighter colours.

The depth algorithm is well suited for the application, because the prostate doesn't have a complex exterior surface. The method of reconstruction developed by us, allows a good reconstruction of the prostate: the perspective did not modify the 3D perception of small irregular regions and at the same time preserved distances and other geometric information.

The volume of the modelled prostate is computed through numeric integration.

The system also maintains a database with the acquired images, being able to show the evolution of the patients.

3. Critique

Many digital imaging or computer assisted medical imaging modalities have been introduced successfully since the 1970's. Clinical three-dimensional imaging is still very much in a research stage and the limitations of three-dimensional ultrasound imaging have caused an attitude of "holding back". Matching of different 3D image volumes is a problem that is encountered in several applications of medical 3D imaging.

The system developed by us is designed to work on-line, near the echograph, as a tool for helping the physician. The program has been tested for the case of prostate adenoma, but it is still necessary to develop our system in order to obtain a good 3D reconstruction of the kidneys and their pathologic modifications.

4. Conclusions

The value of this work is the follow. Firstly it has resulted in new algorithms for processing digital images and using these in 3-D reconstructions. Secondly, and more importantly it has provided a system which can be used in hospitals (the majority of hospitals) which do not have either CAT scanners or NMR/MRI equipment. It thus provides these hospitals with a tool enabling more accurate diagnosis, which in turn improves the efficiency of the hospital, saves money and has a profound psychological benefit to the well-being of the patient. Because of this, hospital managers, physicians, surgeons, radiologists and radiographers should take note of this work.

5. References

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