ARTIFICIAL INTELLIGENCE AND ULTRASONIC IMAGING: THE USE OF LEARNED SHAPE KNOWLEDGE TO ANALYZE 3D DATA

Abstract #1107

Brinkley, J.F.
Dept. Gynecology and Obstetrics, Stanford University

The purpose of this research is the development of accurate three-dimensional organ models for volume and shape measurement. A method was described previously for building a three-dimensional reconstruction from a series of arbitrarily oriented real-time ultrasound scans[1]. An acoustic position locating system is used to relate the scans in 3D. The organ border on each scan is outlined with a light pen; computer programs calculate the 3D coordinates of each outline point and determine volume by an interpolation process. Clinical tests of this system have shown problems including the effects of missing data on the volume interpolation process, and the large amount of time required to manually outline scans.

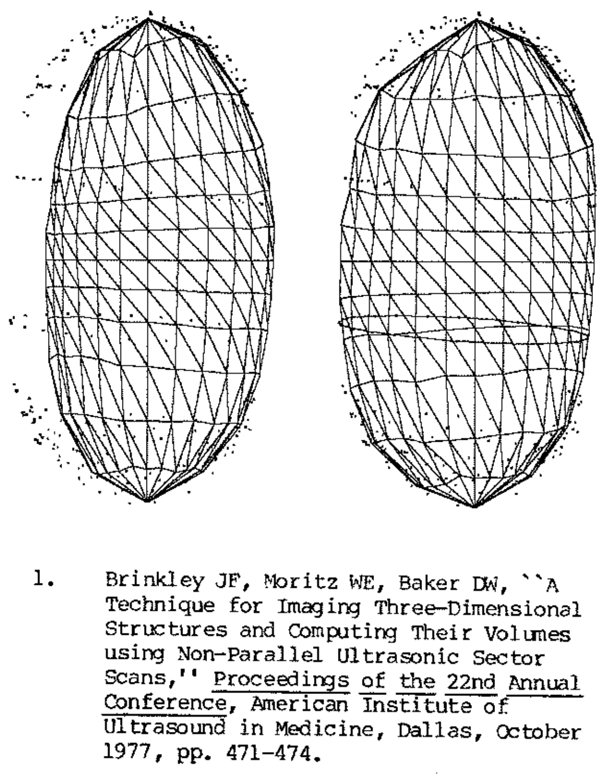
In the current research techniques from the field of artificial intelligence are used to teach the computer the expected shape of an object, then to use this shape knowledge to analyze a new object. The goal is to utilize less information while maintaining accuracy, and to reduce the effects of missing data. The system has been tested on two shape classes of balloons imaged in a water tank.

The computer model is represented by a polyhedron. The 3D positions of the balloon endpoints (as input by the operator) establish a reference organ coordinate system and a long axis. This data interacts with learned shape knowledge to establish an initial tolerance region within which the balloon surface is expected to lie, and an initial bestguess as to the location of the surface. The shape knowledge consists of local slope constraints learned from a training set of similarly shaped balloons. The long axis data propagates throughout the model much as a wave would propagate over a globe covered with water. The maximum amount is known in the vicinity of the axis endpoints; as the wave proceeds outward less and less is known. The lefthand figure shows the initial bestguess for a long thin balloon after only the long axis has been specified. The dots are the actual data from a 3D reconstruction. Even after just the long axis has been specified the system has a reasonable guess as to the location of the balloon surface. Bestguess volume at this point was 351 cc; measured volume 461 cc.

Once the long axis has been specified the system requests a particular ultrasound scan to examine. Initially the system is given the 3D positions of a series of scans acquired throughout the balloon and stored on videotape. These positions are examined to determine which scan can contribute the most information. The selected scan is accompanied by a 2D tolerance region and the border is obtained (manually in this implementation). The border updates the model first in the vicinity of the scan. The information is then propagated via the learned shape knowledge to other parts of the model. The righthand figure shows the bestguess surface after only one scan has been examined (a cross-sectional contour). Bestguess volume at this point was 456 cc; measured volume 461 cc.

This process repeats until it is judged that additional scans can provide no more useful information. For this balloon termination occurred after 7 out of a possible 22 scans had been examined. Bestguess volume was 459 cc.

The system has also been tested on a different shape class of round balloons with similar results. Although additional problems are expected with biologic objects the results on balloons suggest that learned shape knowledge, if employed using techniques from artificial intelligence, can help solve some of the problems of ultrasonic 3D reconstruction.



1. Brinkley JF, Moritz WE, Baker DW, ``A Technique for Imaging Three-Dimensional Structures and Computing Their Volumes using Non-Parallel Ultrasonic Sector Scans,'' Proceedings of the 22nd Annual Conference, American Institute of Ultrasound in Medicine, Dallas, October 1977, pp. 471-474.

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