KNOWLEDGE-BASE DRIVEN ANALYSIS OF CINECARDIOANGIOGRAMS

John K. Tsotsos
Department of Computer Science
University of Toronto
Toronto, Ontario, Canada, M5S 1A7

This short note describes research into the application of AI techniques to the analysis of cinecardioangiograms. These are X-ray films of the heart taken while a radiopaque dye is injected into the heart cavity. The film shows the opacified blood inside the left ventricle, thus outlining the inside wall of the cavity. The problem is to build a knowledge base which can guide the analysis of the motion of the walls in these films, determine the various parameters which physicians use in their diagnoses and recognize abnormalities of heart wall motion.

This research is being done in conjunction with the Cardiovascular Unit at Toronto General Hospital. The role of the medical experts is to provide the knowledge necessary for construction of the knowledge base and, to evaluate the performance of the system we produce.

Another aspect of the project is to develop front and back ends to the knowledge based system. The front end consists of a digitizer for the films, and a picture processing module which can accept guidance from the higher levels of the system. The back end includes displays for the information determined (graphs and movies of what the system recognizes).

Now that the overall scope of the project has been outlined, let us look a little more closely at the knowledge-based understanding part. The general methodology is based on work by Badler [1] and Tsotsos [2]. The low level part has the following features: i) it implements a basic independent algorithm for determining the heart wall border (Freuder [3] has a similarly built low level); ii) it can accept advice from the higher levels of the system on where to look for a border (this is useful for following around the border once its motion characteristics have been roughly determined); iii) it asks the high levels for verification as to whether a particular section of proposed border really does belong to the border; iv) when it thinks it is lost, it asks the higher levels for re-orientation; v) it can communicate with the higher levels of the system while running in parallel with and independently of the remainder of the system. A system with these characteristics has already been implemented (Reeves and Buxton [4]).

The remainder of the system simulates the motion of the left ventricle using a 3-D thick-walled patch model, and uses this model to guide the low level. Each patch is an instantiation of one of several heart muscle frames (Minsky [5]). Such a frame defines the properties of the patch during a heart cycle: shape and size changes (note that the constructs for the representation of these concepts were not handled by Badler [1] and Tsotsos [2]); velocity and trajectory information; normal and abnormal motions with tolerances. Such information is clearly dependent on the actual heart viewed and on the patch location within the wall. It is hoped that such information can be derived from the model using the fact that the contraction of muscle fiber generates a force - but the knowledge of medical researchers on this is very limited and thus this may be hoping for a bit too much.

Using this 3-D model the location of the border is predicted, image by image, by simply using the angle of the X-rays (which is known) incident of the heart and taking a projection on this plane. This information is then used to guide the low level. The low level returns the actual borders found and the model is perturbed to fit this data. During this process, various parts of the patch frame (sub-frames) are activated to account for abnormal or unexplicable motion.

<u>References</u>

[1] Tsotsos, J.K., "A Prototype Motion Understanding System", TR-93, University of Toronto, 1976.

[2] Badler, N.I., "Temporal Scene Analysis: Conceptual Descriptions of Object Movements", TR-80, University of Toronto, 1975.

[3] Freuder, E.C., "A Computer System for Visual Recognition Using Active Knowledge", AI-TR-345, MIT AI LAB, 1976.

[4] Reeves, W., and Buxton, W., AI course project, 1977.

[5] Minsky, M., "A Framework for Representing Knowledge", in <u>Psychology of Computer Vision</u>, ed. by P.H. Winston, 1975.