Active Surface Models for Brain Imaging

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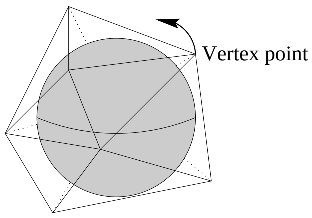
Abstract

In many areas of science a general visualisation problem exist, namely that the fundamental object is a three dimensional structure embedded in a rectangular volume. One example could be data from medical brain scanners. Normally it is qualitatively easy for the human to see and identify the structure from, e.g., images of the individual slices through the volume. It is, however, desirable to have automatic procedures, working in 3D, to track the boundary of the object and to generate a closed set of triangles (polygons). These closed surfaces can be used to visualise the object in 3D, or to perform quantitative measurements within the structure.

In the paper a generic way to track the surface of 3D objects from volumes is presented. Our strategy is to shape a closed surface of connected triangles to match the boundary of the object. There is no easy way to solve this non-linear inversion problem, so the adaptive strategy we suggest invokes minimisation of an energy function containing a set of individually weighted terms reflecting a set of desired goals.



The framework is very general and applicable in many research areas, and in the paper we will show examples from medical imaging where MR images are of interest. We have implemented a general framework where we minimise an energy function based on several terms with individual weighting. Currently we have terms like:

Gradient The absolute gradient of the volume taken as an average over the triangles area. This will try to fit the mesh to the volume. Adaptive smoothing must be invoked here to ensure that this force pulls the mesh to correct positions.

Smoothing A term of squared distances between the vertex position and the mean neighbour vertex position. This term will stabilise against extremes (but will imply shrinking.)

Inertia Squared distances of the distance between the current and the initial vertex position. This reflects the reliability of the initial surface.

Template Matching In a small neighbourhood around the vertex position the error against a similar neighbourhood in a reference volume is compared.

In principle it is possible to optimise each vertex position in every iteration, however when inspecting the energy terms and the scheme in general, it becomes obvious that the vertex positions can be iterated one by one. We will either update the vertex positions sequentially or in a randomised scheme without replacement (every vertex is accesses equally in mean).

In order to minimise the energy function we can apply several approaches. Currently we have chosen to use a simple approach, namely to compute approximations to the gradient of the energy function by computing the difference in the energy function when moving one vertex a small step. With this approximation to the gradient we can, e.g., use a simple steepest descent algorithm to minimise the energy function.

On the homepage `http://hendrix.imm.dtu.dk` a VRML 2.0 model and a movie is found that shows how an initial rough surface is fitted to a Magnetic Resonance image.