

A BRIEF INTRODUCTION TO MY WORK: -

(Consulted Paper: Fast Surface Reconstruction Using the Level Set Method

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Goal:

Development and Implementation of the level set speed function that fits a level set surface to the contour data.

Introduction:

As per my MS theses and my project under Dr. David Breen, I am trying to develop algorithms for implicit surface reconstruction. Implicit surfaces or volumetric representations are used for surface reconstruction. The surface might be unorganized data set and is of three or higher dimension. Here we use the data set to define a signed distance function on rectangular grids and denote the zero isocontour of the signed distance function as the reconstructed implicit surface. The construction of the signed distance function uses a discrete approach and needs an estimation of local tangent planes or normal for the orientation, or a distinction has to be made about the inside and outside information.

Advantages of Implicit Surfaces:

Topological flexibility, simple data structure, depth/volumetric information/ memory storage efficiency, Boolean operations and ray tracing possible using signed distance representation, Marching Cubes algorithm is available to turn an implicit surface into a triangulated surface.

Concept:

The convection of a flexible surface T in a velocity field $v(x)$ is:

$$d/dt (T(t)) = v(T(t))$$

If velocity field is created by a potential field F , then

$$V = -\text{grad} (F)$$

In our model, potential field is the distance function $d(x)$, thus:

$$d/dt (T(t)) = -\text{grad} (d(x)).$$

If the data set contains a single point $x(0)$, the potential field is $d(x) = |x - x(0)|$

Velocity field is $v(x) = -\text{grad} (d(x)) = -(x-x(0))/|x - x(0)|$, a unit vector pointing towards $x(0)$. So, any particle in this potential field will be attracted towards $x(0)$ along a straight line with unit speed. So, for a general data set, a particle, points or curves, will be attracted towards its closest point in S , ultimately a local equilibrium is reached, which is a polygon/polyhedron with vertices as the data set.

In numerical computations, instead of explicitly tracking a moving surface we implicitly capture it by solving a PDE for the level set function on rectangular grids.

Two steps for the level set method:

- 1) Embed the surface: Represent a co-dimension one surface T as the zero isocontour of a level set function.
- 2) Embed motion: We derive the time evolution PDE for the level set function such that the zero level set has the same motion law as the moving surface, or the moving surface coincides with the zero level set.

My Work till now:

Data slices (2D), in the form of contours were provided for the embryo of a mouse. Inside – outside information was used and accordingly points within the contour were colored red, the outside was black with the contours as white. Taking these images as our input images, a signed distance dataset (2D) was constructed. That is, using the ANN library (consult Mount – Arya, University of Maryland), distance from the query points to the data points was calculated. From these data points the distance image was constructed in 2D.

Now, distance information from all the slides was taken and a volumetric distance data set was constructed. This time the data set is in 3D. Once again ANN library was used to calculate the distance from each query point to its closest nearest neighboring data point. (ANN uses KD-tree to calculate the distance in a very efficient way). Once the distance field is generated, the Marching Cubes is run on it, to generate the reconstructed 3D distance image.

ImageMagick has been used to view, read and manipulate the images.

Mug has been used to view, translate, magnify, and rotate the generated .smf images.

Once the distance image with the same resolution as the input image is generated, the resolution for the generated images were made independent of the input images. Here, I have posted images taken from different angles of images with the same resolution as the original image, images with higher resolution than the input image and images with lower resolution than the input image.

Padding has been applied to cover the holes at the top and bottom.