CHAPTER 13 - FEATURE POINT BASED EDGE SEGMENTATION

13.1 FOUNDATIONS

The shape reconstruction method described here is named “Feature Point Based Edge Segmentation.” The technique is an adaptive approximation process based on segmenting the initial data set into regions. The regions are based on the presence of points in the data, labeled \textit{feature points} that represent properties of the surface being approximated.

The eventual goal is to construct a surface consisting of a set of smoothly connected surface patches. These patches would be generated from a triangular mesh that is an approximation to the surface.

Conceptually, the approach attempts to identify “feature curves” which are natural edges of the surface. These curves are constructed by connecting feature points. Feature points are points in the original data set which represent important changes in the surface. The feature points are determined by approximating local surface variations. The local variations are measured by finding a neighborhood for each point and identifying changes within the neighborhood. Therefore, it is important that a proper neighborhood be found for each data point.

The edges that are formed are planar and are approximations to the surface edges. A triangular mesh can be generated from these edges.
Since the feature points are extracted from the original data set, the mesh that is generated consists of a subset of the original data. All of the points in the mesh are in the original data set. A major difference between this technique and others is that the reconstruction is not based on all the data points. Therefore, computation and storage requirements are reduced.

The figure below gives an example. Some of the data points are chosen to represent the topology and shape of the surface. These points are connected to form a segmentation of the surface.

![Figure 13.1 Points and edges for part of a complex surface](image)

(a) Data points
(b) Selected feature points
(c) Generated edges

While the segmentation is performed with the help of edges, the edges are created by connecting points that are carefully selected to represent the surface. Thus, the technique is point based.

It is desired to produce a mesh that is initially smaller than one produced by other techniques so that little further optimization is required. At present the meshes generated are denser than necessary so that an optimization step would be beneficial before surface patches would be
constructed. However, the meshes are less dense than would be created by a technique whose emphasis was mesh optimization.

Connecting detected feature points to represent the structure is not sufficient for many surfaces. Examples include any surface that has smooth regions such as a cylinder. Such regions will not contain feature points, so points are chosen somewhat arbitrarily to represent these smooth regions. The fact that many meshes generated by this approach at present are too dense is a result of the need to include points from these regions.

Another important feature of the approach has to do with surface normals. In many surface reconstruction techniques, the role of the surface normal at a point is critical. Since this normal must be approximated based on local behavior of the surface as demonstrated by the distribution of points near the given point, normal approximation techniques are sensitive to sampling error. The technique presented below is not as dependent on normal approximations for each point as are most similar techniques.

13.2 OVERVIEW

Edge based segmentation is based on three steps which are discussed in the following chapters.

The first step is pre-processing where the data is input, organized, and partially analyzed to prepare for the next steps. Pre-processing includes input, sorting the data, determining the neighborhood for each point, and computing an approximation to the normal vector of the surface at each data point.
The second step is extracting feature points from the data. This process is accomplished by detecting areas where there is an obvious edge based on the distribution of data points in a neighborhood or by detecting areas where there is significant variation in approximate surface normals within a neighborhood. The second technique works well when there is little noise present in the data.

If there is significant noise present in the data, some of the variation detected may be a result of the randomness of the sampling error. Therefore, a smoothing technique may be necessary. The technique used is based on a 2D edge detection approach from computer vision.

The final step can be viewed as adaptive subdivision. In this process, additional points are extracted as necessary, edges are generated, polygons are generated from the edges, and the polygons are triangulated.

If the density of feature points in the data set is based solely on the complexity of the surface shape in a region, the approach is “automatically” adaptive in the sense that there are fewer points in areas of less interest and more points in complex areas. Thus, since the mesh is generated from selected points, the mesh is denser in areas of greater complexity.

The largest challenge in the implementation of the approach has been matching the density of feature points to the complexity of the surface rather than the density of the sampled data.

If the density of data points is relatively uniform, which is not unusual, more points need to be selected in areas of greater surface change. The algorithm works well for this situation except that there may be too many extra points added to represent smooth regions.