A Framework for Multiresolution Modelling*

Anil Maheshwari Pat Morin Jörg-Rüdiger Sack

Carleton University School of Computer Science
{maheshwa,morin,sack}@scs.carleton.ca

1 Introduction

The subject of multiresolution surface modelling has received considerable attention from a number of fields, including computational geometry, geographic information systems, and computer graphics. The research in this area has concentrated on digital representations for 3-dimensional surfaces or solids which allow for viewing and manipulating the surfaces at varying levels of detail [1, 2, 3, 4, 5, 7].

It is the thesis of this abstract that many of the ideas used in multiresolution surface modelling have broader applications. Indeed, some of these ideas have already been applied to the field of geographic information systems [6]. In this abstract we describe further applications in geographic information systems, image processing, and multimedia. In the next two sections, we describe a general framework for multiresolution modelling, and give a number of example applications of this framework. It should be noted that this research is still very much in the preliminary stages, and that the main purpose of this abstract is to raise questions and motivate research rather than present a complete set of research results.

2 A General Framework

A multiresolution model can be thought of as a directed acyclic (hyper)graph $G = (V, E)$, where nodes in the graph represent *drawing operations* and edges in the graph represent dependencies between these operations. As an example, in the multiresolution surface models of Puppo [7] the nodes represent sets of triangles, and there is an edge from one set of triangles to another if the two sets overlap. An edge e is directed so that the $src(e)$ is the set of "lower resolution" triangles and the $tgt(e)$ is the set of "higher resolution" triangles.

As another example, consider a black and white image processing system, in which the only drawing operation allowed is drawing a (black or white) rectangle. In such a system, an obvious multiresolution model is to have a vertex represent a drawing operation (rectangle) and put an edge between two vertices if their corresponding rectangles overlap. By applying the operations in any topologically valid order with respect to G, the original image is recreated.

*This work is supported by grants and a scholarship from the Naturals Sciences and Engineering Research Council of Canada.

A multiresolution model in this framework allows for a number of features not supported by a standard model, including *level-of-detail approximation*, *selective (view-dependent) refinement*, and *progressive transmission*. The challenge, as we see it, is finding an appropriate set of drawing operations for the particular application, and developing efficient algorithms for expressing the data with a small number of these drawing operations. Note that, although we describe the framework in terms of the graph G, if an appropriate set of drawing operations is chosen, it is not always necessary to explicitly store or transmit G.

3 Applications

Next we describe some potential, still largely unexplored, applications of generalized multiresolution modelling. The motivation for these applications is that often these types of data are stored on a server and some clients may require only low resolution data, only part of the data, or immediate access to (at least a rough approximation of) the data over a slow communication link. In such cases, the features of LOD approximation, selective refinement, and progressive transmission offered by a multiresolution representation solves these problems nicely.

GIS

- *Isoline (contour line) maps.* Here, the vertices of G are sets of line segments and the edges of G represent an operation which replaces one set of line segments by another. An interesting challenge is maintaining the non-crossing property of contour lines during view-dependent refinement.

- *Polygonal maps.* These are similar to, and offer the same challenges as isolines, but are less structured since they don't necessarily have the nested tree-like structure of isolines.

- *Unorganized point data.* A multiresolution model could be used as a hierarchical clustering mechanism for viewing and computing on sets of point data.

Image Processing

- *Color and greyscale digital images.* An important and difficult question which must be answered is the choice of drawing operation(s) which allows a general and efficient representation.

Multimedia

- *Digital video and audio.* A multiresolution representation of digital video and audio could allow for the streaming of these data types across communication channels of different speeds, with the highest possible quality allowed by the particular channel. The challenge with video data is in adding the time dimension to digital images. The challenge with digital audio is in finding a scheme that is competitive with the high efficiency of existing compression algorithms.

4 Conclusions

Multiresolution surface models have received much attention from the computer graphics and GIS community. We have describe a generalized multiresolution framework, and presented a number of new application areas for multiresolution models. We hope that this motivates research into these, and possibly other, application areas.

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