REPRESENTATION, COMPRESSION AND PROGRESSIVE TRANSMISSION OF DIGITAL TERRAIN DATA USING OVER-DETERMINED LAPLACIAN PARTIAL DIFFERENTIAL EQUATIONS

By

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A Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

Major Subject: COMPUTER SCIENCE

Approved:

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March 2008
(For Graduation May 2008)

ABSTRACT

We present current research on terrain (i.e., elevation) representations and operations thereon. The work is motivated by the large amounts of high resolution data now available. The significance of our method mainly lies in its ability to highly compress terrain data while preserving important features. The backbone of the method is our ODETLAP representation which generalizes a Laplacian partial differential equation by using two inconsistent equations for each known point in the grid, as well as one equation for each unknown point. The surface is reconstructed from a carefully-chosen small set of known points. The terrain we are using is Digital Elevation Model (DEM) data, stored as a raster of elevations. We combine ODETLAP with other computational geometry techniques including Triangulated Irregular Network(TIN), Visibility Test, Level Set so that the small set of known points could be effective in the reconstruction process.

Based on the novel ODETLAP representation, we propose a new surface compression technique to lossily compress terrain data. Our approach first approximates the uncompressed terrain using ODETLAP. Then the approximation is refined with respect to the original terrain by selecting more known points. These two steps work alternately until we find an approximation that is good enough. We then use run length encoding and linear prediction to further compress the point set to achieve a higher compression ratio.

In addition to terrain compression, we also propose a progressive terrain data transmission method based on ODETLAP. Concretely, our technique is capable of reducing a hilly DEM dataset to 1% of its original binary size and a mountainous DEM dataset to 3% of its original size. The corresponding RMS elevation errors are all below 10 meters. We study the tradeoffs between compressed size and reconstructed surface accuracy and demonstrate that our method is effective in transmitting terrain data over slow links and lays a concrete foundation for further operations like rendering and editing.