Title

Ruimte voor **Geo-Informatie**

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Top-up Project no.: RGI-011

Management summary

The overall objective of the RGI-011 project (leading party Delft University of Technology) on 3D Topography is to make available 3D polyhedron representations of topographical objects from 2D and height data input, and to store these objects through a Constrained Tedrahedronized Irregular Network (TEN) based representation for a broad range of applications. This TEN based data structuring is possible only if the 3D polyhedron representation or Piecewise Linear Complex (PLC) is valid, i.e. the faces should form a closed and non self-intersecting boundary. As the majority of the existing 3D topographic objects are not valid in this sense, there is an urgent need for algorithms that are able to validate and repair 3D polyhedron representations (or PLCs).
The first objective of this project is to research the validation and repair algorithms by means of the tetrahedral Delaunay mesh generator TetGen (made available by WIAS, Berlin). The second objective is the use of the Conforming Delaunay Tetrahedronization for efficient storage and dissemination of 3D polyhedron representations.

Leading organization

Organization: Delft University of Technology – Research Institute OTB – Section GISt

Contact for the top-up: Prof.dr.ir. P.J.M. van Oosterom / ir. E. Verbree

Project consortium

1. Delft University of Technology – Research Institute OTB – Section GISt (Existing member)
2. Weierstrass Institute for Applied Analysis and Stochastics (WIAS) - Research Group of Numerical Mathematics and Scientific Computing, Berlin,Germany (New member)

Project extension*:*

The objective of this top-up proposal is to develop - in international collaboration - an incremental method for the validation and repair of 3D Piecewise Linear Complexes, which is based on the TEN approach itself. This method uses the tetrahedral Delaunay mesh generator TetGen presently developed and maintained at the Weierstrass Institute for Applied Analysis and Stochastics (WIAS) Berlin, Germany. Another objective is the use of conforming Delaunay tetrahedronization for efficiently storing objects based on the point set

only. By extending the existing RGI-011 project 3D topography with the proposed objective, advanced 3D-GIS analyses like 3D overlay and 3D buffering through TEN based representation are becoming feasible and straightforward.

Proposed approach

The scope of the project is to research, based on the existing code of TetGen, a repair method for non-valid 3D polyhedron representations. For the understanding: this process has to be compared with the geometrical transition of 'spaghetti-structured' houses in the GBKN (*dutch: Grootschalige Basiskaart Nederland*) to object-based buildings in the BGT (*dutch: Basisregistratie Grootschalige Topografie*). The repaired (and thus valid) 3D polyhedron representations will be stored using a Constrained Delaunay Tedrahedronized Network (TEN) and ready for advanced 3D analysis like 3D overlay. TetGen is able to create a Constrained Delaunay Tetrahedronization (CDT) from a valid PLC in an efficient way.

The main processing step of this method is to develop the capability of updating of a valid CDT. The atomic step would be the insertion of an edge or a face into this CDT. This task includes finding and computing intersections with already present facets, and inserting the resulting intersection points and lines. So TetGen would incrementally create a CDT containing a valid PLC by starting with the coarsest possible valid CDT and adding and processing the facets of the input CDT one by one. From the resulting CDT, it is possible to extract a PLC with no self-intersections. Alongside with the implementation of such an algorithm, its complexity shall be studied and optimized. However, the problem of closeness of the PLC and other questions concerning PLC repair cannot be resolved using this algorithm. Answering these difficult questions is out of reach for this project. However, it is intended to study them in order to obtain a better understanding of the main problems and to identify possible approaches to their solution.

Another objective of this project with priority second to that of PLC repair is the use of the Conforming Delaunay tetrahedronization for storing objects based on their point set only. Here, an initial PLC based description will be used to create a TEN representation of the object. Augmenting the point set of the PLC with few new points – called Steiner points - on well chosen locations allows to create a point set which is structured in such a way that its Delaunay tetrahedronization will be able to represent the CDT of the initial PLC. The Delaunay tetrahedronization always exists, and can be created from a given point set with high efficiency. The challenge is to minimize the number of Steiner points.

A key issue for the project is the stability and robustness of TetGen, and the improvement of the algorithms implemented therein in order to reduce complexity. Therefore maintenance and further development of this software is another part of the top-up project.

Activities and project output:

1) Research paper on validation and repair of non-closed 3D polyhedron representations by means of Constrained Tedrahedronized Irregular Networks (TENs) to be used within the project RGI-011 on 3D Topography.
2) Research paper on storage and dissemination of 3D polyhedron representations by means of Conforming Tedrahedronized Irregular Networks (TENs) to be used within the project RGI-011 on 3D Topography.

Securing knowledge and communication *(max. 250 words):*

The current code of TetGen is free for research and non-commercial uses. A commercial license is available upon request. The developed validation-and-repair method will be also available under the same conditions.

The method will be described in two publications (scientific journal / major conference proceedings).

Bsik grant

X Less than 50 k euros (if only RGI partners involved)

Plan

Start date: 01-01-07

End date: 31-12-07

Appendices

- Accompanying spreadsheet
- Signed admission agreements WIAS