# First implementation results and open issues on the Poincaré-TEN data structure

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3Dgeoinfo07

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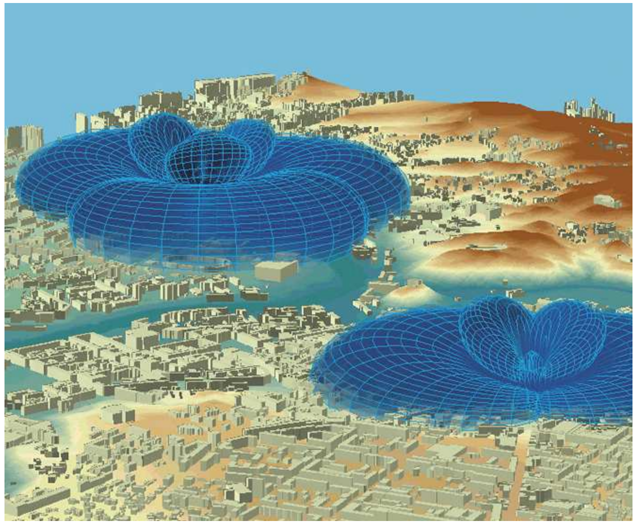
# Presentation outline

- Introduction
- Previous research
  - Characteristics Poincaré-TEN approach
  - Poincaré-TEN applied to 3D Topography
  - Implementation details
- Results Rotterdam data set
- Discussion of open issues
- Conclusions

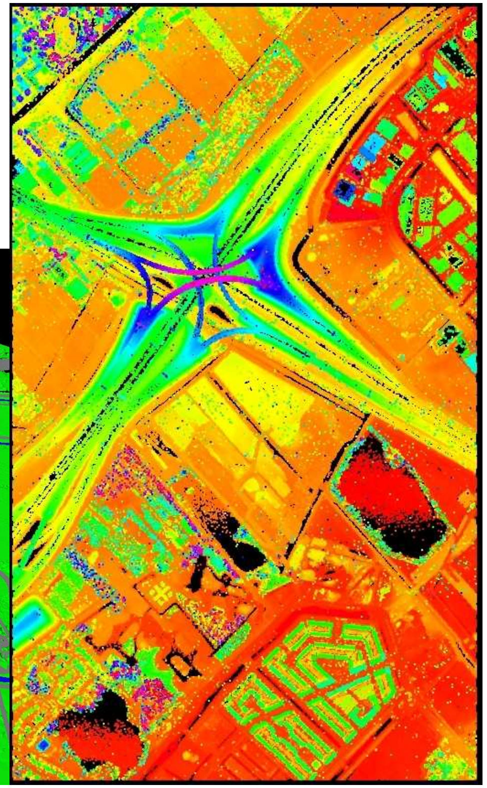
# Introduction

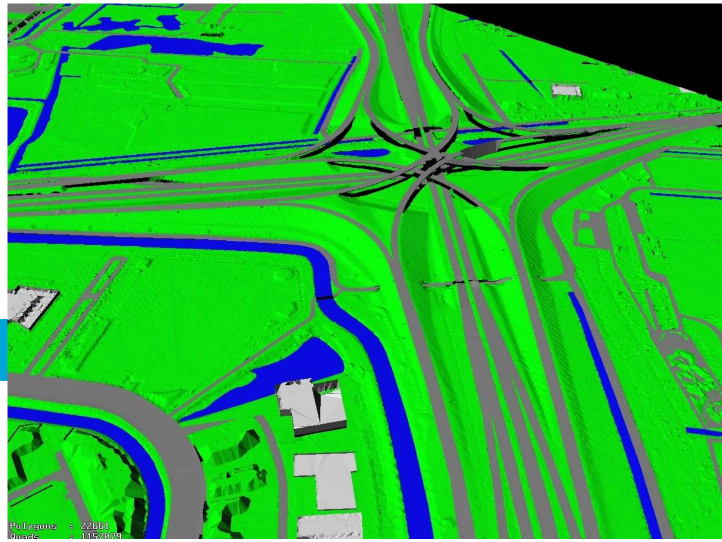


Poincaré-TEN structure:

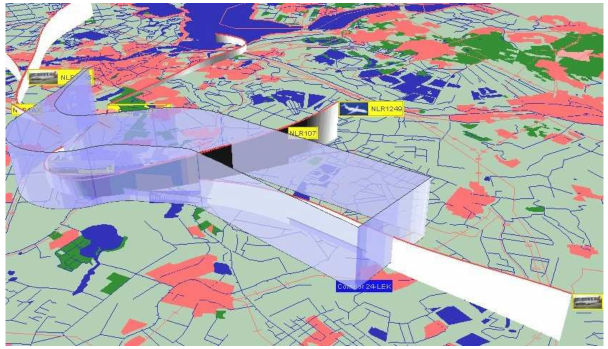
- DBMS data structure
- Supports query, analysis and validation

Developed within research project 3D Topography: focus on 3D acquisition as well as 3D modelling





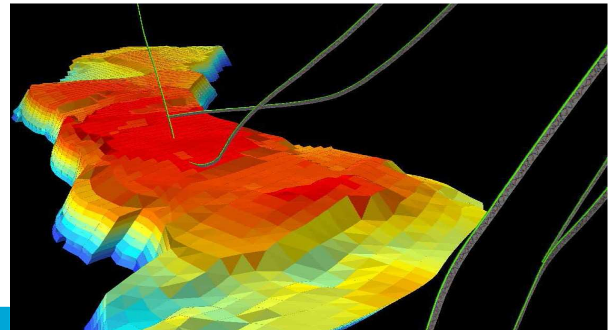
# Previous research (1/3)
# Poincaré-TEN characteristics



**Characteristic 1:** Full decomposition of space

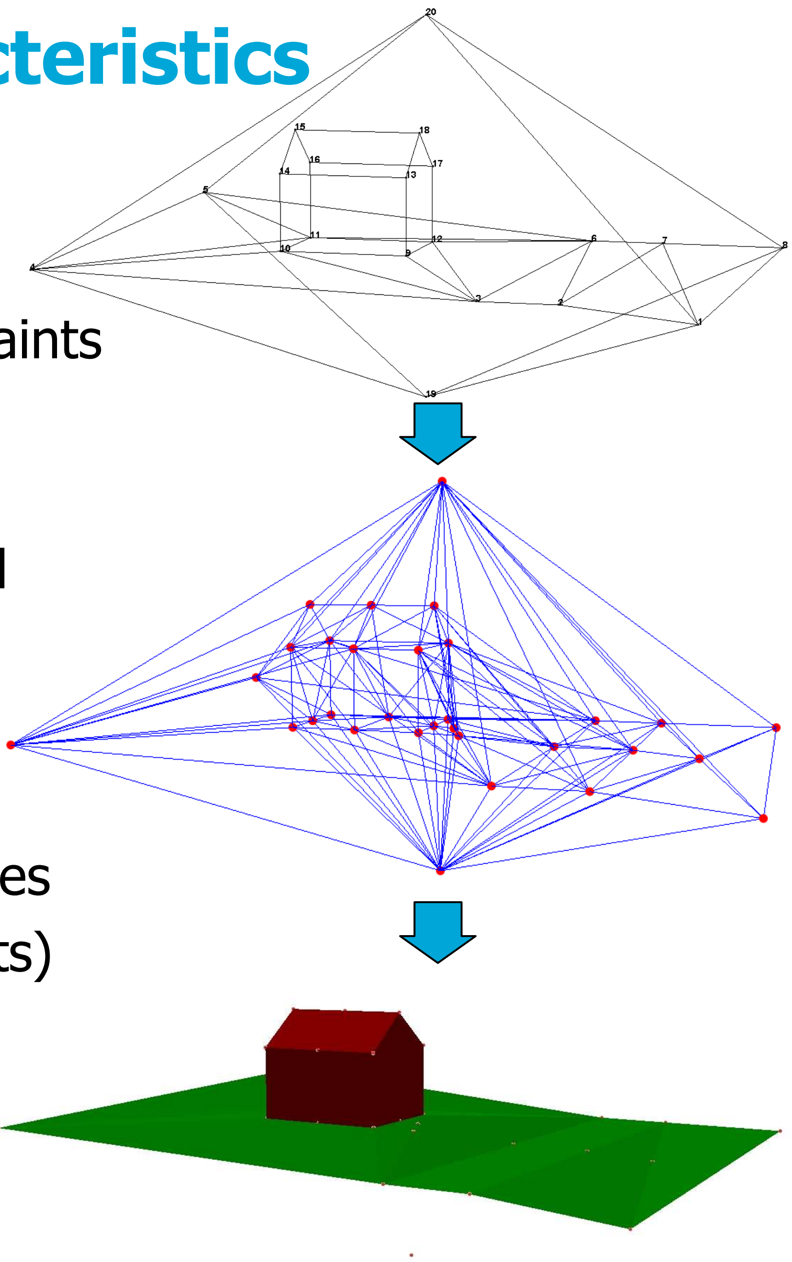
Two fundamental observations (Cosit'05 paper):

- ISO19101: a feature is an 'abstraction of real world phenomena'. These real world phenomena have by definition a volume
- Real world can be considered to be a volume partition (analogous to a planar partition: a set of non-overlapping volumes that form a closed modelled space)



Result: explicit inclusion of earth and air

# Previous research (2/3)
# Poincaré-TEN characteristics

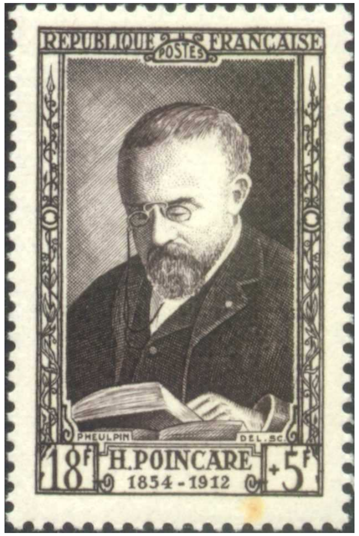


**Characteristic 2:** constrained TEN
object boundaries represented by constraints

Advantages of TEN:

- Well defined: a n-simplex is bounded by n + 1 (n - 1)-simplexes.
- Flatness of faces: every face can be described by three points
- A n-simplex is convex (which simplifies amongst others point-in-polygon tests)

# Previous research (3/3)
# Poincaré-TEN characteristics




**Characteristic 3:** based on Poincaré simplicial homology solid mathematical foundation (SDH'06 paper):

Simplex $S_n$ defined by $(n+1)$ vertices: $S_n = <v_0, \ldots v_n>$

The boundary $\partial$ of simplex $S_n$ is defined as sum of *(n-1)* dimensional simplexes (note that 'hat' means skip the node):

$$\partial S_n = \sum_{i=0}^{n} (-1)^i < v_0, \ldots, \hat{v}_i, \ldots, v_n >$$

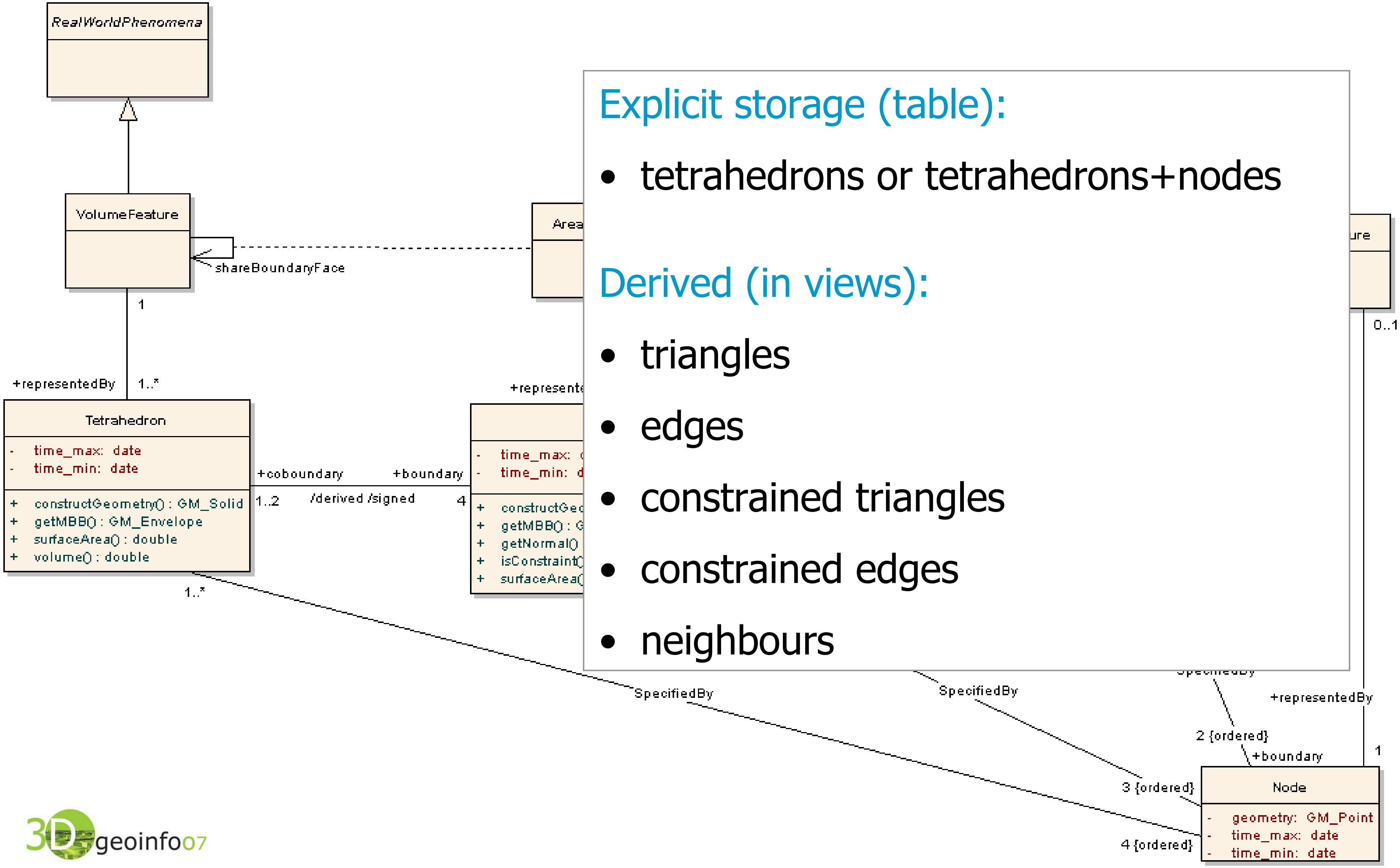
remark: sum has n+1 terms

$$S_1 = <v_0, v_1> \qquad \partial S_1 = <v_1> - <v_0>$$

$$S_2 = <v_0, v_1, v_2> \qquad \partial S_2 = <v_1, v_2> - <v_0, v_2> + <v_0, v_1>$$

$$S_3 = <v_0, v_1, v_2, v_3> \qquad \partial S_3 = <v_1, v_2, v_3> - <v_0, v_2, v_3> + <v_0, v_1, v_3> - <v_0, v_1, v_2>$$

# Poincaré-TEN applied to 3D topography




## Explicit storage (table):

- tetrahedrons or tetrahedrons+nodes

## Derived (in views):

- triangles
- edges
- constrained triangles
- constrained edges
- neighbours

# Implementation details
# DBMS

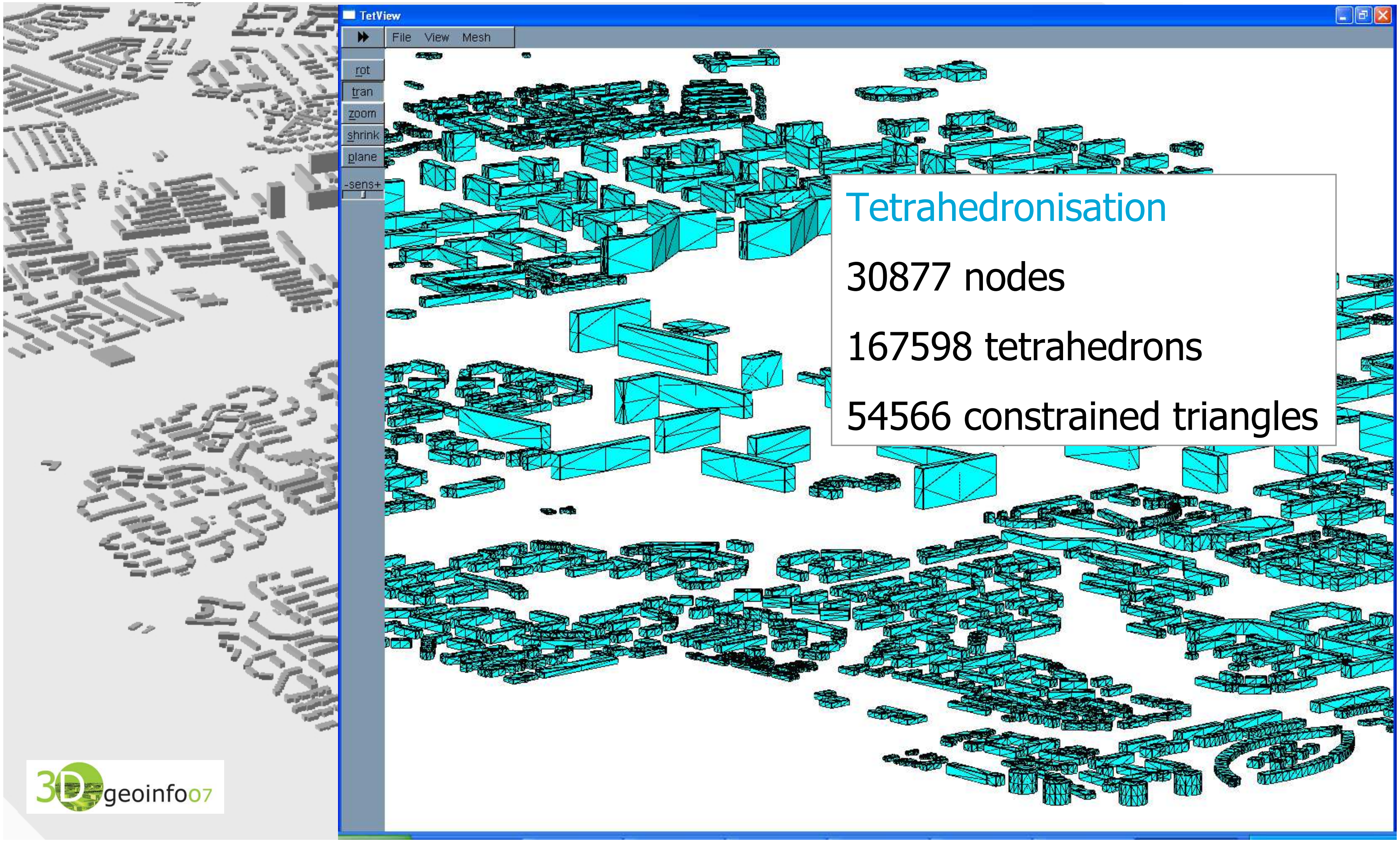
$$\partial S_n = \sum_{i=0}^{n} (-1)^i < v_0, \ldots, \hat{v}_i, \ldots, v_n >$$

Boundary operator implemented in PL/SQL procedure

Procedure used to define views with triangles, edges, constrained triangles (object boundaries!), constrained edges, e.g.:

```
create or replace view triangle as
    select deriveboundarytriangle1(tetcode) tricode,
    tetcode fromtetcode from tetrahedron
    UNION ALL
    select deriveboundarytriangle2(tetcode) tricode,
    tetcode fromtetcode from tetrahedron
    UNION ALL
    ...
```

# Results (1/2)
## Rotterdam data set



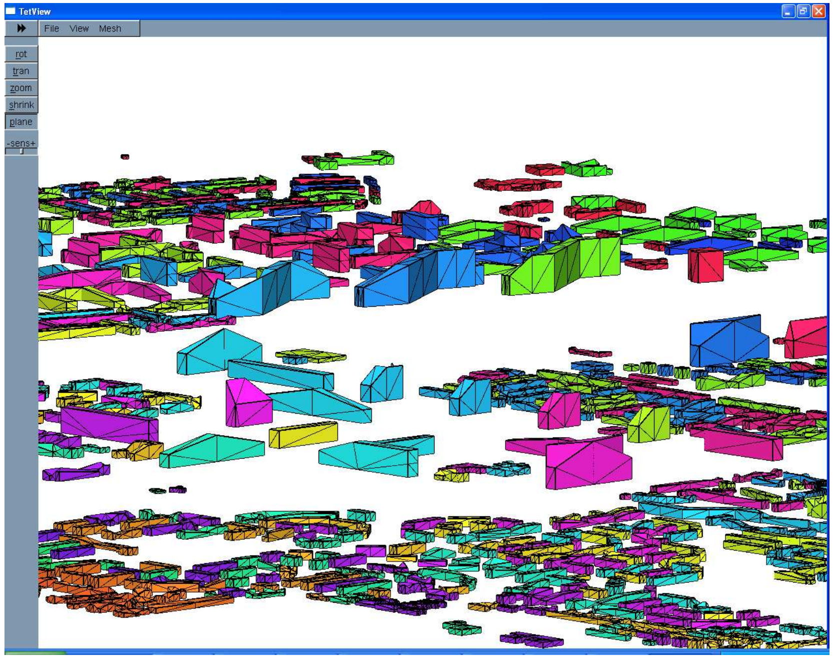

Tetrahedronisation

30877 nodes

167598 tetrahedrons

54566 constrained triangles

# Results (2/2)
# Rotterdam data set




Data storage requirements

| Poincaré-TEN | Polyhedron |
| --- | --- |
| 21.09 MB | 4.39 MB |
| *(node 1.44 MB)* | |
| *(tetrahedron 19.65 MB)* | |

PT-approach costs about 4.8 times more storage…

new *(but over 77.7% of tetrahedrons represent either air or earth, so buildings require about 5.76 MB. So factor 4.8 → 1.3)*

# Open issues
## 0. Spatial clustering and indexing

Basic idea:

Why add a meaningless unique id to a node, when its geometry is already unique?

0.1 Bitwise interleaving coordinates → Morton-like code → sorting these codes → spatial clustering

0.2 Use as spatial index → no addtional indexes (R-tree/quad tree)

Objective: reducing storage requirements

# Open issues

## 1. Minimizing storage requirements: tetrahedron only vs. tetrahedron-node

**Tetrahedron only:** describe tetrahedrons by node geometries:

$x_1y_1z_1x_2y_2z_2x_3y_3z_3x_4y_4z_4$

**Tetrahedron-node:** describe tetrahedrons by node id's:

$id_1id_2id_3id_4$ with $id_1$:$x_1y_1z_1$, $id_2$:$x_2y_2z_2$, etc.

A node is part of multiple tetrahedrons (Rotterdam data set: av.20), so either repeating geometries or repeating identifiers in tetrahedron table.

Tetrahedron-node will require less storage space (as long as id takes less storage than coordinate triplet)

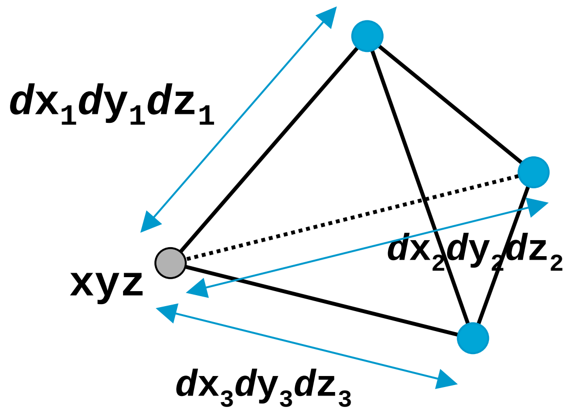
# Open issues
## 2. Coordinates vs. coord. differences

Four nodes of a tetrahedron will be relatively close:
only small differences in coordinates

Alternative tetrahedron description:

**xyz*dx₁dy₁dz₁dx₂dy₂dz₂dx₃dy₃dz₃***

Description is based on geometry
(so still unique) but smaller



# Open issues
## 3. Feasibility assesment

Delicate balance between storage and performance

# Open issues
## 4. Object snapping

Focus on snapping to earth surface:
buildings, roads, etc.

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Ensuring correctness of the model

# Open issues
## 5. Incremental updates

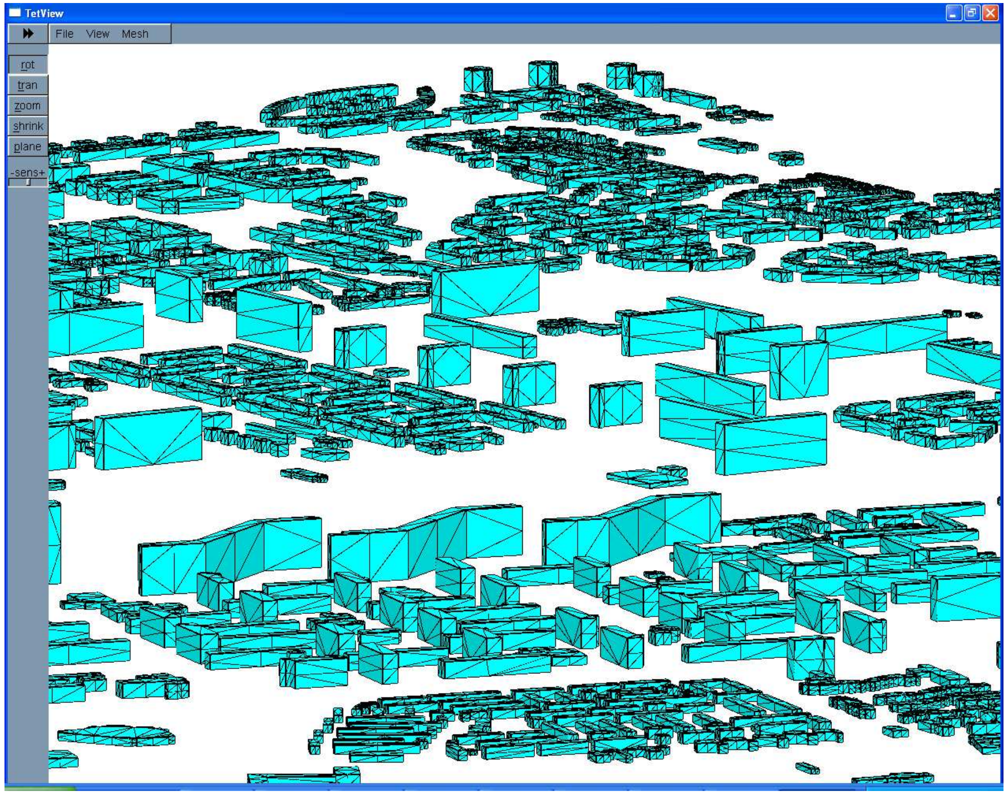
Topography changes continuously

Need for incremental updates

act as locally as possible ⟷ ensuring tetrahedronisation quality



# Discussion

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