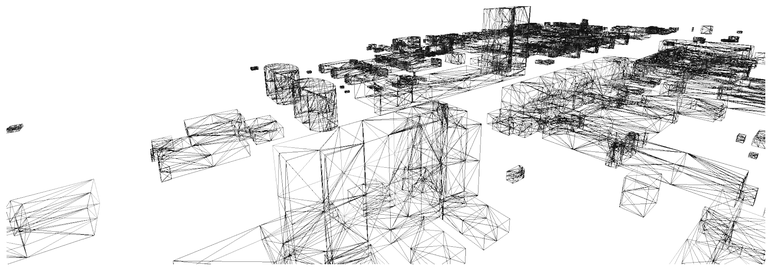
5D Data Modelling: Integration of 3D space, time and scale

Ken Arroyo Ohori (G.A.K.ArroyoOhori@tudelft.nl)
Section GIS Technology, OTB Research Institute, Delft University of Technology, The Netherlands

TU Delft — Delft University of Technology

Introduction



Tetrahedralisation of the TU Delft campus

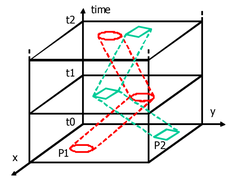
A Geographic Information System (GIS) captures, stores, analyses, manages, and presents data that are linked to a location on the earth surface. This geographic data represents real world phenomena that can be divided into two abstractions: discrete objects (a house, a gas-pipe) and continuous fields (noise level at a location, changes of objects). The geometrical description of geographic data is usually annotated by x-, y-, and z- coordinates (or longitude, latitude, and elevation) to represent the data in three dimensions. Commonly, the fourth dimension of geographic data is time. In this research, we have identified a fifth dimensional characteristic which is scale: some applications require detailed data, while other applications require data that gives an overview. Although (multi-)scale is a well-known concept in the geo-information technology domain, regarding it as an extra dimension of geographic data, integrated with the other dimensions, is new.

Within this project, we propose to lay the foundation for integrating these five dimensions in one formal data representation. The formal definition of geographic data in a conceptual 5D continuum will enable managing and querying geographic data most efficiently via one integrated approach.

Scientific background

Spatio-temporal Modelling

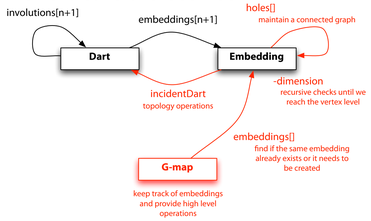
Storage and handling of the temporal aspects of spatial information (e.g. monitoring changes, describing processes). Temporal operations allow for spatio-temporal analysis.



Visualisation of time as a third dimension: moving objects.

n-Dimensional Modelling and n-D Data Structures

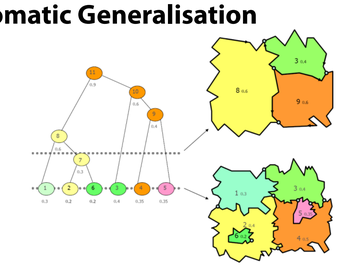
Integration of an arbitrary number of geometric or thematic fields as axes of an n-dimensional model. Few data structures are able to support n-dimensions efficiently and elegantly.



A modified G-map data structure, adapted for use in spatial information.

Multi-scale Modelling and Automatic Generalisation

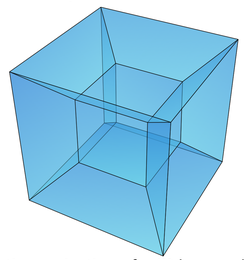
Managing different levels of detail representing the same spatial features. Automatic generalisation involves the creation of simplified models based on detailed ones.



Generalisation using the tGAP data structure based on the importance value of the objects.

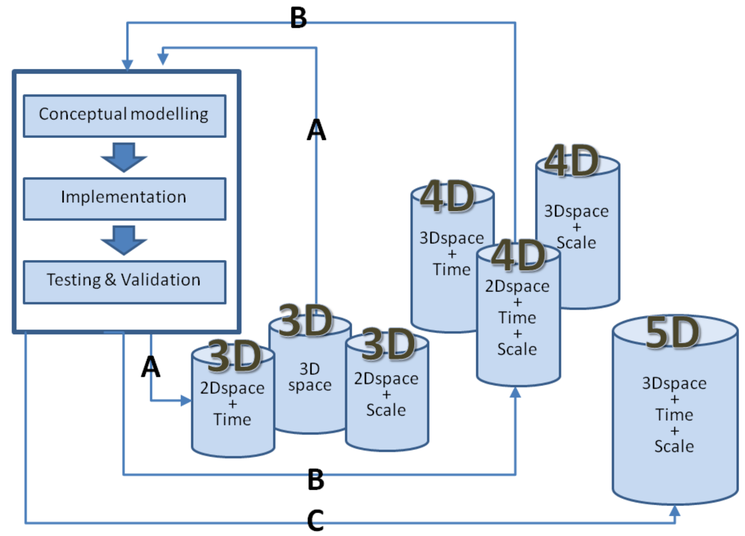
Operations on n-D Data

It is necessary to have operators to analyse and display high dimensional data (e.g. slicing, projections to lower dimensions).



Perspective projection of a 4D hypercube (from Wikipedia).

Methodology



Different options for the integration of space and time will be tested iteratively.

My contributions to the project

- **N-dimensional data structures**
- **Operations on n-dimensional data**
- **Visualisation**
- **Database integration**