Simplifying and Exchanging 3D Utility Network Objects using CityGML

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Fig. 1. CityGML model extracted from network object: a) 3D network object in b-rep b) extract the profile and extrusion axis (centerline of the 3D object) c) store the extracted information in the developed data type (swept representation) d) retrieve the graph representation and b-rep from the data type, which are required to exchange network objects using the CityGML schema.

Abstract—3D city models are becoming increasingly popular with a rising number of cities building up a digital representation. Today, they are used in a variety of fields of urban management and planning processes (Benner et al. 2005) such as disaster management, building architecture, facility management and tourism. As a result, standards for 3D city models have been introduced, like CityGML.

CityGML is a standard provided by the Open Geospatial Consortium (OGC) for the storage and exchange of 3D city models. Besides containing geometry and appearance information, CityGML is composed of a general purpose information model (Kolbe et al., 2005). Today, CityGML seems to provide the best framework for semantic-geometric relations of 3D objects above earth surface (Emgard and Zlatanova, 2008; Groneman and Zlatanova, 2009). It maintains a smart taxonomy and aggregations of Digital Terrain Models, sites (including buildings), vegetation, water bodies, transportation facilities and city furniture. Nevertheless, the current version of CityGML needs improvement; it still lacks the integration of subsurface features. The standard is not able to model geology, utility networks and underground constructions such as tunnels. Recently, the Special Interest Group 3D (SIG 3D) has been working on several application domain extensions to enhance the capabilities of CityGML including the possibility to model utility networks in cities (Becker et al., 2010). The first draft version of the UtilityNetWorkADE is published and supplies an abstract level data model that provides the main concepts to model utility networks regardless of their type (Hijazi et al., 2010).

Geometry information in current city models is stored using boundary representation (b-rep). 3D objects are represented as a collection of polygons enclosing the volume of the 3D object (Breunig and Zalatanova, 2005). However, for utility networks this would mean a huge waste of space for the storage in databases in contrast to storing them using swept representation (swept-rep). Swept-rep is a schema used in CAD for solids of uniform thickness in a given direction as well axisymmetric shape like cables or pipes. These characteristics allow us to reduce the essential information to the centerline of the utility network object along with the profile. Additionally, topological analysis requires a graph to represent the connectivity of network objects.

In this paper we present a methodology to simplify the geometry of 3D utility network objects from their boundary representation. Implemented in a spatial DBMS, the algorithm extracts centerlines from network objects as well as their profile information and stores them in a suitable custom data type compatible to swept representation. Another function is implemented that allows for the generation of b-rep for visualization using scene languages (e.g. KML) utilizing the concept of prototyping. Finally, we accomplished the export of utility network objects for exchanging using the CityGML UtilityNetworkADE. The developed methods were tested on several 3D network object types (e.g. pipes, fittings). The results shows the feasibility of the data type to reduce the used space, re-extracting of the b-rep for visualization as well as extracting of a graph for analysis (see figure 1).
Index Terms— CityGML, 3D City Models, Spatial DBMS, Utility Networks

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