Towards Defining a Framework for the Automatic Derivation of 3D CityGML Models from Volunteered Geographic Information

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ABSTRACT

High-quality geographic data sources are eminent for urban data management and the creation of detailed 3D city models. In the past two decades, Volunteered Geographic Information (VGI) increasingly gained attractiveness to both amateur users and professionals, resulting in a broad availability of urban data within VGI communities and especially OpenStreetMap (OSM). OSM provides detailed information about urban regions and more buildings are also mapped. Existing 3D-VGI applications, e.g., KOSMOS Worldflier (Brejc, 2011) or the OSM-3D project (OSM-3D, 2011) only focus on visualization purposes, but a standardized usage for exchanging and sharing urban city models is not combined with VGI. Therefore, this paper presents a framework for an automatic VGI-based creation of 3D building models encoded as standardized CityGML models. The usage of VGI as a proper data source for the creation of standardized city models will be proven.

Keywords: *3D City Models, CityGML, Computer Science, Information Systems, Openstreetmap, Urban Data, Volunteered Geographic Information*

INTRODUCTION

Three-dimensional urban city models are used by the economy and public administration for different purposes, e.g., environmental simulations or facility management (Kolbe, 2009). Thereby, the field of application evolved from traditional applications such as network planning, typically requiring pure geometric models with low level-of-detail, to advanced applications in areas such as tourism. That is, the requirements of city models heavily increased, meaning that besides geometric information there is also a strong need for semantic information. However, the creation and maintenance of such detailed models is very expensive (Benner et al., 2005), because it is largely done manu-

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ally and automatic procedures are rare, while semi-automated approaches are becoming more and more popular.

The City Geography Markup Language (CityGML) became the international standard for storing, visualizing and exchanging three-dimensional urban city models, thus allows an interoperable access to 3D city models (Kolbe et al., 2005). CityGML models do not only contain geometric information, but also a variety of topologic and semantic information, e.g., names, building types or addresses. The creation of CityGML models typically requires high-quality data, which is usually captured and provided by professional surveyors and cartographers, public authorities or commercial data providers. Existing standards such as Building Information Modeling (BIM) or Industry Foundation Classes (IFC) have also been shown to be transformable to CityGML (Benner et al., 2005). Nevertheless, a large percentage of CityGML models are created manually by exporting the models from different CAD and 3D graphic applications (e.g., Google Sketchup).

In the last couple of years, the term Volunteered Geographic Information (VGI) became popular, whereat VGI describes that an ever expanding range of users collaboratively collects geographic data (Goodchild, 2007a). That is, hobbyists create geographic data based on personal measurements (via GPS, etc.) and share those in a Web 2.0 community, resulting in a comprehensive data source of humans acting as remote sensors (Goodchild, 2007b). Especially in urban regions the coverage of VGI data is very good, leading to an increase of the usage of VGI in urban data management (Song & Sun, 2010).

Nevertheless, the data in VGI communities is mostly used for creating two-dimensional maps (e.g., OSM, 2011a). However, one step towards the usage of VGI in a 3D platform has been demonstrated by Schilling et al. (2009). This example also shows the potential of VGI for visualizing urban regions with 3D city models, but only focuses on the visualization of the geometry and not on semantics. Therefore, the main contribution of this paper is the development and suggestion of a framework for the automatic creation of CityGML models by purely using crowdsourced geographic information from OpenStreetMap (OSM). With such a framework, it shall be evaluated and demonstrated that VGI is capable for the creation of standardized city models which can be exchanged via Open Geospatial Consortium (OGC) standards (e.g., Web Feature Service, WFS) and utilized in professional applications and analyses, e.g., the mapping of environmental noise pollution (Czerwinski et al., 2006), urban planning, city business development, tourism (Döllner et al., 2006), homeland security (Lapierre & Cote, 2007), disaster management (Kolbe et al., 2008) or indoor navigation (Mäs et al., 2006).

The remainder of this paper is organized as follows: First, the CityGML standard is described in the detail required for the subsequent work and discussion. This is followed by an introduction to OSM, providing the basics for understanding the conducted research. Afterwards, there is an overview about related work regarding 3D city model creation as well as (3D)-VGI. Thereafter, a framework for the creation of CityGML models from VGI is introduced. The last chapter summarizes the presented work and discusses future research.

INTEROPERABLE ACCESS TO 3D CITY MODELS

A model for the semantic and geometric description of urban regions is the City Geography Markup Language (CityGML) (Gröger et al., 2008; Kolbe et al., 2005). CityGML became a global standard for storing and exchanging three dimensional city models, thus allows an interoperable access to 3D city models. It is based on the Geography Markup Language 3 (GML3) (Lake et al., 2004), which is commonly used for exchanging data in spatial data infrastructures (SDI) (cf. Zipf et al., 2007) and web environments. Additionally GML3 is the native data format of the OGC WFS (Kolbe, 2009). CityGML does not only cover geometric