SMART POINT CLOUDS IN VIRTUAL GLOBES – A NEW PARADIGM IN CITY MODELING?

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ABSTRACT:

In this paper we propose the integration of 'smart' 3D point clouds into virtual globes as a highly-efficient enhancement or even replacement of conventional 3D city models. The integration of point clouds into virtual globes is at a very early stage and the presented investigations are work in progress underpinning the potential and importance of the proposal. For this purpose, we describe a testbed established within the virtual globe technology i3D for comparing different types of 3D virtual models (e.g. boundary representations and point cloud models) and demonstrate static and dynamic visualisations of this testbed. We discuss first results indicating that point clouds have the potential of dramatically enhancing or even fully replacing conventional 3D city models in many application areas.

Initially we review recent progress and trends in the fields of laser scanning, mobile mapping and virtual globes. A particularly important trend in laser scanning is the capability of providing colour or even multi-spectral radiometric information for each point. This radiometric information is either directly obtained from the laser scanning measurements or more likely obtained from integrated or co-registered high-resolution imaging sensors. In mobile mapping there has been a strong trend from the original recording of road geometry towards the capturing of rich 3D scene data using georeferenced still and video imagery as well as laser scanning data. The mobile capturing of such rich 3D scene data has promoted the development of data structures and algorithms enabling the real-time visualisation of the resulting very large geospatial data sets (e.g. Brenner, 2008). Last but not least, we review state-of-the-art and trends in the research and development of virtual globe technologies which have been boosted by the very prominent examples of Google Earth and Microsoft Virtual Earth. Recent investigations and developments include the integration of real-time contents including video imagery enabling augmented and mixed reality applications within virtual globes (Eugster and Nebiker, 2008), the integration of abstract information within virtual globes (Bleisch et al., 2008) and the use of virtual globes for real-time observations and sensory feedback (Nebiker, 2008).

In a review of recent 3D city modelling research and development activities, we observe diverging trends towards reality-based modelling on the one hand and abstract cartographic modelling and rendering on the other. In the prevailing 'traditional' reality-based 3D city modelling approach based on boundary (B-Rep) or CSG representations, there has been significant progress in the automatic reconstruction of building geometries, typically using a combination of laser scanning, photogrammetry and map data (e.g. cadastral data). Additionally, there are a number of solutions for (semi-) automatically texturing these building geometries from georeferenced oblique aerial imagery and – to a lesser degree – approaches for the automatic detection and correction of obstructions. Alternatively, building facades are being textured from ground based imagery. In practice, both automatic texturing approaches yield a number of shortcomings, namely a relatively poor texture quality and poor close-range appearance in the case of airborne imagery and numerous obstructions such as vehicles or vegetation. In conclusion, any close-to-reality 3D models with a good graphical (and geometric) quality still need to be edited manually – a very expensive process which cannot be justified in many cases. Today's 3D city models further suffer from missing or poor vegetation models. In conclusion, there is an urgent need for alternative or complementary city modelling approaches which are: geometrically accurate, efficient to obtain and update, rich of information and suitable for typical applications of 3D city models. While, for example, image-based information systems such as Google's Street View might offer some interesting alternatives, we believe that there is a far greater potential in integrating laser scanning point clouds into future virtual globe environments.

Before presenting the integration of point clouds into virtual globe environments we introduce the concept of 'smart' point clouds. In the future, 3D laser scanning point clouds acquired with mobile mapping systems will become readily available over entire cities and along all major traffic routes. This future geospatial base data is predestined to be integrated into highly scalable internet-based 3D geoinformation technologies, namely virtual globes. The term 'smart' implies that these 3D point clouds not only consist of 3D position data but that they a) include additional information such as spectral information in the visible and increasingly non-visible bands (e.g. NIR and TIR) and b) that they are automatically clustered and classified based on geometric and radiometric properties. The spatial and semantic properties of these smart point clouds play an important role in moving from visualisation environments to geospatial interaction and working environments, thus enabling the 'geoinformation loop' (Nebiker, 2008).

In the paper we subsequently describe the i3D virtual globe technology developed at the Institute of Geomatics Engineering of the University of Applied Sciences Northwestern Switzerland FHNW. i3D is a new high-performance 3D geovisualisation engine supporting the web-based streaming of very large amounts of terrain and POI data. The paper outlines the architecture, basic features and the extensions mechanism of the i3D virtual globe using the Lua scripting language. The paper then highlights selected design and implementation aspects, namely the support for 3D point clouds including radiometric properties.

In a testbed, parts of the campus of FHNW in Muttenz were modelled using different 3D modelling approaches with multiple levels of detail, including a 3D model consisting of point clouds only. These models were imported into the i3D technology and used for visual comparisons of different modelling variants, both in static and dynamic visualisations. Preliminary results support the hypotheses, that smart point clouds in virtual globes are very valuable additions to virtual environments and that point cloud based virtual models are in many cases superior to conventional 3D models. These findings also indicate that point cloud based 3D city models could make traditional city modelling obsolete – namely for vehicle or pedestrian navigation in areas with good point cloud coverage.

Changing the city modelling paradigm from conventional 3D modelling based on boundary representations (B-Rep models) to point cloud models raises a whole range of unresolved research questions. From a data capturing perspective, for example, there will be an increasing demand for low cost and lightweight mobile mapping solutions providing integrated geometric and radiometric point cloud data. New research issues in virtual globe technologies include the efficient clustering and streaming of smart point cloud data, the (incremental) updating of smart point cloud data, the interaction with such smart point cloud data and the integration of abstract (cartographic) information, such as automatically extracted 3D symbols or library objects (e.g. traffic signs). Another research issue is the usefulness of such point-cloud based 3D city models in comparison with traditional city models.