Handheld Geospatial Augmented Reality using Urban 3D Models

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Abstract
Handheld outdoor augmented reality requires geo-referenced models of the environment to present world-registered overlays to a mobile user. We present a pipeline for managing such models that cover a wide urban area. To this aim, a geospatial database must be created, maintained and delivered to the mobile user.

Keywords
Mobile augmented reality, geospatial modeling, online 3D reconstruction, 3D modeling

ACM Classification Keywords
H.5.1 Artificial, augmented and virtual realities, H.2.8 Spatial databases and GIS

Introduction
Augmented Reality (AR) is a technique to superimpose registered 3D graphics over the user's view of the real world. Mobile AR requires highly accurate geospatial databases describing the surrounding environment. To address this requirement, the models must be managed in geospatial databases which in turn are implemented and maintained using geospatially enabled database management systems (GeoDBMS).

Current data sets available for urban areas are mostly 2D or 2.5D. Often those data sets are held in geospatial databases from organizations like public authorities or utility companies. The exploitation of those GeoDBMS allows for use of comprehensive, up-to-date, consistent and highly accurate real-world data that we use in our AR applications for visualization registered in 3D. Scaling AR models to such wide area coverage is only practical by leveraging existing GeoDBMS.

Geospatial 3D models for augmented reality

We believe that the availability of geospatial models from real-world data is a key enabling factor for the success of applications for handheld devices. However, the structural complexity and the scale of the model can pose problems. Consider, for example, the task of completely modeling an urban area, down to the level of water mains and electric circuits in walls of buildings. As mentioned by Höllerer and Feiner there are significant research problems involved in such a modeling task [2].

Our work is based on the *Studierstube*[1] framework and addresses the management of urban AR models, which we organize along the lines of an information processing pipeline (see Figure 1): data acquisition, filtering and encoding, storage, delivery and use.

Data acquisition

The most effective way of creating large and accurate urban 3D models for AR is achieved by querying a geospatial database which could run on a GeoDBMS such as *Smallworld*™. An arbitrary selection of data of any spatial extent can be retrieved on demand. Examples of geospatial data sources are Web Feature Services (WFS) or servers for virtual globe browsers such as *Google Earth*[2]. Since many geospatial databases are already in productive use in areas such as cadastral survey or utility asset management, AR can largely benefit from the up-to-date data.

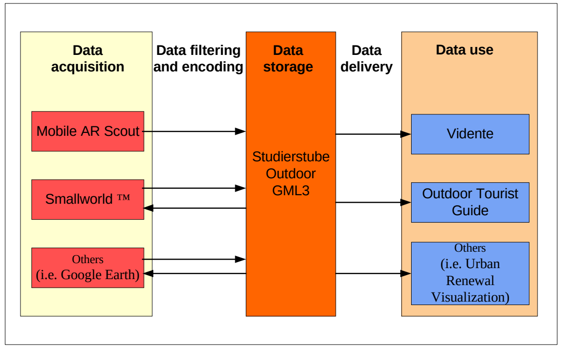

Figure 1: The management of AR models is organized as a pipeline consisting of acquisition, filtering and encoding, storage, delivery and use stages.

AR Scouting: We think that in near future, mobile AR users will participate in the update process of databases. Reitinger et al. [4] have shown the *AR Scouting* application, which allows to automatically reconstruct 3D objects from series of 2D images taken by a human user at interactive rates. The reconstructed object can be stored in the geospatial database. Figure 2 shows the pipeline from 2D input images to the GML output file.

[1] http://studierstube.icg.tu-graz.ac.at/

[2] http://earth.google.com/

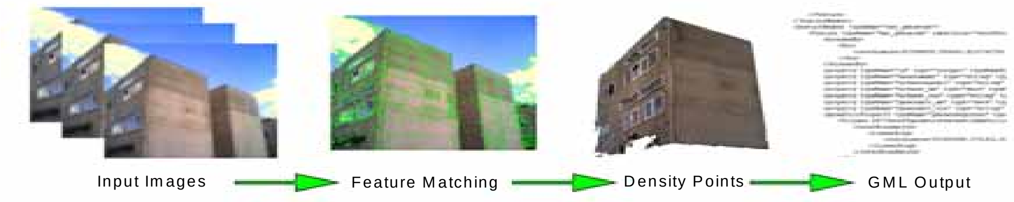

Figure 2: Pipeline from 2D images to the GML output file

Data filtering and encoding

In order to obtain a data set suitable for urban AR model, both data filtering and transcoding have to be applied to the data from a geospatial data source. Data transcoding describes the conversion of the data representation used by a GeoDBMS into an XML-based encoding for the description of the urban AR model.

Data storage

The main challenge is to find out how AR models must be structured so that they are flexible to address a wide range of AR applications. Consequently, we have begun to design an extension to the *Geography Markup Language (GML3)*[3] specifically targeted at AR. GML is an XML-based encoding for exchange of geographical objects (so-called *features)*. The hierarchical nature of XML encodings conveniently fits hierarchical modeling techniques for geometric models. We use the association mechanism to describe which feature geometry is to be used for visualization at a particular level of detail. Furthermore, the non-geometric attributes of a feature provide hints on the visualization style (e. g. color coding, size, etc). As a result of the GML design, an urban AR model can be described as a collection of multiple related features. The thus encoded 3D model provides information to allow for rapid view reconstruction in real-time.

Data delivery

For true mobility, the AR client needs to connect to the pervasive environment to obtain the urban 3D model. For view generation we use XSLT style sheets and a custom 3D visualization engine [6].

Data use

The presented pipeline allows for a clear separation of model content and presentation and provides us with the advantages of a GeoDBMS like data access control and data integrity checks [1]. This can be best explained by looking at an example application, *Vidente*.

Vidente Application

Vidente stands for egocentric visualization of subsurface infrastructure data from *Smallworld™,* providing a variety of dynamic visualization styles [3]. The user's position and orientation is given by an EGNOS enabled GPS and an InertiaCube3 orientation sensor. Users are able to roam an outdoor environment and see the subsurface infrastructure overlaid in

[3] http://www.opengeospatial.org/standards/gml

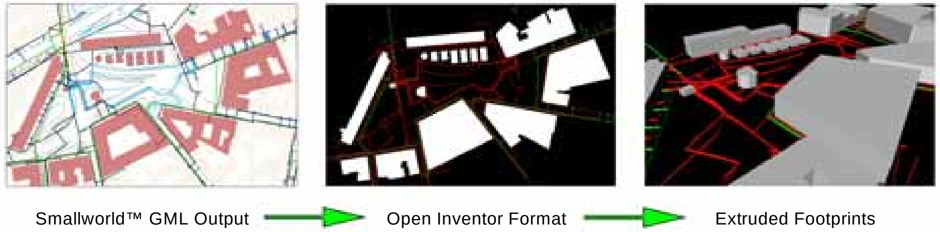

Figure 3: Pipline from Smallworld to extruded footprints

the video see through display. An example of a working *Vidente* prototype is given in Figure 4, which depicts a user with the handheld device seeing the superimposed urban AR model. Figure 3 depicts the pipeline from a *Smallworld*™ data store via the Open Inventor file format to the resulting extruded model.

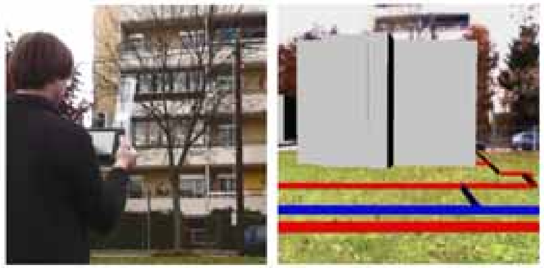

Figure 4: Tracked outdoor user seeing superimposed AR buildings and subsurface infrastructure (e. g. water mains)

Summary

For managing urban AR models we have shown a pipeline taking advantage of existing urban databases. A major strength is the extensibility of the urban AR model through both transcoding of large geospatial databases as well as online reconstruction of 3D objects. This is an important step towards our vision of allowing a mobile user seamless and intuitive spatial interaction in a pervasive environment.

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