A pipeline for procedural modelling from geospatial data

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Abstract

Virtual urban environments can be used for purposes like municipality planning and management. Due to the complexity and large extent of these environments procedural modelling techniques can be used to generate these 3D environments automatically. However these methods need large amounts of spatial data, that is generally available through Geographic Information Systems (GIS).
This paper presents a pipeline to integrate semantics and GIS data into the procedural modelling techniques used to recreate virtual urban environments. GIS data can already be used in procedural modelling tools but it does not incorporate semantic information. As such, this pipeline is capable of transforming semantic and geometric data contained in GIS into three dimensional models that represent such urban spaces.

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1. Introduction

Procedural modelling tools can be used for the generation of virtual urban environments, reducing both the amount of human interaction needed as well as modelling times and costs. Although producing good results for fictional spaces, these techniques still present some limitations to generate accurate 3D models of real urban areas. Furthermore, municipalities often store semantic data of urban features in GIS that could be integrated as the data source for the procedural modelling.

Section 2 presents a brief overview on related work, followed by a presentation of the proposed pipeline and a description of its three stages in section 3. Finally, conclusions are presented along with future work in section 4.

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2. Related Work

Procedural modelling of urban environments originates from the use of L-Systems [PM01]. Its limitations led to the development of CGA Shape [MWH*06], a shape grammar capable of producing architectural models with high detail, that is integrated in CityEngine. CityEngine allows importing GIS files directly, but since data models may differ, it is necessary to adapt existing production rules to different cases.

Nevertheless, these systems lack the support for complex spatial queries. As such, Geospatial L-Systems were introduced [CBSF07] as an extension of parametric L-Systems incorporating spatial awareness. Combining the ability of data amplification provided by L-Systems with the geospatial awareness of GIS it is possible to integrate the semantic data of GIS data sources in the axioms that are fed to the production rules of the modelling processes.

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3. A pipeline for geospatial data

To meet the research goals we propose a pipeline capable of generating 3D environments, resembling real spaces, based on GIS data incorporating semantic attributes. This pipeline can be implemented in a distributed architecture and can be easily integrated into procedural modelling systems, as long as they provide means of external manipulation. This pipeline consists in three steps (see figure 1).

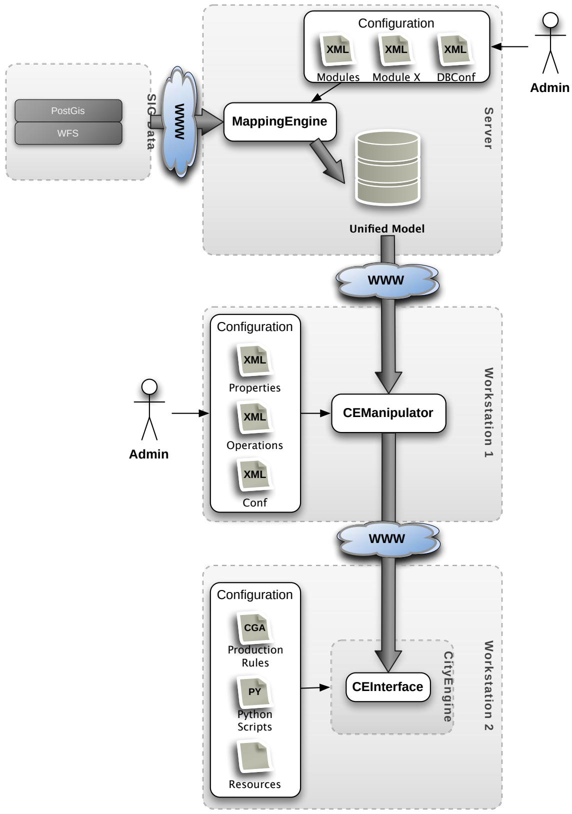

Figure 1: *Pipeline for procedural modelling from geospatial data*

The first step maps the original data into an unified model based on an Urban Ontology [MSCS12] allowing for modelling processes that are both uniform and independent from the original data source. This Urban Ontology defines several urban features (e.g. Buildings and Roads) and their attributes in a consistent manner. It also supports user defined attributes allowing to adapt to different cases. To accomplish this step, the concept of Mapping Module was introduced, being responsible for the mapping of several urban entities into the unified model as well as geospatial awareness. After this step, the unified model contains the relevant data in a uniform manner (e.g. buildings with height data and roads with pavement type). The Ontology also defines several Levels of Mapping (LOM), describing the minimum amount of information required for each level and feature [MSCS12]. Some processes will only require the building footprint and its height (LOM1) while others need information about the facade description for each floor (LOM4).

However, the procedural modelling phase expects a consistent amount of data (i.e. in a specific LOM). As such, amplifying features in a lower LOM to correspond to the expected one (normally the highest the tool permits) becomes necessary. The second step does this through the use of LOM Converters which infer new data using some heuristics.

The last step takes on the responsibility of procedurally generating the models for the urban environment. The Esri CityEngine® software was used in this study (see figure 2).

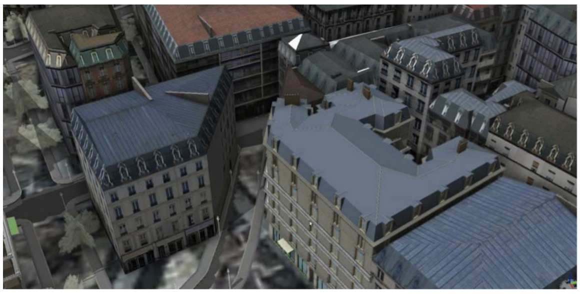

Figure 2: *City model generated from municipal GIS*

4. Conclusions and Future Work

The main contribution of this paper is the development of a three stages pipeline providing semantic data to the modelling process of virtual urban environments, separating GIS from procedural modelling, promoting reusability.

The Mapping Modules were developed specifically for the study case and, as such, there is a need for more generic and configurable Modules, as well as LOM Converters for all the entities and mapping levels. Further research on metadata will provide the automation of the mapping process.

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