PROCEDURAL MODELLING OF MONUMENTAL BUILDINGS FROM TEXTUAL DESCRIPTIONS

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Abstract: The generation of three-dimensional models of urban environments using procedural modelling is presented as being a solution which allows financial and temporal gains, maintaining an acceptable visual fidelity level. Nevertheless, the modelling of anchor buildings (or monumental), identifying certain urban areas, needs a more careful modelling due to the high level of detail necessary, using, generally, manual modelling. We present an automation proposal of the building modelling process through the introduction of additional knowledge from textual descriptions in a procedural modelling system. The results show that the data model is flexible enough to build distinct models of churches. The data model can also provide an initial structure for high level modelling, providing the global shape for the building and the location of doors, windows or other structures. High detailed models can be built from this initial structure. The results demonstrate also that it is possible to create a 3D model from a text and thus permitting that non-specialised users may increase effectiveness using a procedural modelling system.

1 INTRODUCTION

Virtual Reality is being used in diverse areas, from leisure applications, such as digital games until more technical uses, like urban planning. The technological advances have lead to the vulgarization of its use, showing the way to an improvement of the services offered and to cost optimization.

Although there are several interactive tools for 3D building reconstruction, these demand specialized technicians and great amount of informatics resources. The use of procedural modelling tools for generating urban buildings, allows a great reduction of costs, either by the non-use of specialized technicians, or by the reductions of the time spent during its execution.

Among the most representative buildings of an urban environment, the monuments are the ones that need more detail, in order to be easily recognized, increasing the modelling time, and being therefore more expensive.

Although procedural modelling allows saving time and money, the definition of the modelling processes for monumental buildings can be quite complex, because most of these tools are based on formal grammars which also demands for highly trained professionals. This way, we introduce a proposal for procedural modelling of buildings from a descriptive text that can be used on the modelling process. The descriptive text is converted for an intermediate format in XML, being then converted to cityGML (Kolbe, Gröger *et al*. 2005).

The article is structured like this: in section 2 we will present some related work in this area, showing the architecture proposed in section 3. Section 4 will display some of the results and in section 5 will present the conclusions and future developments.

2 RELATED WORK

2.1 Three-dimensional Modelling

The creation of three-dimensional models of buil-

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dings for urban environments is a long lasting process that can be used in archaeology (Pollefeys, Proesmans *et al*. 2000), (Uotila and Sartes 2000), (Bernardes and Martins 2003) and (Frischer 2008), in environmental simulations and in architecture or urban planning (Shiode 2001) (Döllner, Kolbe *et al*. 2006).

The proposal cityGML (Kolbe, Gröger *et al*. 2005), covers the geometric, topologic and semantic aspects of three-dimensional urban models. It is a free format and based in ISO standards and sustains 3D simple or complex geometry and topology. It stores not only the geometric information, referring to shape and topologic characteristics of buildings, but also semantic information, with a correspondence between the geometric object and the semantic object.

2.2 Procedural Modelling

The costs and time used to model urban environments have led to the appearance of some research works for automating those tasks, aimed to the creation of procedural modelling solutions.

There are two guidelines for this process, automating the collecting process and data interpretation or enlarging the original data through a wider base of knowledge.

In the first case, it is necessary to collect a wide set of information about the environment to be modelled. Beside photos and video, the data can also be gathered from three-dimensional point meshes or from laser or x-ray sweeping.

In the second case, the widening of the original data is obtained through mathematical tools, which amplify the original information. The L systems and shape grammars are among the tools that allow a high level of data amplification.

With the proliferation of informatics systems, information has become available in several sources and often, not compatible. A proposal of semi-automatic expeditious modelling (Coelho, Bessa *et al*. 2007) proposes a system for modelling urban environments, with access to different information sources, and that uses L systems to carry out the modelling.

The works of Wonka and Müller, from the definition of split grammars (Wonka 2003) to the development of CGA Shape grammars (Mueller, Wonka *et al*. 2006) allows the creation of detailed building facades (Mueller, Zeng *et al*. 2007).

In the range of graphic computing, a system (Liu, Xu *et al*. 2006) was presented for the reconstruction of old Chinese houses, using a semantic model. This system converts the geometric components, like points, lines or triangles into semantic components, such as, streets, blocks and houses.

3 PROCEDURAL MODELLING OF BUILDINGS FROM TEXTUAL INFORMATION

In this section we describe a modelling process for extracting all relevant information, from textual descriptions, in order to create a 3D model. Since this is a complex process it has been divided in several development phases.

In the first phase, the system reads a text that describes a simplified monumental building using a simple grammar.

The proposed modelling process will generate a 3D model of a church, in cityGML format from a natural language text, written in Portuguese.

Figure 1 presents the general architecture scheme of the modelling process.

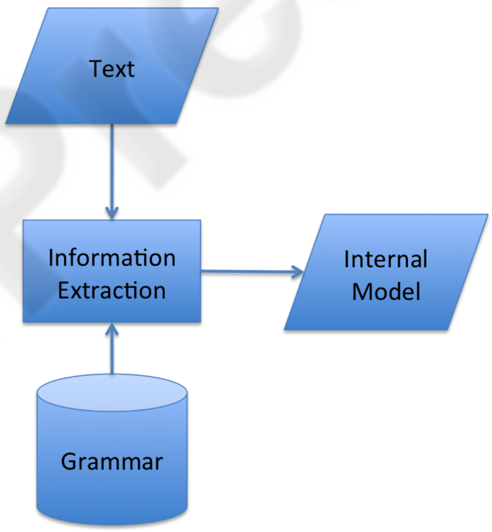

Figure 1: General architecture.

The modelling process is divided in two stages:

- Extraction of the model’s characteristics, contained in the text file written in natural language, for an interoperable format and stored as a XML file. This file should obey the specifications of the XML scheme from which we can see an extract in figure 2;
- Conversion of the data model to a 3D model, in cityGML format.

```
<xs:element name="building">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="type" />
      <xs:element ref="name" />
      <xs:element ref="main" />
      <xs:element ref="towers" />
    </xs:sequence>
  </xs:complexType>
</xs:element>
```

Figure 2: Extract of XML scheme of the internal model.

3.1 Natural Language Processing

The information extraction module, was developed using NooJ (Silberztein 2004). This grammar uses the recognition resources implemented by the portal Port4NooJ (Ribeiro 2008), having been developed specific resources for this area.

The formats of churches and their descriptive texts have been analyzed, and a typical text has been created for this type of building that describes it realistically.

Therefore, the text should indicate the type of building being analyzed, describing its constitution in terms of buildings or towers. The text should also indicate the relative position of the towers.

A generic church can be described by a text as the one presented in figure 3.

"The church of XYZ has a main body and 2 towers.
The bell tower is on the right and front.
The tower is on the left and front."

Figure 3: Textual representation of a church.

The information extraction module, retrieving the related information for the data model, processes this text.

3.2 Data Model

The data model can store one or more buildings, but the first building is set as the origin of the referential. All buildings can be composed by a main body (or central wing), one or more towers and one or more entrances.

All buildings have, necessarily, a main body. Figure 4 shows an extraction of the XML internal model created from the Figure 3 text. The description of a building must always be carried out with the observer facing the main entrance.

For each tower, besides its attributes (length, width, height and span) one must also refer the position in relation to the main building and axis X and Y. Then, the posX may assume the value "left", "centre" or "right", being also indicated, in percentage, how much of the tower is (or not) inside the main building. In the case of posY, the possible values it can assume are "front", "middle" or "back". In case it is not mentioned in the text what the value of this percentage is, the natural language processing module assumes that the tower is leaning against the building. The shape of the roofs is also automatically associated to the type of roof, having a pyramid shape in the towers and a triangle in the others.

```
<main ID="XYZ">
    <location>
        <x>0</x>
        <y>0</y>
        <z>0</z>
    </location>
    <features />
  <doors />
    <windows />
  </main>
  <towers>
   <tower ID="A">
     <position>
       <posX deviation="-1.0">right</posX>
       <posY deviation="1.0">front</posY>
    </position>
…

    <features>
       < bell / >
    </features>
  <doors />
    <windows />
   </tower>
…
```

Figure 4: Extract from XML file, representing a church with two towers.

3.3 Creating the 3D Model

The data model contains semantic information that identifies the type of building (main or tower) and also information about its position. A geometric shape corresponds to each type of building, as defined for this prototype phase. This way, it is possible to convert this data model to a 3D representation. We choose cityGML because it is possible to combine semantic and geometric information and has several levels of detail.

We created two types of buildings that correspond to the two main structures presented in the data model, the main building that represents the church core building and the tower that in most of the cases has a bell or a clock.

This module explores each XML node from the data model, checks if the node represents a structure, and creates the cityGML building represented in that node. The type of structure and the level of detail used define the final shape of the building. Highly detailed templates can be used for each component (door, window or facade) or basic solid geometries.

We have developed a module that converts the data model into cityGML. This module was created using a free library provided by cityGML and called citygml4j.

4 RESULTS

To test the prototype a couple of churches from Oporto were created. Figure 5 shows some cityGML3D models.

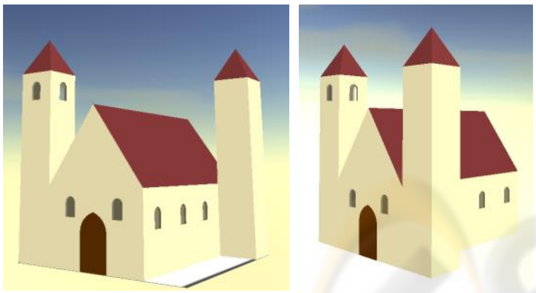

Figure 5: CityGML models created by the prototype.

5 CONCLUSIONS AND FUTURE WORK

The results demonstrate that the data model of the prototype is flexible enough to build countless church models, with an acceptable level of realism in LOD3. The results also show that it is possible to create a 3D model from a simple text.

This way, future work will concentrate in increasing the level of detail of the model adding textures and evaluating the use of the model for high level modelling, since detailed doors and windows would increase the level of visual fidelity.

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