Architectural Styles Dependent Shape Grammar Representation of Facades

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Abstract

In this poster, we present an idea to utilize formal rules and descriptions for architectural styles from various time periods. We focus on facades of historical buildings with identical purpose located in a specific geographical area. We have chosen the CGA shape grammar as a formal language to represent and visualise the rules and we demonstrate our approach on facades of the residence-type historical buildings located in Prague. Our aim is to show that differences in formal descriptions of various buildings are tightly related to differences in architectural styles. Having a proper metrics for such CGA grammars, we will be able to generate new virtual buildings of certain architectural style and to control their possible transitions among distinct styles.

Categories and Subject Descriptors (according to ACM CCS): I.3.6 [Computer Graphics]: Methodology and Techniques—Languages, I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Virtual reality

1. Introduction

The procedural modelling of cities, in which we can generate an urban scene by a set of rules, started in 2001 by Parish and Müller [PM01]. Since this time, various sub-problems have arisen in this field. Procedural modelling of buildings and facades is one of them. A shape replacement method is often used in city generation. A grammar called Computer Graphics Architecture (CGA) was presented in 2006 [MWH*06] especially for creation of cities. Mass models are the basis of the building structure and rules derive a design of objects by iterative generating details by non-terminal rewriting. Rules operate on the geometry in a locally oriented bounding-box. The CGA enables basic geometric transformations and also extruding, splitting etc. In 2007, a paper about inverse procedural modelling of buildings was published [ARB07]. Authors presented an interactive tool that generates a formal descriptions of a given building. However, their approach does not fulfil our requirements dealing with keeping and measuring architectural style differences.

2. Architectural Styles and Formal Rules

Every architectural style can be understood as a mirror of the specific time period and culture. Each style has its own rules, construction materials, typical features, characteristic parts and shapes. There are differences in a segmentation (regular, irregular, symmetric, chaotic) and fractal dimension of facades from miscellaneous historical eras. Our aim is to formalise this knowledge and use it in the procedural modelling of architectural styles.

In our opinion, descriptions of the same style, but for buildings created for various purposes (e.g. religious or secular) are distinct. On the other hand, all buildings of the same kind (e.g. train stations, churches, town halls) keep their own characteristic parts. Footprints and silhouettes of one kind of objects (but from different centuries) are significantly similar. For example, church towers have different shapes in detail, but they have the same rough characteristics (thin, tall, narrowing to top), which clearly distinguishes them from other kinds of buildings. Configurable property of appearance is also symmetry (of footprint or front facade). The footprint is symmetric mainly when there is a lot of space (e.g. manor houses). On the other hand, an adaptation to natural environment (e.g. castles on rocks) implies an asymmetric shape. Differences also depend on location binding. For example, gothic cathedrals in continental Europe and in England are distinguishable on the first view. There can be influences from other culture or religion on the design of buildings, which is often visible on country boundaries. Sometimes, it is hard to recognize an architectural style, because

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the building may contain a mix of styles. We intentionally avoid such buildings in this phase, however, this style transitions will be taken into account when new virtual buildings will be generated upon the rules describing pure styles. The appearance of a building depends also on owners and architects. Moreover, the same building changes in time. Various uses of building during centuries, the elements, other priorities in lifestyle may influence the appearance of building. The layout of street network has been changing through history and sometimes it affected the arrangement of buildings and their shapes. We believe that rebuilds are more often visible on large scale buildings than on smaller ones.

Formal rules and descriptions of buildings should consider all characteristics mentioned above in order to both generate buildings of various styles and compare differences among existing ones.

Figure 1: *Front facade of (a) the Tuscany and (b) the Thun-Hohenstein Palace in Prague. On the right side are facades created by CGA shape grammar.*

3. Case Study

We have chosen the Tuscany Palace and Thun-Hohenstein Palace in Prague, which were build at the turn of the 17th and 18th century and which are examples of secular, baroque architecture in the city. They are built in one style, have similar usage and are located nearby. This eliminated differences mentioned in Section 2. For simplicity, we concentrate on front facades only (Figure 1). From those two facades, we have created rules in the CGA grammar. We have tried to catch and keep an architectural style specific to this kind of buildings when creating a hierarchy of CGA rules. The resulted grammars then have similar shapes that can be measured, compared and evaluated. For comparison of our two palaces, it is possible to find the same parts and also differences in their hierarchies (Figure 2). For example, the second facade does not have balconies. Within these grammars, we can measure and compare regularity or chaos of decorations, windows placement on facade, absolute or relative sizes, ratio of elements, a number of the same or different objects, existence of architectural components, repetition of elements, average dimensions or colours of objects and much more. Then, we receive rough rules that describe a given architectural style for selected kind of buildings.

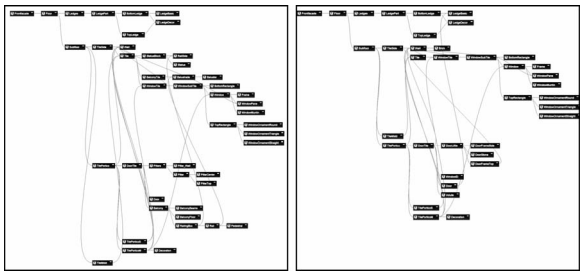

Figure 2: *Two facades described using hierarchies in CGA.*

4. Open Issues

To efficiently compare and evaluate a formal description of historical buildings, several issues have to be solved. Firstly, we have to collect a representative number of buildings together with their CGA grammars. We also need to define semantic rules for CGA creation in order to obtain such sets and hierarchies of rules that are comparable, where it is necessary to define the smallest detail that is to be generated. Another point is to specify a metric for comparison of differences in numerically measurable quantities (sizes, counts). The last issue is a proper definition of a metric that will allow us to measure differences in structures of CGA grammars.

5. Conclusion

We introduced a new idea, which enables the creation of architectural style according to formal rules and using it for newly generated virtual buildings. We have presented an example on two residence-type historical buildings in Prague and an idea of extraction and comparison of rules defining an architectural style.

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