Virtual World Grammar

(Extended Abstract)

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ABSTRACT

Organization-based multi-agent systems (MAS) can be represented by means of 3D virtual worlds facilitating then the interaction among participants, i.e humans and agents. In this paper we propose a system that can automatically generate a 3D virtual world from formal specifications of both a MAS and a design visual style (i.e a shape grammar). We propose an extension of shape grammars in combination with virtual world paradigms, called Virtual World Grammar (VWG), to support the design generation process. Virtual World Grammar includes semantic information about both MAS specification which establishes the activities participants can engage on and shape grammar elements. This information, along with heuristics and validations, guides the generation process and allows us to produce functional designs. The Virtual World Builder Toolkit, integrated in our Shape Grammar Interpreter tool, supports both the definition and execution of the Virtual World Grammar.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent systems; H.5.1 [**Multimedia Information Systems**]: Artificial, augmented, and virtual realities

General Terms

Algorithms, Management, Design

Keywords

Shape Grammars, Virtual Institutions, 3D virtual worlds

1. INTRODUCTION

Hybrid virtual worlds populated by both humans and agents can be used in many different domains, as for instance, e-commerce, e-goverment, e-learning or for participatory simulations. The construction of such a 3D virtual world is a process usually performed by graphic designers, which model the world depending on some specification properties. Upon the change of specification properties, the graphic designer has to rebuild the design and so the visualization of the virtual world. There are several approaches that have worked in the generation of VW designs from conceptual specifications [1][4]. These approaches bring some challenges for the scaling of the sizes of the different rooms and the flexibility of the generated design. In this paper we propose a system that can automatically generate the 3D virtual world from a multi-agent system specification, therefore it eliminates the problem of the "by hand" and hard modifications of the virtual world design. Our system relies on the shape grammar technology, that allows us to generate many different functional designs with limited additional cost.

We propose an extension of shape grammars in combination with virtual world paradigms, called Virtual World Grammar (VWG), to support the design generation process. The Virtual World Builder Toolkit, integrated in the Shape Grammar Interpreter tool [3], supports a definition and generation of VWG.

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2. VIRTUAL WORLD GRAMMAR

A Virtual World Grammar includes a shape grammar and semantic information about both MAS specification and shape grammar elements. This information, along with heuristics and validations, guides the generation process and allows us to produce functional designs. In the following we give a brief description of virtual world grammar parts:

- An *ontology* is a formal definition of the relevant concepts of a domain. In the context of a virtual world grammar the ontology contains two different kind of concepts that are necessary during the generation process. On the one hand those related to the description of the activities that will take place in the virtual world. They define how the activities are conceptualised, the relationships among them and in the combination with shape grammar determine the *structure* of the virtual world. On the other hand, there are the concepts that define the *properties* of the virtual world elements. That is, the properties of the shapes in the virtual world design. Hence, the ontology defines the properties containing semantic information about those shapes that are later used during the generation process and to validate the obtained design.

- A *shape grammar* is a method of generating designs by using primitive *shapes* and the *rules* of interaction among them [2]. Shape grammar rules are composed of left-side shapes and right-side shapes, where a right-side shape of a rule replaces a left-side shape. Designs

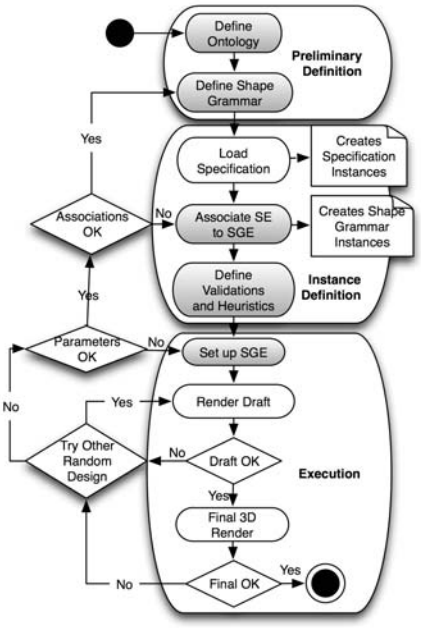

Figure 1: Workflow for definition and execution of VWG

are generated from shape grammar by starting with the initial shape and recursively applying its rules.

- *Validations* provide mechanism for testing and evaluating the execution of a shape grammar. Validations can be evaluated in two different stages of generation process. Specifically, they can be evaluated after each generation step (*step validations*) or at the end of the generation process (*final validations*).

- *Heuristics* guide the process of world generation. They have two important roles. First, to decide in which order to process the elements from the specification. Second, how to find possible rule to execute in the curent execution process for currently selected specification element.

Definition and execution of the virtual world grammar is supported by our Virtual World Builder Toolkit, a plugin for our Shape Grammar Interpreter [3]. This toolkit consists of a set of visual interfaces for the definition of VWG and a set of algorithms for the execution of VWG.

3. WORKFLOW

Virtual World Grammars bring many creative possibilities into virtual world design process. Designers have the possibility to explore many different designs based on shape grammars. Shape grammar elements serve as a visual style sheet for generation process. Trying different values for parameters, or even having prepared multiple sets of instances brings possibilities of *theming* or *skinning* virtual worlds. Figure 1 describes the workflow process for the definition and execution of a virtual world grammar. Depending on the results of *draft* or *final* generation we can readapt the grammar.

a) Floor Plan b) 3D Model

Figure 2: Virtual World Grammar outputs

Designer can either browse possible designs or modify existing parts of the shape grammar to obtain satisfiable results. The workflow is divided into three main parts. First, in the *preliminary definition* user defines the ontology of the grammar and a shape grammar. Second, in the *instance definition* user loads the specification and creates and defines all specification instances and shape grammar elements. Finally, in the *execution* designer browses random designs and modifies instance parameters to produce the 2D draft (see Figure 2a) and transforms this draft to 3D (see Figure 2b).

4. CONCLUSIONS

In this paper we have presented a virtual world grammar for the automatic generation of 3D virtual worlds in which inhabitants can be both humans and agents. The VWG holds semantic information about a multiagent system specification, describing activities and relationship between them, a shape grammar, introducing design elements and their characteristics and a list of validations and heuristics guiding the generation process. The Virtual World Builder Tollkit provides a user-friendly interface allowing a comfortable definition and execution of virtual world grammars. An important feature of the VWG workflow is that the user can explore many different designs or modify existing parts of the shape grammar to explore new designs. In the near future we will study run-time features contemplating both MAS system and virtual world events.

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