Populating Virtual Environments using Semantic Web

Emanuele Ruffaldi and Chiara Evangelista and Massimo Bergamasco
PERCRO
Scuola Superiore S.Anna
Pisa, Italy
{e.ruffaldi, chiara, bergamasco}@sssup.it

Abstract

Keywords--- **Visualization, Virtual Environments, Ontologies.**

The construction of Virtual Environments from information is based on the choice of a representation and of a metaphor of interaction. The operation of mapping from the information to the representation is domain specific, and the flexibility of Virtual Environments makes it a complex task. The concepts and technologies introduced by the Semantic Web not only provide new sources of information but they can be used in an effective way to construct Virtual Environments. This work proposes an approach to create multimodal representations of ontology based information that can be presented in an information landscape tool.

1. Introduction

The creation of a Virtual Environment (VE) is a domain specific task that can be decomposed in design operation. The initial operation is the choice of a metaphor of representation of the information, starting from its visual appearance and the spatial relationship between the information units. With the development of multimodal Virtual Environments this design phase has been enriched with the introduction of additional channels, like visual, physical and haptic.

The mapping of non-semantic based data into visual representation has been well discussed, but the technologies of the Semantic Web offer new possibilities that has to been explored.

The conceptual model of Virtual Environment discussed in this paper follows the Model View Controller approach. The Model is the information, the View is the multimodal representation of the information, and the Controller is the interaction paradigm with the user. Basically the Virtual Environment is made of objects that can have one or more visual representations in three-dimensional space and can be interacted by the user.

This paper presents an approach to populate virtual environments from semantic data using a set of rules. The user defined ontology is mapped onto a VE ontology that can be used to describe multimodal object in the virtual environment.

Furthermore we present how a non-semantic enabled visualization tool has been extended to use the VE ontology for the construction of the VE.

This paper is organized in the following way: first related work is presented relatively both to data mapping and semantic approach. Then follows the description of the proposed architecture, the VE ontology and the rule system. Next we present the visualization tool (VTEXGL) and how it has been extended for presenting the VE ontology. We conclude with an example application and some consideration for future work.

2. Related Work

The presentation of information through VE has grown with the computing power and over time better metaphors of representation have been searched. Robertson [1] presented how the technological advances have created new possibilities in the information presentation field. Although the improvements on the technological side and the reduction of visualization system costs, some problems remain.

One of this problems is how the information is mapped into Virtual Worlds. [2] (Santos and al.) addresses the problem on a specific domain through the selection of different metaphors (see also [7]). An approach for mapping is through the use of a template matching algorithm, in which the developer defines a set of rules for the selection of information into items, and how each property of the item is associated to visual properties. Such solution has been deeply discussed in the Web for the separation of presentation and content. Cascade StyleSheets (CSS) are a first example of this matching approach, but the real difference has been made by XBL and sXBL [3]. The solution proposed by XBL is to extend the HTML vocabulary (or in general the visualization vocabulary) by new words, that aggregate simpler elements and provide new interaction logic. Moreover XBL has a matching system for mapping RDF based information into visualization tags.

The standardization of knowledge management technologies in the Semantic Web opens new possibility both in the expressiveness of the visualization vocabulary and in the mapping technology. Most of work has been done on generic visualization of ontology in the Semantic Web [4] [6] [8], in which the greatest problem is the aggregation of the entities and the presentation of their relationships. A more domain specific solution has been presented in [5] where knowledge-management is used on both the ends of the visualization pipeline.

The full knowledge-based approach for visualization requires the definition of a visualization ontology (one of the objectives of [9]). The vocabulary for multimodal VE is the starting point for the integration of the Semantic Web technologies in the visualization fields.

3. Architecture

The new solution proposed by this work is to identify an Ontology for VE and to use reasoning tools to transform an initial data set, expressed in a user defined ontology, into the ontology for construction of VE.

The conceptual model of VE is made of a set of objects that have multimodal properties, and expose some actions to the environment. The objects can be organized in a spatial hierarchy and the user can interact with them depending on manipulative properties. The image (1) shows the building block of this VE model. The concepts that describe these objects are the objective of the identification phase of the VE ontology.

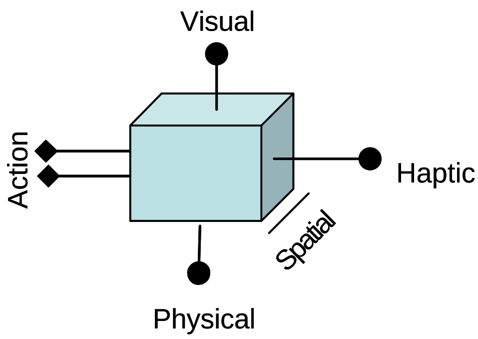

Image 1 VE Building Block

The image (2) shows how the same object (in this case a statue) can have multiple aspects, in this case (from left to right) a visual texture, a geometry, an haptic texture for haptic bump mapping, and a simplified geometry for physic simulation.

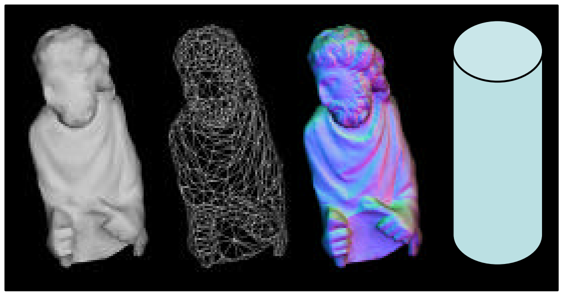

Image 2 Object's aspects

The building blocks can be grouped logically into more complex blocks, and they are the result of the transformation from the initial data set. Concepts in the data set are selected, transformed into objects, and their properties transformed into other objects or simple properties.

The instances obtained from this transformation are sent to the visualization engine (VTEXGL), that can be used to navigate and manipulate the initial data set.

The knowledge based system and the reasoning mechanism are based on the standard Semantic Web technologies, built around RDF (Resource Description Framework), in particular OWL (Web Ontology Language). The introduction of XML provided an abstraction over the syntactic aspects of data representation but syntax is not enough for supporting intelligent information exchange. With RDF Schema first, and OWL later, it's possible to construct hierarchies of concepts (classes) that can be related each other and can be subject to constraints.

4. An Ontology for Virtual Environments

The ontology for VE has been defined using the typical phases of Specification, Knowledge Acquisition, Conceptualization and Implementation. The Specification phase has not to be complete, in terms of all the possible features of a VE but it has to present a simple but functional solution. The Knowledge required for the construction of this ontology comes from the experience of PERCRO in VE development, where graphics, haptics and physics are integrated in a single system [10].

Actually the ontology for VE is an ontology set where the core component is the multimodal object described above, and its additional properties are stated by satellite ontologies.

4.1 Ontology Set Description

The ontology set will be composed by the following sub-ontologies:

4.1.1. Core VE Ontology

The core VE ontology defines the building block of the VE, with its extensibility features, and its spatial properties. Each object is inserted into an hierarchy of objects with relative position and orientation; additional spatial properties are defined through the use of the layout concept, that specifies how to organize children objects (e.g. as a grid or sphere). Layouts could be extended by supporting typical information visualization algorithms (like treemaps or cone-trees).

4.1.2 Physics Ontology

Physical Based Modeling is one of the more recent aspects in development of VE that was excluded because of its computing requirements. It introduces an additional level or realism and it is fundamental in simulation environments. The physical model behind a hierarchy of objects can be a separate physical model for each object or a single simplified model.

Each object can be associated with a physical shape (that can be a simplification of the visual shape), a mass, and friction. The concepts related to joints can be taken out in this initial release of the ontology.

4.1.3 Visual Ontology

This sub-ontology covers the aspects of visual presentation of the object, like the graphic shape, the material properties and lighting effects. The graphic shape of an object can be used also as the physical and haptic shape without simplifications.

4.1.4 Audio Ontology

The initial audio ontology takes into account only object as audio sources themselves, with all the spatial audio properties. The concepts relative to audio effects caused by object collision or haptic rendering have been taken out.

4.1.5 Haptic Ontology

This ontology contains the concepts for the specification of haptic properties of an object in the VE. The stiffness is the simplest property for haptic rendering but it can be augmented by using haptic textures that can simulate bumpy surfaces [11].

5. The visualization tool VTEXGL

The visualization and navigation of the VE is performed using an Information Landscape based tool called Virtual Text-o-Graphic Library (VTEXGL) [13]. It is a presentation and authoring system for visualization of information spaces based on a XML dialect called ILX, Information Landscape Xml. The ILX provides an hierarchical organization of content, that is presented using spatialized text element, images, and pure three-dimensional objects. This content can be generated by a web server using standard hypertext tools, with the possibility to access information stored in a database. The image (3) is an example of landscape for book reading.

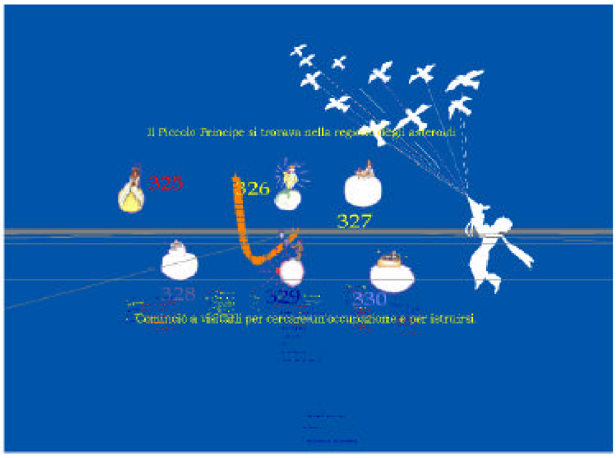

Image 3 VTEXGL Example

The elements of the landscape can be connected using visual hyperlinks that represent the three-dimensional version of standard web links. A support for the JavaScript language provides the required flexibility for the construction of interactive environments. The user can navigate and interact with the environment using standard input devices or haptic devices (e.g. Phantom or GRAB).

The standard solution of VRML has been discarded because of performance problems in text visualization, and the need of a stronger interaction with devices and the need for novel graphic effects.

The integration of the semantic aspects into VTEXGL has been performed on the Web Server side. The Web Server translates the RDF representation of the instances of the VE Ontology into ILX tags. The reason for this choice was to keep the visualization tool simple and lightweight. Eventually a Java version of VTEXGL could integrate on the client the rule system component and the semantic management tools..

6. Example

An example case of this work is the visualization of emails in a VE. A similar functionality can be found in a 2D GUI application that is RDF enabled [12]. For this example we assume that an ontology for Email has been defined with the simple concepts of email, attachment, user.

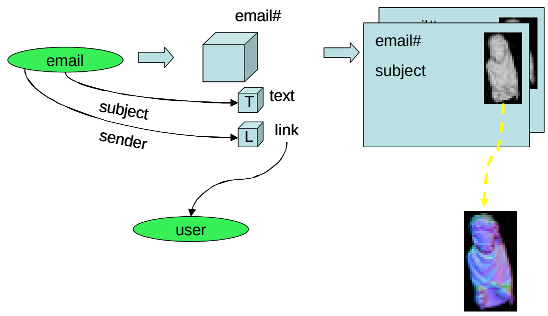

Image 4 Transformation Example

In this case the rules transform each email into a detail form, that has a simplified version of the sender user and a navigable link to the complete – avatar based representation of the user.

Conclusions

In this work it is proposed an approach for the construction of VE based on semantic content through the definition of an ontology for VE and transformation rules from the source ontology. The main contribution is the overall description of the approach and the prototype implementation that is based on the evolution of a non semantic enabled visualization tool (VTEXGL).

Actually the entities defined by the VE ontology are passive but a very promising evolution would be the integration with entities that provide actions and that can invoke web services.

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