Applying Semantic Rules for Web Based Virtual Environments

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Abstract: There have been vigorous advances in the area of virtual reality and interior decoration. Our system innovates by automating the application of high level aesthetic rules to virtual worlds. The system takes advantage of three dimensional presentation technologies for the world wide web such as Web3D and appropriate vocabularies such as ontology languages (OWL). End users may thus edit their desired room or scene via the web and then apply high level aesthetic and decoration rules.

Keywords: virtual reality, semantic web, case based reasoning, decoration

1 INTRODUCTION

The evolution and spread of virtual environments has led to significant production of interior design artifacts for virtual reality during the last years. Such artifacts that are offered in groups, libraries or individually but there is only limited, if any, functionality for efficiently combining them for the purposes of decoration that is, though the application of high level rules that directly reflect decoration styles, or directives. Through systems such as the one presented in this paper, vendors can describe their products in a standard way, suitable for use by interior design & decoration artifact vendors that take advantage of the internet. Such systems may lead to easier and more efficient design and decoration of virtual worlds, however implementing the general case inevitably has to address a number of technological issues. First, the basic type of information necessary to describe all objects and their aesthetic value within a virtual environment must be identified. That is, how the basic information about characteristics or value of objects/artifacts would be represented, where it can be stored, how or if such information can be acquired from the visualization or the virtualization technologies.

Currently, there are very few, if any, attempts to organize the descriptive information of visual objects in terms of a specific ontology for interior design. There are scientific papers that cover the need for the existence of architectural ontology, without specifying specific ontological form; at the same time the need and benefits from the use of ontology in architecture, interior design, cultural services etc is clear, due to the capabilities such a representation would offer. Our system attempts to introduce a suitable schema for keeping the aesthetic qualities of objects that is, features such as multiple languages, information for the disabled, and more. Unlike CAD tools that take advantage of data about visual objects, as offered by the technology that implements them, and leave all types of decisions to users, our system has aimed to support all types of aesthetic qualitative characteristics and correlate them in order to infer decorative relations among them and thus facilitate the user in selecting matching components. It has been essential for such a system to review the existing standards for decorative information description and identify the ones capable to support its purpose. And then, pieces of this information or descriptions of artifact objects need to be shared through the world wide web and also need to be exploitable by visualization tools.

The rest of the paper is organized as follows: section 2 presents the related work as far as research and current practice in the relevant fields are concerned, section 3 presents the our platform architecture, components and how it can be used. Section 4 presents our conclusions and future work.

2 RELATED WORK

Web3D technologies have seen a significant rise during the last decade, especially as WebGL have become widely accepted. Other technologies such as X3D have existed for a long time however, recent advances in hardware and software allow for significant progress in integrating interactive 3D graphics for the web. X3D in particular has drawn a lot of attention, largely due to the emergence of the X3D object model (OM) framework, which enables modern browsers to display fully interactive 3D content, written in X3D code, without the use of plug-ins or additional software. While WebGL allows powerful graphics manipulations in itself, X3D-OM offers a significant advantage; it relies on code written in XML and is thus easily accessible and modifiable, allowing information extraction, DOM manipulation and also integration of textual meta-data, all of which fit nicely with the content of services over the internet. Semantic web technologies on the other hand, promise to transform information management by integrating high-level, human language concepts and their interrelationships with everyday information structures in order to facilitate organization and search. Various efforts to incorporate and organize real world facts into structured ontologies have been made over the recent years and, in the current state-of-the-art, domain-specific solutions can offer particularly helpful tools to handle and extract information in an intelligent and organized manner.

There has been a number of cases where semantic technologies have been used for visualization purposes. The AsIsKnown project [1] aimed at the collection of product data from European textile businesses, and their organization into ontological structures. The aim was to automate the design of spaces by appropriate selection of textile materials, colours and patterns. The system also proposed a virtual reality interface and a smart profiler in order to sample configurations and create demonstrations. There has also been further attempts to organize textile patterns into

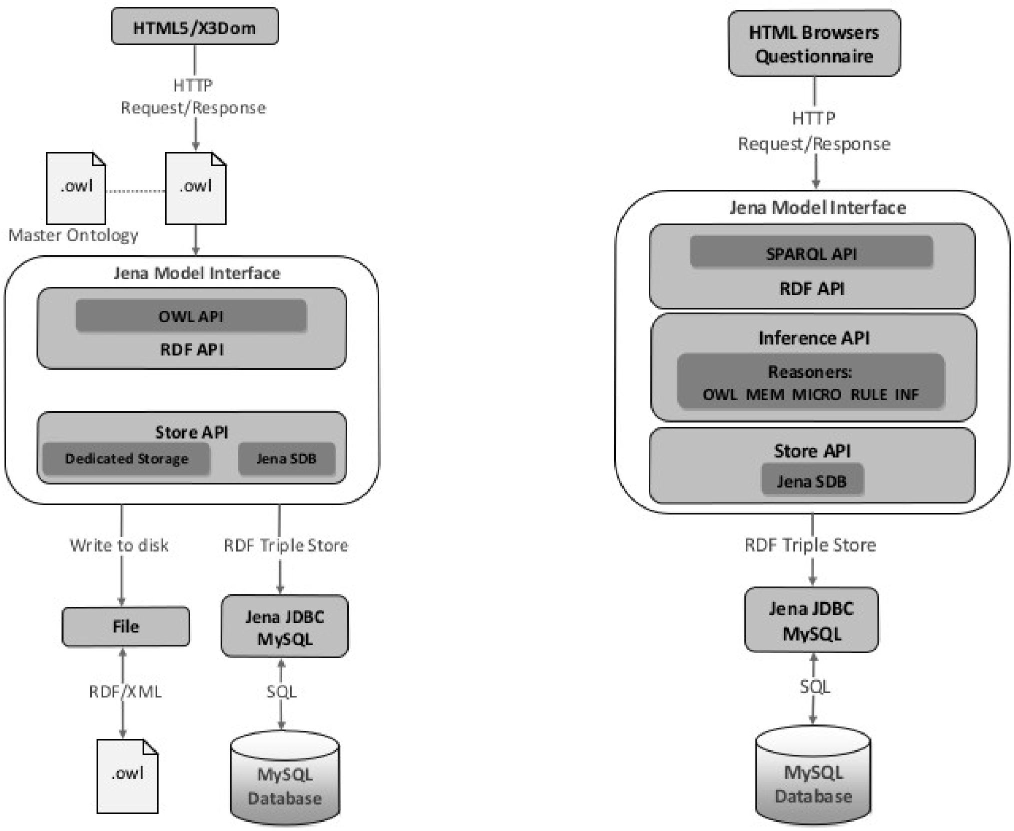

Fig. 1. The component architecture of the DECO system. The administrator architecture to the left and the SPARQL querying pipeline for the end-user to the right.

ontological structures [2]. A recent overview of the subject can be found in [3]. An interesting article [4] describes an integrated environment for architecture, engineering and construction where professionals from different disciplines can work over the same building plan document. The systems presents each user with the elements of their direct interest and hides objects of no interest. The system takes advantage of resource description framework (RDF) ontologies written in OWL, encompassing all aspects of the building process, conceptualizing elements, including engineering details to functional, design elements. The ontological descriptions are accompanied by X3D models for a potential authoring system to display in a virtual reality environment. The system displays significant similarities to our own, with respect to the merging of OWL ontology with X3D models for display.

3 THE DECO SYSTEM

Our system aims to provide an integrated framework for all types of users to communicate and indirectly exchange information. The basic user roles that the use case scenario is aimed at are content providers, designers and potential customers. The first step in the process is the population of the knowledge base with items to be

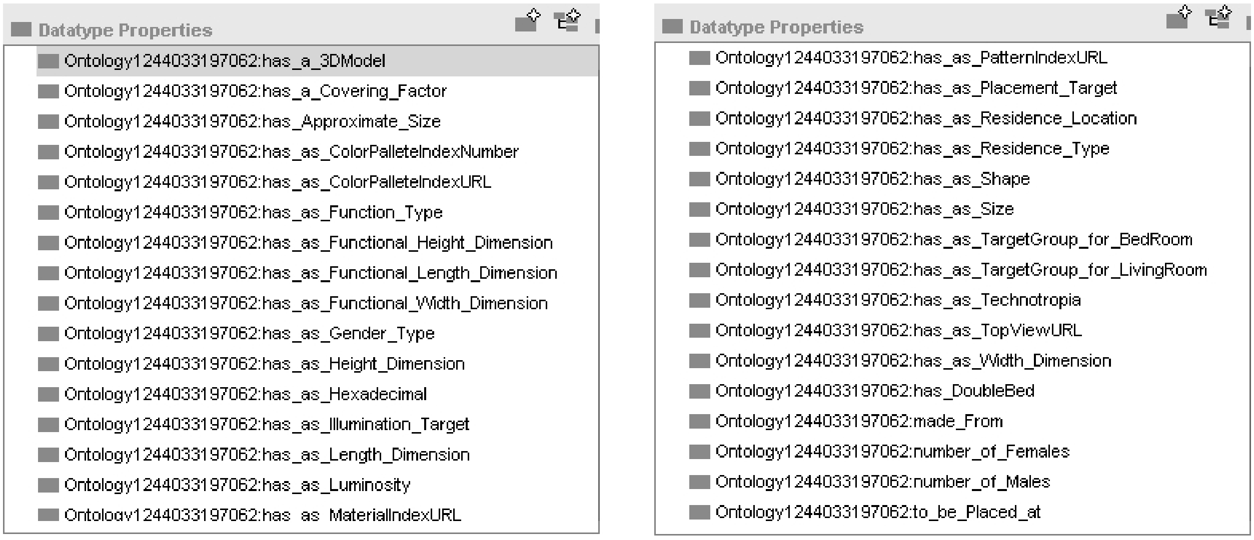

Fig. 2. The datatype properties for the proposed ontologies

used in rooms. A content provider, such as a furniture or textile retailer can use the web-based platform interface to assign individuals to classes and define their properties. Fig.1 (left) shows the flowchart for this operation. Using the Web interface, a furniture retail company can introduce their chosen items into the ontology, and specify their characteristics. The object materials, colours and design style can be selected from the ontology, and X3D models of the objects can be provided by them for incorporation into the knowledge base. Thus, using the administration wizard the database is populated with options offered to designers for the creation of room proposals.

Designers make use the same wizard to access the knowledge base and create new scenes. The room object, its intended style and use are first defined, and then the floor, the walls and ceiling are added. Each such individual can be accompanied by an SVG plan that will define the spatial structure of the room, and of course the various individuals corresponding to structures, furniture and items that are to be placed in the room. To the extent that these items are also accompanied by X3D models, a 3D reconstruction of the room can then be built. The designer can then visualize the room they have created, using our SVG-to-X3D converter, and drawing information from the ontology and the corresponding X3D files. Furthermore, using the drag sensor interface we have incorporated in our system, they can manually customize the positioning of items within the room down to a high level of precision.

Far from simply allowing designers to make any choice they like on a room, out of a very large list of possibilities, we have also integrated the SWRL recommender system in our project. The designer begins by setting up the basic aspects of a room, such as the shape/area, the basic room components and a small number of aspects (e.g. the floor colour, or some pieces of furniture). The SWRL system is then enabled, which proceeds to determine other aspects (as a rough example, ”If the floor is Terracotta, the carpets should e Ginger with Persian Motifs”). The 3D visualization subsystem operates in parallel, offering visual representations of the room and the result of the rules implementation by automatically filling the room with additional items and altering the colouring and materials of the existing ones. Thus, the user can, in real time, try specific options and then experience the resulting recommended room set-up that follows these choices. When the result is deemed satisfactory, the room can be stored in the knowledge base for future use.

3.1 THE ONTOLOGICAL FRAMEWORK

The core of the system is an ontological framework that aims to organize all relevant aspects of an interior space into a coherent and usable structure. The framework relies on previous work in interior design ontological design [5] implemented OWL-DL, a sub-language of OWL intended to convey maximum expressiveness while retaining computational completeness and decidability. The design of the ontology follows the object oriented approach starting from the abstract room at the top of the hierarchy. Our system has defined all necessary elements for the description of two major room object types, that is bedroom and living room. The ontology defines four distinct classes beneath owl:Thing, the root of every OWL ontology, “Content”, “DataTypesCandidates”, “Room” and “Structural”. Each one of these classes contains subclasses for the efficient annotation of a given room space with physical objects and abstract or material characteristics. In this subsection, we will describe the basics of the class hierarchy, to give an idea of the ontological structure of the knowledge base. The subclass “Content” contains all physical objects that can be found in interior space such as doors, windows, accessories, fabrics and furniture. Each one of these objects comes in the form of a separate subclass, where three of them (accessory, fabrics, furniture) are further used to group closely related objects. The subclass “DataTypesCandidates” contains enumerators for the qualitative characteristics of an interior space and/or an object. Each enumerator contains individuals that can be assigning characteristics. The subclass “Room” contains the interior spaces available for annotation and presentation. The subclass “Structural” contains subclasses that point to individuals that is, core objects of interior space that are mostly built-in and not movable such as the ceiling, the floor, the walls and other objects that can be defined as permanent constructs. The knowledge base is under continuous development in order to represent more concepts. Fig. 2 illustrates sets of datatype properties. The design of the ontology aims to give the ontology fundamental relational functionality by interconnecting classes in individuals. For instance, there are properties designed to assign a particular aesthetic mood to a room such as the one name “has a Mood”. Datatype properties, on the other hand, are used to link OWL individuals with typical data values. One example of high significance is the “has a 3D Model” property of an individual of class “Structural” or “Content”, containing the URI of an X3D model for the individual of reference.

3.2 CASE BASED REASONING

The CBR system is based on a set of distinct components offering alternative aesthetic solution that relies on artificial intelligence results. More specifically, it uses a matching algorithm that carries out a structure similarity procedure among XML documents. The matching is applied on the XML pattern document produced by the

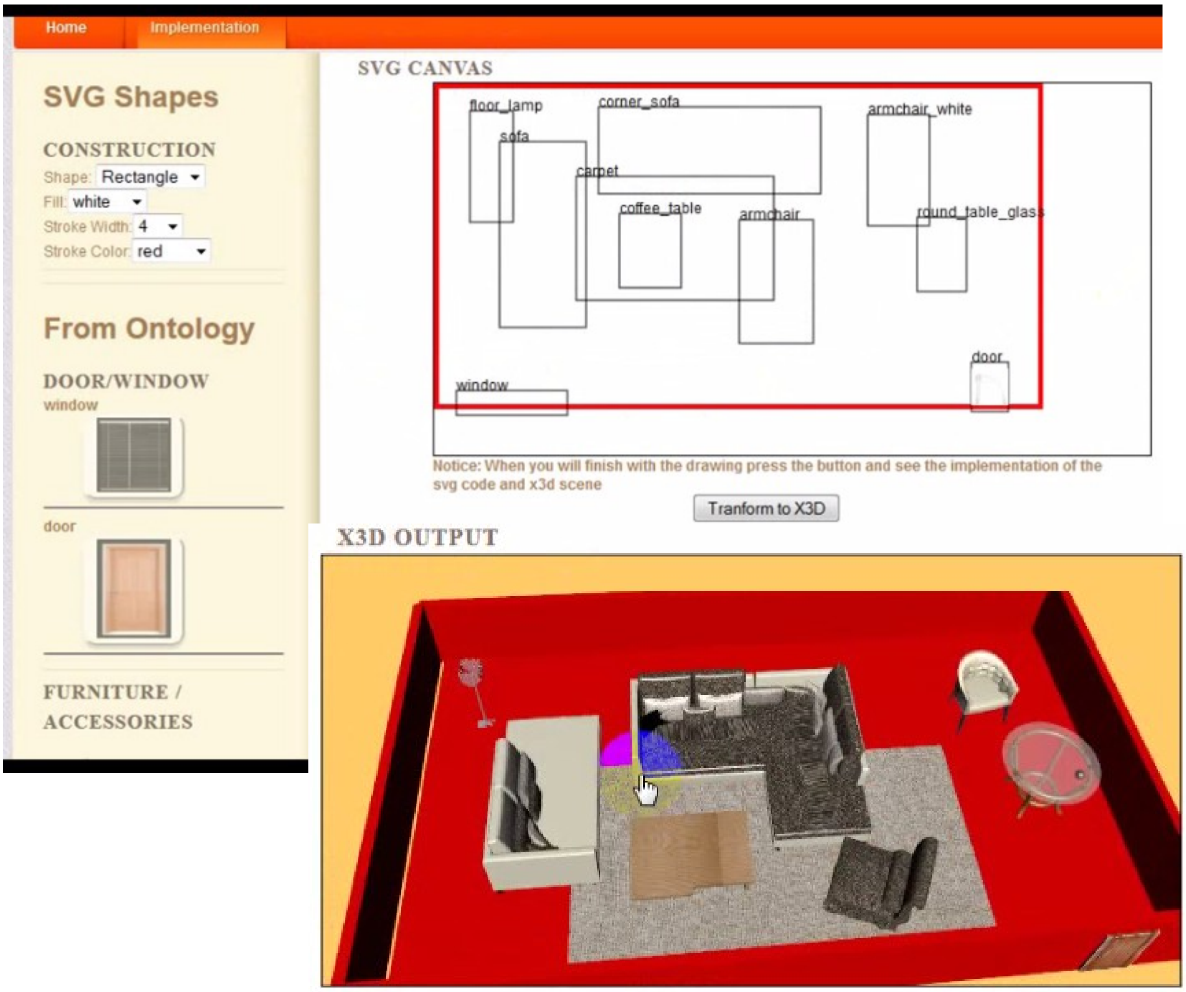

Fig. 3. the X3D output of the system presents the final scene where interior design rules have been applied

system and then makes use of the representation of the interior design and decoration aspects which can be used to annotate a room space.

The matching algorithm takes as input two graphs and retrieves any identical parts amongst them that is, it returns the common sub-graph. The graphs to be used correspond to real world or realistic room spaces that conform with interior design principles. The XML representation itself has been developed in such a way that makes efficient the appliance of an XML matching algorithm. While the XML representation comes clearly in a hierarchical form, the rooms' corresponding graph representation will be in the form of a tree. In this structure, the root denotes the room space, while its branches represent different objects of this room space. The relationship of trees' nodes are not only correlated to the root of the tree, but also to the other nodes of the tree. This is made feasible through the assignment of every node with a specific attribute stemming from the XML representation. Following this pattern, we can claim that the name of a tree node corresponds to an attribute, while its data correspond to the value of this attribute. In this way, the hierarchical status of a node of the tree reflects its spatial position in the room space being described each time. For example, a "Vase" node type can be nested inside a “Table” node type, implying that this vase object is placed on the table. Based on the above, any room space matching problem is simply reduced to an XML tree matching problem.

4 CONCLUSIONS AND FUTURE WORK

Fig. 3 presents the final output of the system, after semantic information is processed and aesthetic rules have been applied. Future work will focus on the evaluation of the output of the system that is, assess how good it is and also compare it with results produced by interior designer professionals. This procedure will provide feedback for the elaboration of our platform that is, the improvement of the interior design rules and the reasoning. From the technical perspective, future work will focus on improving some of the features of our system in order to make it more suitable for the web. Last but not least, it would be interesting to investigate if the ability of our X3D viewer to take advantage of ontological date can be included in the X3DOM framework in order to ensure that it can be used without the need for pre-installed software.

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6 References

[1] T. Valintinat, W. Backhaus, K. H Enning: Non invasive, cross-sector development and management of trends. In Proceedings of the 13th ISPE International Conference on Concurrent Engineering, Frontiers of Artificial Intelligence and Applications, vol. 143, pp. 393-400 (2006)

[2] D. Arnold, S. Elmer, R. Rando: Towards building a knowledge base for research on andean weaving, The Final Frontier, 26th British National Conference on Databases, LNCS, vol. 5588, pp. 180–188 (2009)

[3] S. Nasir, N. Ooor: Automating the mapping process of traditional malay textile knowledge model with the core ontology, American Journal of Economics and Business Administration vol. 3, iss. 1, pp. 191-196.

[4] J. L EE, Y. J Eong, Y: User-centric knowledge representations based on ontology for AEC design collaboration. Computer-Aided Design vol. 44, iss. 8, pp. 735–748 (2012)

[5] I. Horrocks, et. al.: SWRL: A semantic web rule language combining OWL and RuleML, W3C Member submission (2004)