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Using Semantic Annotations for Customizing Navigation Paths and Virtual Tour Guides for Virtual Environments

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Abstract

Nowadays more Virtual Environment (VEs) are becoming available on the web. This means that VE are becoming more accessible to a larger and more diverse audience. It also means that the interpretation of VEs and their virtual objects (i.e. how to interact with the virtual environment and the meanings of the associated virtual objects) are more likely to differ from one group of persons to another group of persons. In order for a VE to be a success on the Web, end-users should easily get familiar with the VE and understand the meanings of its virtual objects. Otherwise, the end-user may be more tempted to quit the VE. Therefore, the process of annotation and the creation of navigation paths for virtual tour guides are important to ease the use of VEs. Most of the time, this is done by VR-experts and the annotations are very poor and often only text based. This paper describes an approach and associated tool that allows a layman to add or update annotations to existing virtual environments. In our approach, annotations are not limited to text but may also be multimedia, i.e. images, videos, sounds. Furthermore, the approach (and the tool) also allows creation of navigation paths and tour guides.

Keywords: Virtual Reality, Semantic Annotations, Navigation Paths, Tour guides

1 Introduction

Virtual Environments (VE) are becoming more available through the Internet thanks to formats like X3D (X3D, 2007), VRML (Hartman and Wernecke, 1998). Although Virtual Reality (VR) applications are becoming visually appealing, they often lack any kind of semantics, i.e. extra, non-visual information about the virtual environment and its objects (Ibanez, 2004). The success of a VR application on the Web also depends on how the user is capable of interacting with the VE and how he can add meanings to the objects inside the VE and to the VE itself. This helps him to find his way in the VE and to a certain extent adapt the VE to his needs. As a result, the user is less tempted to leave the VE. A good example of this can be found in Second Life (SecondLife, 2007) where the user is not only discovering new visually attractive virtual places, but he can start to give meanings to the different objects and places in which he is immersed. For instance, he can jump to the IBM area and then find new information about a product of IBM.

Semantic annotation is information that is added to some media to enrich it with a well-defined meaning. Semantic annotations are especially important in the context of the Semantic Web because they make the content of the Web machine-processable and enable computers and people to work in cooperation. In the same way, semantic annotations can be added to VEs and to their objects through the process of annotations. The process of annotation is not only useful for making the content machine-processable, but in the context of VE it is also very important to increase the usability of the VE (as illustrated above).

However, the process of annotating is not easy. VEs can be annotated during development or afterwards. Currently, this is often done using authoring tools that provide very limited mechanisms for annotations. Usually, some textual annotations can be added and often even only keywords. Furthermore, the annotations are often stored in the same file as the one containing the VE. VEs are often annotated by VR-experts and less often by domain experts. Another observation is that the meaning that people gives to objects can change from person to person and also may depend on the task under consideration. Take for instance the meaning of a building in a city. For an employee working in that building, the meaning of that building would probably be the place where he is working. But for someone else it may be the location of that building inside the city. For this reason, it is important to provide an approach where someone can easily add and update semantic annotations to existing VEs, so that existing VEs cannot only be extended with semantic annotations, but the annotations can also be customized to a particular domain, task or group of people. As a result, the same VE can then be used for different purposes.

Another important aspect also related to enhancing the usability of VEs is navigation. Navigation is very important in VEs and especially in the context of the Web as these VEs are reaching a large audience. Web users are very demanding. They not only expect visually attractive VEs, but they also want to explore them very quickly. In general, if they need to spend too much time wandering how to interact with the VE and its objects, the chance is higher that they will leave the VE quickly. This is why navigation and virtual guided tours are very important. But the requirements for navigation may also vary from person to person and from task to task. For instance a guided tour inside a virtual human body can be different for an audience of doctors than for an audience of non-medical people. Even for medical doctors, a guided tour may be different if it is needed to teach medical students than if it is used to discuss the health problems of a patient. Furthermore, the process of creating a navigation path as well as a virtual tour guide is usually not easy and therefore, it is often performed by a VR-expert.

This paper describes an approach that helps someone (who may not be a VR-expert) to add and update semantic annotations to existing VEs and to create navigation paths and virtual tour guides that are customized towards the semantic annotations added. In addition, the semantic annotations can be multimedia, i.e. texts, images, sounds and Web links.

The paper is structured as follows. In the next section, we provide related work. Section 3 describes the approach. Section 4 discusses the work presented in this paper and talk about future work.

2 Related Work

The work presented in this paper is related to annotation and navigation mainly. Therefore, this section will firstly describe some research works related to annotations and semantic for VE. The second part of this section will then describe some of the research works related to navigation and tour guides.

In (Ballegooij and Eleins, 2001), the world is annotated using information from the 3D structure of the virtual world. The annotations take into account viewpoints, areas of interest, objects, persons, and text. The annotations are used as semantic data to help the user to navigate inside the virtual world. The user is navigating through the virtual world by querying, i.e. the user is taken from one place to another using suitable viewpoint transition. Although the navigation improves, the annotations are mainly related to the 3D structure of the virtual world and they do not provide semantics of the real world objects like e.g., price, quality, or delivery time. In our approach, the semantics are not related to the 3D structure of virtual world, but are concerned with real-world semantics and the semantics annotations can be images, videos, music, web links and texts.

In (Abaci *et al*, 2005), the notion of smart object is used to provide not only the geometric information necessary for drawing objects on screen, but also semantic information useful for manipulation purposes. Here, the semantic information in the smart object is used by virtual characters to perform actions on/with the object e.g., grasping, moving, operating. Using the semantic information, the user is much more aware of the sort of manipulations that he can perform. For this reason, our approach also provides these features by using the semantic annotations which have been created and customized towards a group of end-users.

In (Kleinermann *et al*, 2005; Mansouri, 2005; De Troyer *et al*, 2006), the authors propose a method in which the domain expert is annotating the virtual world when it is being created. The world is being created using ontologies and therefore, the semantic annotation is richer. The semantic annotation can be any kind of information. The navigation can then exploit these semantic annotations using a search engine. However, the navigation assumes that the world has been created and annotated using their method.

In (Bolter *et al*, 1995), the authors explain that not only perceptual information are important for VR, but also Symbolic Information are as well very important. They talk about the importance to relate different type of information i.e., text, video, images. But it is difficult to understand how generic their framework is.

In (Van Dijk *et al*, 2003), the authors develop an approach for navigation assistance in virtual environments. This approach allows non-professional visitors of a virtual environment to find their way without having previous training. To assist the user in his navigation, they give a map of the environment where landmarks are added to identify a part of the virtual environment. They provide personal assistant that has knowledge of the virtual environment and the current user. They also provide a navigation agent for taking the user to a particular position. Although it is very interesting work, the information used to assist the user in his navigation is limited to the geometrical and spatial aspect of the virtual worlds and its objects. Furthermore, it is not clear how generic the approach is.

Part of the work presented in (Ibanez, 2004) is also about navigation by querying, but the author provides a querying model that allows users to find objects and scenes in virtual environment based on their size and their associated meta-information. This model is based on fuzzy logic. Nonetheless, the amount of meta-information data used in this work is still limited to object properties such as name, width, height, and locations. It is not context oriented.

In (Pierce and Pausch, 2004), the authors present a technique that allows navigation to cope with large virtual worlds. This technique uses place representation and visible landmarks that scale from town-sized to planet-sized worlds. However, the semantic annotation is only on place hierarchy which determines which visible landmarks and place representation that users can see.

In (Drucker and Zeltzer, 1994), the authors describe a framework for exploring intelligent camera controls in a 3D virtual environment. They describe a methodology for designing the underlying camera controls based on an analysis of what tasks are required in a specific environment. They also apply it to a prototypical virtual environment which is a virtual museum. The framework also performs automatic navigation. Although this is a very interesting work, it is difficult to know how generic the framework is and also how the path planning can deal with different scenarios.

In (Dennis and Healey, 2002), they describe their work in terms of navigation in large information space. They propose a navigation assistant designed to help users identify and explore areas of interest within their data. The technique presented for creating navigation is interesting and certainly works for large dataset oriented towards scientific visualization. It is less clear how their technique will cope with datasets less oriented towards scientific visualization.

3 Approach

This section explains our approach, which allows adding or updating semantic annotations, and to create new navigation paths and virtual tour guides. To help the reader understanding the approach, a concrete example is also given. The example is a virtual city park containing buildings, roads and a park.

The approach is made of two *views* namely a *Designer View* and an *End-user View*. The *Designer View* provides the designer (or domain expert) a way to add semantic annotations, to modify them or to delete them. It is also in this view that the designer can create a navigation path and associate an avatar to it in order to create a tour guide. The *End-user View* allows an end-user to select a tour guide and start it.

3.1 Designer View

We will now explain how the designer in the *Designer View*, can annotate an object using Point of Interest; create a navigation path using navigation landmarks and add a tour guide.

A) Semantic annotation

As it is easier for designers to give meanings to an object (or a place) when seeing it, the approach allows users to add semantic annotations when navigating through the virtual world. To achieve this, the concept of Point of Interest (POI) is used. POI is defined by a position, an orientation and associated multimedia information, which can be images, videos, Web links, or texts. A single POI may contain several multimedia elements. Furthermore, an object can contain several objects or be made of different parts. For this reason, our approach also allows annotating the objects (or parts) inside such an object. For instance, if we take an object car made of a body and four wheels, then the designer may want to annotate not only the car as a whole, but also each of its components i.e., the wheels and body.

The positioning of POIs can be done in two different ways namely a *freehand* mode and a *grid* mode. In the *freehand* mode, the designer can visually position a POI anywhere on (or inside) an object to add semantic annotations to this specific location (see figure 1). Note in the tool implementing the approach and in that mode, a POI is represented by a red cone. The designer can also define an orientation by using the orientation of his view.

As it is not always easy to position a POI visually, the approach also provides a *grid* mode. In that mode, a grid of spheres overlaying the selected object is displayed. Each sphere represents a possible POI. The designer selects the spheres that he wants in order to define a POI. In other words, the *grid* mode has a number of predefined positions for the POIs. The grid has the size of the selected object based on its bounding box information. The number of spheres and the space between them can be customized according to the designer's specifications. The designer can also select group of different spheres to annotate areas of an object. For instance in the case of a virtual city park, the designer can select the object representing a city block. The city block is made of three parts namely a street, a sidewalk and a green area. By selecting a number of spheres covering the street, he can then add semantic annotations only related to the area of the street. He can repeat this for other areas.

B) Accelerating the semantic annotation process

The annotation process can be time-consuming and therefore our approach also provides a way to accelerate the annotation process. By selecting an object and then annotate it either using the *freehand* mode or the *grid* mode, our approach will then identify group of objects similar to the object that he is annotating. It will then give the opportunity to the designer to decide to propagate the semantic annotations of that object to the group of objects which have been identified to be similar. As the tool implementing this approach is based on Ajax3D, this feature is achieved in our tool by using the X3D instructions like “ProtoInstance”, “ExternProto”, “USE”, “DEF” which help to identify group of similar objects. In other words, the semantic annotations can be created once for a complex object and be propagated to a number of similar objects populating the VE. That way, the process of annotation is less time-consuming and more consistent.

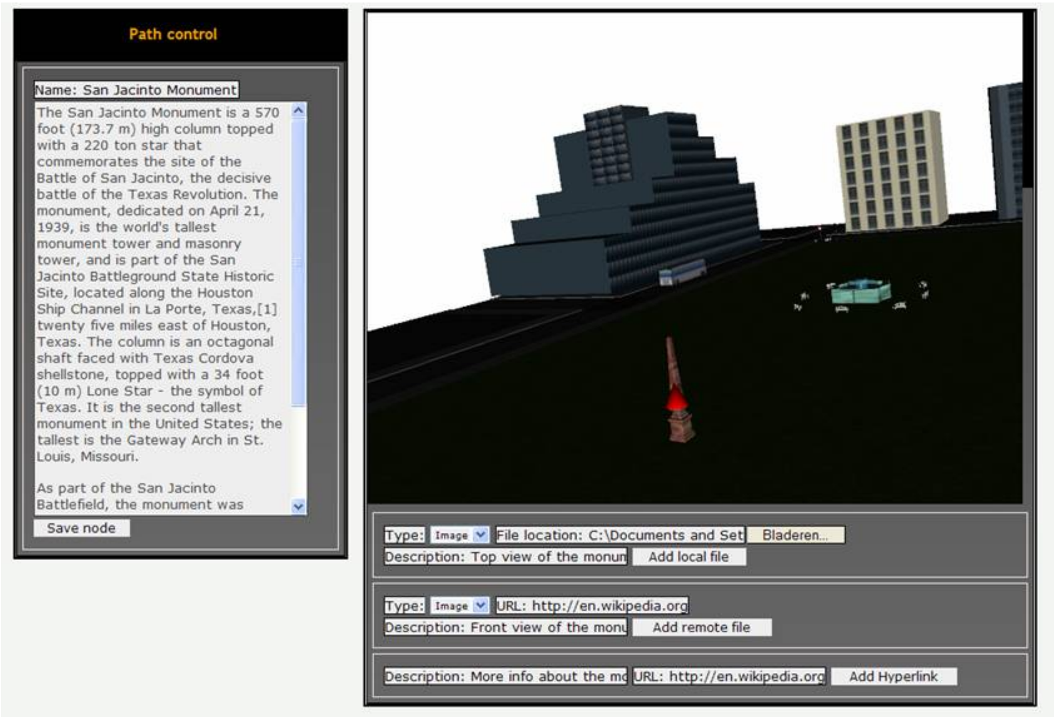

Figure 1. Placing a POI (represented by a red cone) in a freehand mode. Annotations associated to this POI are images, videos, web links and text.

C) Defining a Navigation Path

In our approach, the designer can create navigation paths by navigating through the virtual world. The navigation path is performed through the concept of navigation landmarks. A navigation landmark has a position and an orientation. The creation of navigation paths can be done in two different ways. The first way does not use any semantic annotations and consists of positioning a number of landmarks. The positioning of landmarks is done also through a *freehand* mode and a *grid* mode. Similar as for defining POIs, in the *freehand* mode navigation landmarks are positioned visually and freely by the designer on (or inside) an object (see figure 2). The *grid* mode allows the designer to specify the navigation landmarks by selecting specific spheres of the grid. The navigation path is then composed by linking the different landmarks.

The first way for creating navigation paths is not efficient. For this reason, the approach uses semantic annotation to help the designer to create more efficient navigation paths. If the virtual world has been annotated, the designer can then create navigation paths based on these annotations. The semantic annotations can help the designer to identify areas of an object more easily and more intuitively. For instance in our virtual city block, suppose that the city block has been annotated with words like roads, sidewalk and green zone. The designer can then create the navigation path by selecting these keywords which will highlight the parts of the city block for which they relate to. This will help the designer to create more easily a navigation path. Secondly, the semantic annotation can also be used to indicate to the designer where a navigation path can be specified. For instance, if the designer has added semantic annotations to one object using the grid mode and that same object is part of the navigation path, the approach allows the designer to select that object in a *grid* mode in order to see the different parts of that object for which semantic annotations have been added. The designer can then constrain the navigation path. For instance suppose that the designer wants to constrain the path of the tour guide inside a virtual city tour by stating that the tour guide can only walk on the sidewalk. And suppose that the designer has annotated the city block using the grid mode. Therefore, he can select sidewalk and the spheres of the grid covering the sidewalk area of the city block will be selected (see figure 3). As a result, the navigation path for that object will be constrained to the volume defined by the selected spheres.

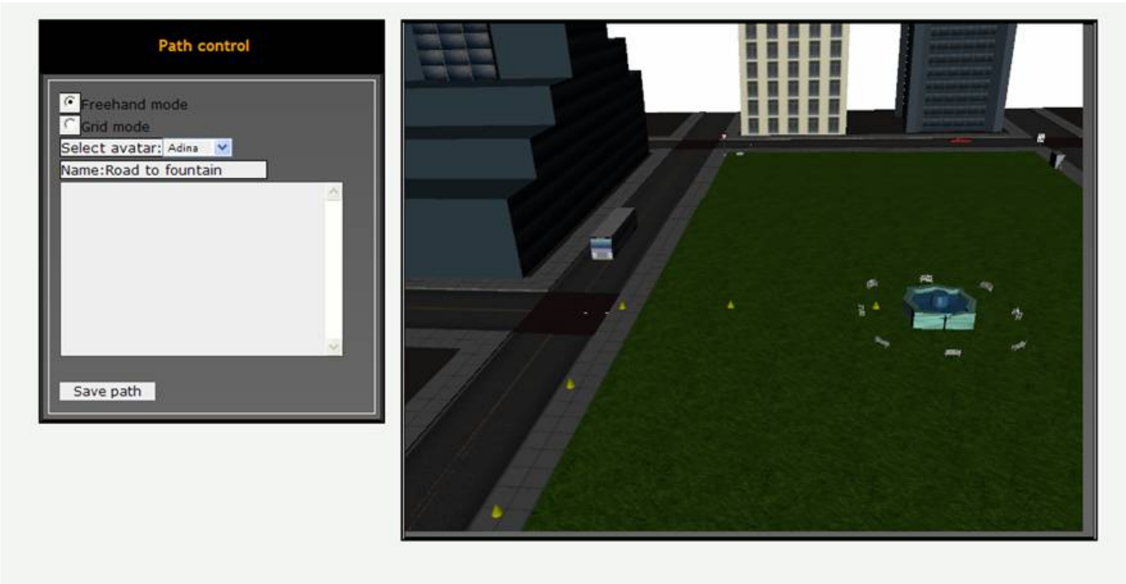

Figure 2. Placing navigation landmarks (represented by yellow cones) in freehand mode.

The navigation path can involve several objects like for instance several city blocks in our virtual city. These objects have their own possible internal paths as described above for the *grid* mode. In fact, these internal paths are represented in a graph where each nodes of the graph represents a navigation landmark and each edge represents the shortest path between a node and the next one. The algorithm will connect the different navigation landmarks of the navigation path based on these graphs and based on the position of POIs. That way, not only the shortest path is found but also the shortest path will be the one passing close to POIs so that tour guide can relate appropriately the different semantic annotations to the end-user.

D) Accelerating the process of defining navigation paths

The designer can also confirm to propagate the navigation path defined on an object to a group of similar objects. Like in the process of adding semantic annotations, this also accelerates the process of defining navigation paths.

E) Creating tour guides

The navigation path tells a tour guide (represented by an avatar) how to navigate through the virtual world. To define a tour guide, an avatar and a navigation path must be selected. In our approach, the tour guide will move following the navigation path associated to it and will show the semantic annotations associated to a POI when it encounters a POI in his range. The range corresponds to the radius of a sphere where the center of the sphere is the current position of the avatar at a given time.

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3.2 End-User View

The approach also provides an end-user view. This view allows an end-user to select a tour guide for a VE and to start it (see figure 4). Furthermore, in that view, the end-user has the possibility to directly go to a POI, by jumping from where he is in the VE to a POI. The selection of a POI is done based on a match between search information entered by the end-user and semantic annotations associated with POIs. Currently, the matching is only done for text.

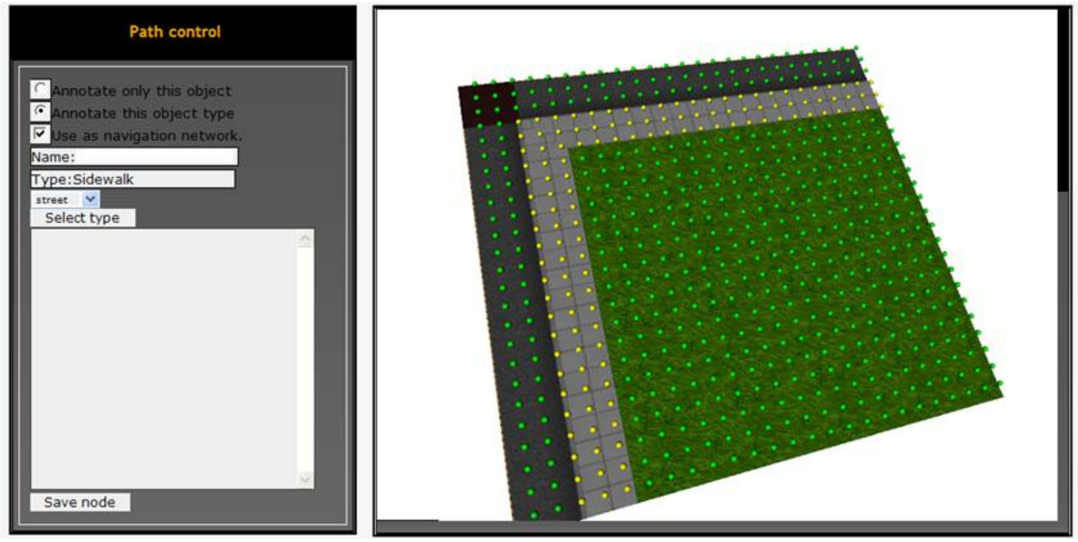

Figure 3. Grid mode selection where the navigation landmarks related to sidewalk are selected (here represented by the yellow spheres of the grid).

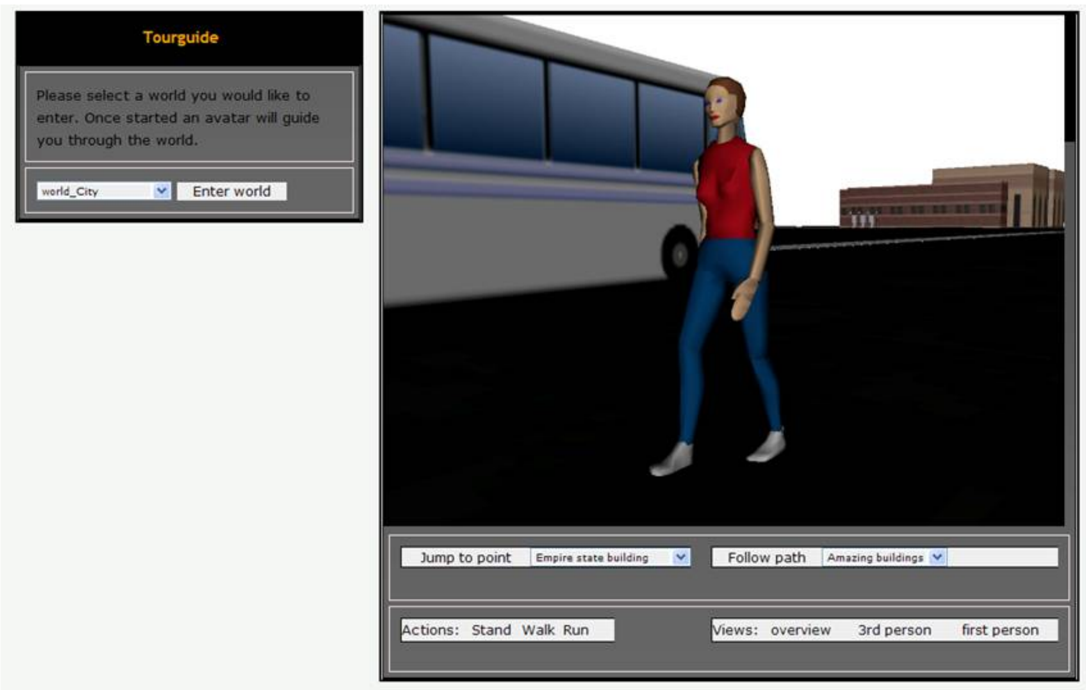

Figure 4. End-user view. Here the avatar is human avatar (Humanoid Animation, 2007).

4 Software Architecture

To support the approach, we wanted to have a tool that could be accessed over the Internet and could be used by a large audience. To achieve this, we decided to implement it using Ajax3D (Ajax3D, 2007), which combines Ajax with X3D through the Flux player and its Scene Authoring Interface (Ajax3D, 2007). The tool is a Web application consisting of three modules, namely a server and two different types of clients namely Designer View Client and End-user View Client. These Clients can be accessed through a normal web browser. The semantic annotations, the navigation paths and the tour guide are stored in separate file. Each of these files is stored in an XML format and contains also *id* of the virtual world they are related to. These files are stored on the server and can be uploaded once the end-user through the End-user View Client uploads a virtual world and chooses a tour guide.

5 Conclusion

The approach proposed here is very flexible and provides a way to add and to modify semantic annotations for any VE. Navigation paths and virtual tour guides can also be created easily. Multimedia types of semantic annotations are possible, i.e. images, text, videos and Web links. The approach also provides a way to make the annotation process less time-consuming and to create navigation path for virtual objects made of several objects. To add annotations and to specify landmarks two different modes are available.

The *freehand* mode allows visually positioning, while the *grid* mode uses predefined grids of spheres. In addition, the concept of grid can be combined with the semantic annotations. Nevertheless, this approach and the tool allow designers to quickly customize VEs with semantic annotations and navigation paths. A VE can have multiple semantic annotations, navigation paths and tour guides. Each of them represents a designer's (or a domain expert's) view. It also provides an End-user View which is used by an end-user to see the annotations and to use the navigation paths and the tour guides. The tool implementing this approach is not limited to a certain type of VE but is very general. It uses X3D and Ajax3D and therefore the tool can be deployed on the Web and is accessible to a large audience of designers as well as of end-users.

Note that the tool can also be used to create virtual "post-its". A person can quickly add some annotations and a tour guide and then share them with other users. This can be very useful for education, medical diagnostics or engineers to relate different types of annotations to a particular virtual model and then share them with colleagues who can then modify them or add their own remarks.

Future work will focus on making the approach to deal with the dynamic aspects of VE like objects moving. It will also allow designers to add semantic annotation to behaviours and to allow creating navigation paths more intuitively using the semantic annotations combined with spatial relations.

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