Semantic Virtual Environments for interactive planning agents*

Fran Grimaldo, Fernando Barber, Miguel Lozano, and Juan M. Orduña

Computer Science Department, University of Valencia,
Dr. Moliner 50, (Burjassot) Valencia, Spain
{francisco.grimaldo, miguel.lozano, fernando.barber, juan.orduna}@uv.es

Abstract. This paper proposes the use of ontologies to provide virtual environments with semantic information, that can be also used by intelligent virtual agents. We present our semantic architecture focusing on the ontology which mainly supports complex object representation and interaction. This approach helps the actors when sensing complex objects such as containers (e.g. cabinet, shelf, box) and it also allows them to interact with different sort of objects, looking at the class taxonomy defined by the ontology of the world. We finally show how the semantic information can be introduced in STRIPS based planners to enrich the actors activities that can be interesting for both narrative games and storytelling systems.

1 Introduction and related work

Game narrative [4] and storytelling systems [2] have productively applied planning techniques to generate dynamic and interactive stories. Curiously, although these approaches are well known as *knowledge intensive* [2], no structure is normally used to manage the knowledge associated to the environment. Instead, it is generally assigned only to the actors plans. Semantic Virtual Environments (SVE) can benefit production, since objects interactions can be reusable and scalable, and more interactions can be finally animated. Nevertheless, SVE systems normally focus at the construction of the environment [6][3] instead of dealing with interaction performed by virtual agents inhabiting the world. On the other side, *Non-player-characters* presented in [1] integrate semantic environmental concepts into their decision making. In this system, actions are also modelled using ontology relations but they have several expressiveness limitations.

In this paper we present a SVE approach which uses ontologies to enhance both agent-object interaction and manageability of complex objects such as containers (e.g. a tray with glasses, a cabinet containing dishes, shelves with bottles on top, etc). These objects are part of the ontology we are working on to model cooperative roles in a bar.

* Supported by the Spanish MEC under grants TIN2006-15516-C04-04 and Consolider Ingenio 2010 CSD2006-00046.

2 An ontology-based Semantic Virtual Environment

The multi-agent framework proposed is presented in figure 1. The central point is the *SVE Core Ontology*, that provides the highest-level classification for the components of the virtual world, also defining the properties and relationships between them (see next section). *Domain Specific Ontologies* can be used to extend the core ontology in order to represent concrete classes related with some particular domain. Finally, the environment is created from a *World Specification*, which is a particular instantiation of these ontologies (e.g. a virtual bar with thousand of objects: bottles, glasses,...).

The *Semantic Layer* is responsible for managing the information flow between the agents and the 3D environment (sense/act). Sensing all the semantic information during simulation can be unaffordable in many situations (e.g. a tray with 20 glasses, spoons,...), thus, we avoid redundant data by means of the hierarchy of relations established in the ontology. Furthermore, the object taxonomy defined by the ontology will be also used to generalize the actor activities (see section 2.2).

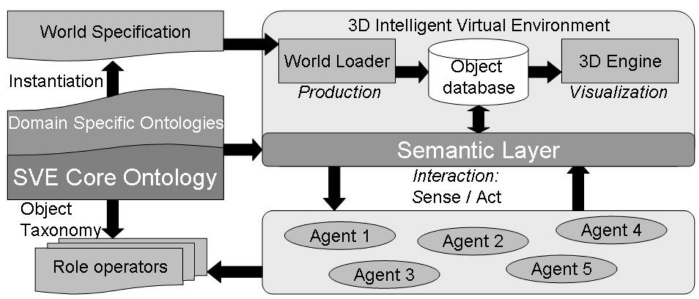

Fig. 1. Ontology-based SVE architecture

2.1 SVE Core Ontology and Domain Specific Ontologies

We have adopted OWL DL language [7] to implement the ontologies. Figure 2 shows a fragment of the SVE Core Ontology focussed on the hierarchy of classes defined to represent container objects. Here, containers of uncountable substances (e.g. a pot with salt) are distinguished from those that hold countable elements. Particularly, *ServiceContainers* will provide services of substances (e.g. a bottle of whisky) while *ObjectContainers* will contain graphical objects. Moreover, we have separated *HeterogeneousObjectContainer* from *HomogeneousObjectContainer*. For instance, a shelf with different items (e.g. books, bottles,...) and a tray with clean and undistinguishable glasses. Although figure 2 only depicts the hierarchy of classes, the ontology also establishes their properties

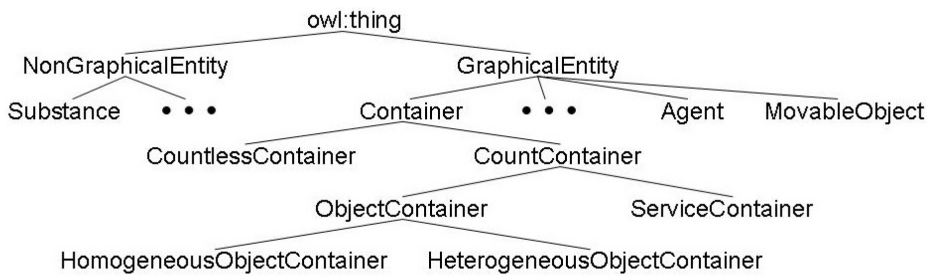

Fig. 2. Containers in the SVE Core Ontology

(e.g. *height*, *empty*, *full*) and the possible relations between them (e.g. *in*, *on*, *pickedBy*).

Currently, we are working on a bar ontology for cooperative planning agents. In this context, a *Domain Specific Ontology* is used to define classes such as *MovableTrays*, that extend the base concepts defined in the core ontology. For example, this class allows an agent to carry a tray full of donuts.

2.2 Semantic Layer

Sensorization: Semantic environments can be hard to sense for interactive planning agents (e.g. a shelf in a bookstore contains too much information for any search state). To be able to balance properly expressiveness and manageability and, finally, to inform the agents about the semantic environmental state, we have introduced a dependency scene graph into the *Semantic Layer* (see figure 3). This structure is used to manage complex sensorization, summarizing the semantical information in a hierarchical way. According to this, the *HomogeneousObjectContainer* presented can summarize the information about the contained objects. Lastly, the behavior coded for this kind of containers will only publish the sensorial information of the first k objects [1].

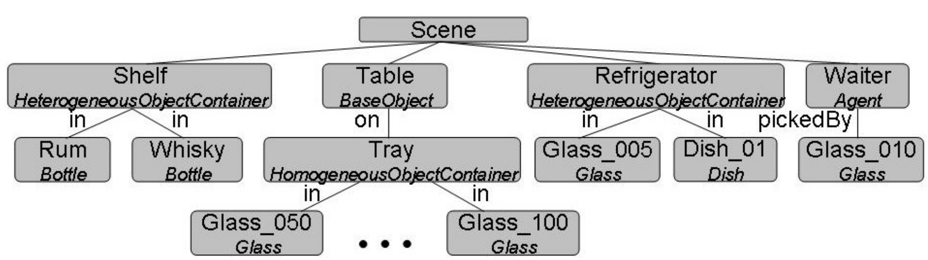

Fig. 3. Sensorial dependency tree

[1] Where k is a configurable object property

Actors operativity: Planning based agents [2][5] usually suffer from different drawbacks when an actor is interested in reusing their operators with different objects of the environment. Thus, their activity should be reviewed to incorporate semantic information from the ontology. For example, picking up an object is possibly one of the most frequent actions carried out by many 3D actors. The following general operator interacts with any entity that is placed in any kind of object container:

```
operator PickFromContainer:
    parameters:
      ?object - MovableObject
      ?container - ObjectContainer
    preconditions:
      ?object in ?container
    add:
      ?object pickedBy ?me
    delete:
      ?object in ?container
```

The parameters section contains the objects involved, and the *preconditions*, *add* and *delete* lists follow normal STRIPS assumptions. Reusable operators can be defined using typing and this reflects in a higher degree of interaction.

3 Conclusions

Ontologies can be useful in knowledge intensive 3D environments such as games, storytelling systems, etc. In this paper, we use semantics to enhance complex sensorization and actuation for interactive planning agents.

References

1. Chang, P. H-M., Chien, Y-H., Kao, E. C-C. and Soo, V-W. A knowledge-based scenario framework to support intelligent planning characters. In *IVA'05*. Springer LNCS. Vol: 3661. 2005.
2. Charles, F., Lozano, M., Mead, S.J., Bisquerra, A.F. and Cavazza, M. Planning Formalisms and Authoring in Interactive Storytelling. In *1st International Conference on Technologies for Interactive Digital Storytelling and Entertainment*, 2003.
3. Gutierrez, M. A. Semantic Virtual Environments. *PhD thesis*. 2006.
4. Harris, J. and Young, M. Proactive Mediation in Plan-Based Narrative Environments. In *IVA'05*. Springer LNCS. Vol: 3661. 2005.
5. Lozano, M., Grimaldo, F. and Barber, F. Integrating miniMin-HSP agents in a dynamic simulation framework. In *Proceedings of the 3rd Hellenic Conference on Artificial Intelligence*. Springer-Verlag LNAI. 2004.
6. Otto, K. A. Towards semantic virtual environments. In *Workshop Towards Semantic Virtual Environments (SVE'05)*. 2005.
7. W3C. OWL web ontology language guide. *Available at http://www.w3.org/TR/owl-guide/*. 2004.