Using Semantics in the Environment for Multiagent-Based Simulation

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INTRODUCTION

According to (Ferber, 1995), six elements constitute a multiagent system (MAS): an environment; active objects (agents), passive object, relationships between objects, operations modeling the behavior of the agents, and the behavior of the environment.

An agent is an autonomous entity which is capable to act on itself or on its environment. It communicates with other agents, and its behavior is the result of its views, its knowledge and interactions with other agents. Multiagent-based simulations (MABS) solve problems that cannot be solved by an individual agent or a monolithic system. In MAS, situated agents are mentioned when they are located in an environment. The environment is a key point in MABS. (Weyns, Ominici, & Odell, 2007) propose three points of view on the environment:

1. The part of the system which is outside the agents' community,
2. The coordination medium among the agents,
3. The running platform.

The physical environment provides and manages the laws, rules, constraints and other policies that govern and support the physical "existence" of agents and other entities. To carry out properly an environment for the MABS, three main points have to be considered: the topological and geometrical description, the dynamics of the environment, and its semantics. The first two points are usually efficiently addressed by the various simulation systems that are available. However, it is not the case for the semantic that form a problem to solve to obtain realistic simulations. This article is a survey on the use of semantic to define the "meaning" of an environment.

BACKGROUND ON SEMANTIC IN ENVIRONMENTS

Semantic Virtual Environment (SVE) is used to enrich the information by semantic data, which cannot be deduced from the geometry (walkway, roadway, etc.) It enhances the interactions between agents and objects in the environment (Otto & Berlin, 2005). Indeed, it provides information on the environment (color of traffic light), including the possible actions that may be carried out on the environment.

The semantics in virtual environments can occur at three levels (Tutenel, Bidarra, Smelik, & Kraker, 2008). The lower level is dedicated to the objects. An object contains a number of physical and functional properties. For example, the opening state of a door is

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provided to an agent to decide to do. At a higher level, the relationships between different objects are specified: inclusion, proximity, coordination...

The formalism that has emerged for modeling the semantic information is the ontology (Troyer, Bille, Romero, & Stuer, 2003) (Otto & Berlin, 2005) (Pellens & De Troyer, 2005). They represent the knowledge embedded in the environment. For example, (Chu & Li, 2008) describe the semantics of the objects in a virtual environment with ontology, so that users can design their own animation procedures, and facilitating the agents' path planning.

Several approaches propose to separate the representation of the environment, and the action-selection modules of the agents (Farenc, Boulic, & Thalmann, 1999) (Marwan Badawi, 2004) (Abaci, Ciger, & Thalmann, 2005) (Grimaldo, Lozano, Barber, & Vigueras, 2008). The two following sections are dedicated to these two parts.

Semantic in the Representation of the Environment

The environment representation may be enriched with semantic according to several points of view. The first is the description of the topological relationships between the zones or the objects. The semantic may also be used to detail the objects' properties.

Topology Description with Semantic

One of the referent approaches for SVEs is proposed by (Farenc, Boulic, & Thalmann, 1999). They propose to include semantics in the environment, to be used by the agents and the simulator itself. The proposed model relies on a tree structure, and splits the environment into various levels. They have a node for the whole town; the children of this node represent the districts... The semantic part relies on roads and sidewalks that are grouped together. An agent (vehicle, walker…) stays on its place, and may not perceive the other places. The tree building is done automatically, thanks to a 3D representation of the environment, and a manual tagging of the environment objects. This tagging activity is considered as a drawback. One other drawback is that a specific kind of agent is only able to move on its dedicated zones. For example, walkers are not allowed to walk on the roads. If they want to cross a road, a crosswalk must be defined during the design phase. The proposed approach presents some lacks that can be avoided with a merging that lowers the quality of the semantics, or a need to improve the semantic handling in agents. (Thomas & Donikian, 2002) and (Mekni & Moulin, 2010) present the same kind of approach, but the first one adds some solutions for animating agents during the visualization of the simulation. The second one splits the environment into layers with semantics but without tree structure. (Rodriguez, Hilaire, & Koukam, 2006) propose an holonic model in which they associate a semantic to the various levels, thus allowing a labeling of the space, in a way that looks like the one proposed by (Farenc, Boulic, & Thalmann, 1999).

One of the first semantic add-ons usually set up is the relative position (above, under, in front of…) of an object to another (Lozano, Morillo, Lewis, Reiners, & Cruz-Neira, 2007) (Trinh, Querrec, Loor, & Chevaillier, 2010). This approach can be interesting even if the data that they are describing can be found by exploring the geometry. Indeed, the reason why a certain link is made and not another is significant. Several concepts are added to support this approach: an importance coefficient to determine which object is the referral; definition of the object's orientation; object identification capacity.... Each agent may be able to determine the process or value of these concepts according to its characteristics. (Irawati, Calderòn, & Ko, 2006) use this approach, but it is not specifically designed for the agents. They use it to place objects by voice in the environment. To address the identification of the objects, they use a tagging, which is also often used in the semantic inclusion in the environment.

Tagging of the Objects

The tagging of the environment can take various forms such as a label associated to an object or a specific object placed in the environment. In the second case, the objects do not have a "physical" existence, but they can be perceived by the agents to help them in their decision making processes. Such tags can be placed, for example, on doors to inform agents that this object is crossable. One weak point of this kind of approach is that labels or objects have to be placed in the environment during the modeling step. (Lugrin & Cavazza, 2007) extend this principle by proposing a model in