Extending JaCalIVE Framework to Create Virtual Worlds by Means of an OWL Ontology

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ABSTRACT

The development of Intelligent Virtual Environments is still a growing area from a technological perspective. Current implementations of Intelligent Virtual Environments require a high consumption of resources while new requirements should be also supported. Distributed approaches seem to be a good solution for systems of this kind, as in the case of the multi-agent paradigm. Nevertheless, MAS approaches lack of elements that facilitate flexibility and dynamism during the execution of an Intelligent Virtual Environment. To address these aspects, a semantic representation of an IVE is proposed in this paper. The main contribution of this proposal is to provide an ontology that can enhance the knowledge representation features and reasoning capabilities of an agent-based Intelligent Virtual Environment.

1. INTRODUCTION

Intelligent Virtual Environments (IVE) are virtual environments that simulate a physical world inhabited by autonomous intelligent entities [1]. Over the last few years, applications of this kind are between the most demanded ones, and are typically addressed to a huge number of simultaneous entities. Therefore, current IVEs must be supported by highly scalable software, which should be able to adapt to changes, and to incorporate human requirements and needs. Traditionally, this kind of applications use the client/server paradigm. However, due to their current features, a distributed approach seems to fit better, such as the multi-agent systems (MAS) paradigm. This paradigm allows developing components that will evolve in an autonomous way and coordinated with the own environment's evolution. Moreover, though many approaches have popularized the use of ontologies in different areas, very little research on conceptual modeling for IVEs has been done. The employment of ontologies for the design of virtual environments offers a richer and more expressive representation of IVEs. The construction of virtual environments should contain semantic annotations about the environment [2]. Moreover, the use of ontologies enables semantic reasoning and can be used as a common vocabulary in agent-oriented programming. The MAS design is more easily expressed and communicated, and the model can be more easily converted to a formal verification system. Ontologies provide functionalities such as consistency checking, concept satisfiability, classification, and realization.

The rest of the paper is structured as follows: Section 2 briefly explains the main concepts of the $JaCalIVE$ framework which serves as a basis for the work presented in this paper; Section 3 describes the proposed ontology and the use in the development process of IVEs; finally, some conclusions are explained in Section 4.

2. JACALIVE

In the last years, there have been different approaches for using MAS as a paradigm for modelling and engineering IVEs, but they have some open issues: low generality and then reusability; weak support for handling full open and dynamic environments where objects are dynamically created and destroyed. As a way to tackle these open issues, and based on the MAM5 meta-model [3], the $JaCalIVE$ framework was developed [4]. It provides a method to develop this kind of applications along with a supporting platform to execute them. According to MAM5 meta-model, an IVE can be designed as composed of parts that have a representation in such environment and parts that have not. This last one is composed by the same elements that were in the A&A meta-model (Workspaces, Agents and Artifacts, mainly). The entities situated in the environment are populating IVE Workspaces that may have different IVE laws controlling their physical behaviour. These situated entities are Inhabitant Agents (with a special kind for that modelling humans immersed in the system) and IVE artifacts (in that case, the special ones are modelling real artifacts to be included in the system). The steps that should be followed in order to develop an IVE according to the $JaCalIVE$ framework: **Model** (the first step is to design the IVE. $JaCalIVE$ provides an XSD based on MAM5 meta-model. According to it, an IVE can be composed of two different types of workspaces depending on whether they specify the location of its entities "`IVE_Workspaces`" or not "`Workspaces`". It also includes the specification of agents, artifacts and the norms that regulate the physical laws of the IVE Workspaces), **Translate** (the second step is to automatically generate code templates from design. One file template is generated for each agent and artifact. $JaCalIVE$ agents are rational agents based on JASON. The artifacts representing the virtual environment are based on $CArtAgO$. $CArtAgO$[1] is a tool based on

[1]http://cartago.sourceforge.net

Appears in: *Proc. of the 16th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2017), S. Das, E. Durfee, K. Larson, M. Winikoff (eds.), May 8–12, 2017, São Paulo, Brazil.*

the model *A&A* (Agent and Artifact)[5] that allows to create and to program artifacts. The developer must complete these templates and then the IVE is ready to be executed), **Simulate** (the IVE is simulated. JASON offers support for BDI agents that can reason about their beliefs, desires and intentions. *CArtAgO* offers support for the creation and management of artifacts. JBullet offers support for physical simulation).

3. DEVELOPING IVES BASED ON ONTOLOGIES

According to the *MAM5* meta-model, in the development of *IVEs* we can find two principal elements: *Agents and Artifacts*. These elements are the most important in the *IVEs* design, as they allow to represent the intelligence (Agents) and the objects (Artifacts) that compose the IVE. The agents represent the intelligent part in the IVE, integrating all their characteristics such as reactivity, learning, communication, etc, whilst the artifacts represent the different objects that compose the IVE. Even though the artifacts are the elements that don't have an intelligence, these objects can be used by the agents to interact with the IVE or in the real world. In most cases, the *Artifacts* are those who build the world, including a series of physical and not physical objects such as: *walls, trees, desk, tables, street, database, etc...*, which provide services that agents can exploit to support their individual and social activities. However, these elements need to be modeled and programmed. As before commented, we employ *CArtAgO* as a tool to create and to program the artifacts. The *IVE_Artifacts* are artifacts representing objects in the IVE, thus having a series of physical properties as position in [X,Y,Z], mass, acceleration, shape, etc...

3.1 MAM5 Ontology

In this section we describe the proposed ontology and also, how this ontology is employed by the *JaCalIVE* framework. The main concepts of the MAM5 ontology[2] are the following: **Agents** (represent the autonomous pro-active entities in the IVE. They can be specialized into Inhabitant Agents which represent the autonomous entities "including humans" present in the virtual world and that interact with it), **Artifacts**(model the basic bricks used to define the environment. One interesting type of Artifact is the Smart Resource Artifact (SRA) which is an artifact that incorporates embedded sensors and actuators providing access to the environment), **Workspaces** (model the conceptual containers of agents and artifacts), **Actions** (correspond to physical interactions in the IVE), **IVE Law** (defines the physical aspects of the IVE Workspace, as, physical laws, gravity,...), **Physical Properties** (instances of observable properties corresponding to the relation of the IVE Artifact with the virtual environment), **Physical Events** (instances of observable events related to IVE perception).

4. CONCLUSIONS AND FUTURE WORK

This paper presents a new approach to designing Intelligent Virtual Environments or Virtual Worlds, where the designer creates the system as a new ontology, based on the *MAM*5 Ontology, and the different elements forming the initial state of the system, and the evolution of it is defined as a set of instances of such *IVE Ontology*.

This is carried out by using an *Ontology Artifact* that allows accessing to the ontology to the *Manager Agent* of the system, and to all the agents that are allowed to access the ontology, or even the designer or any user that may have access to the ontology to consult or modify it during the execution of the system.

As a future work we intend to enhance the load management of the *JaCalIVE* Framework, so when the load of the *Manager Agent* increases too much, it will be able to clone itself, dividing the load between it and its clone by means of dividing the amount of entities in the ontology it must control. This will be facilitated by the dynamism incorporated by means of such ontology.

[2] http://users.dsic.upv.es/%7ecarrasco/JaCalIVE_Ontology.owl

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