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Semantic oriented data structuration for MABS Application to BIM

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Abstract. The design of a building combines many heterogeneous skills and data from stakeholders specialised in different domains (plumbers, electricians). Many problems can occur during this partnership once the building is undergoing construction. To minimize these problems, this paper presents a multiagent-based simulation approach to qualify the usage of buildings from the design phase. Our approach combines ontology and evolution process based on machine learning algorithms. The ontology relies on semantic data structures for the representation of environment components, agent knowledge and all data generated during the simulation.

Keywords: ontology, modular ontology, Building Information Modeling, Multi-Agent-Based Simulation

1 Introduction

One of the first steps in the lifecycle of a building is the design phase. The output of this phase is a 3D digital mockup that represents the future building. From this digital modeling, each stakeholder, according to their business, adds information to enrich the specification of the building model. All of this data represents the Building Information Model (BIM) [2]. During the lifecycle of the building, the BIM will be enriched with financial data, legal information and so on. Each actor in this lifecycle uses specific norms and tools according to their domain of expertise. Thus, the conception of the BIM is a difficult task due to the heterogeneity of the data and skills involved. Nevertheless, the Building smart consortium developed a standard, called Industry Foundation Classes, that merges structural and geometrical data of a building to reduce heterogeneity. Unfortunately even if the structural, syntactic and semantic heterogeneity of data is limited, this standard doesn't deal with the gap

between the conception of the building and its final use (for example health and safety norms, access for the disabled, secure access to the building, etc.).

To bridge this gap, this paper presents a new approach which addresses the heterogeneity problems between design rules and constraints of use. This approach combines an ontology with machine learning algorithms. This method enhances the multiagent-based simulation proposals and reduces the complexity of the agent's development. Simulation is a well-known tool used to analyze the quality of a building in different contexts. Based on this facts, our idea consists in simulating the behavior of the end users of a building in order to assess the quality of a building in terms of safety (e.g. security protocols), usability (e.g. the adaptation of capacity building are consistent with its use), comfort (e.g. limitation of movements required for routine tasks), etc. . An advantage of our solution is that it allows identifying such issues during the design phase. The final goal aims at developing a software application to compare and assess building configuration at the design phase (or redesign phase) to assist decision makers in their strategic choices. To do so, we use the field of Multiagent-based simulations (MABS), which are simulations that imply a group of interacting agents. An agent is defined by its capacity of being autonomous and able to perceive and interact with its environment. The environment is made up of various objects that can be handled by agents, relations between these objects, operations/operators to manage interactions between agents and their environment (Ferber, 1999). From there, we propose a new creation process for MABS. It is based on an auto generated phase of different parts of MABS: environment, agents, interactions, simulations (specific features, logs, etc.). For this paper, we focus on the design of the used data structure. This new way of data handling is based on high-level semantic description of simulation elements and agents. All information of the MABS is stocked in a meta model based on ontology that we create. On the one hand, the semantically informed environment of the simulation is auto generated from an industrial file format of building representation IFC. On the other hand, minimal patterns of mobile learning agents are auto generated, based on specific features, from the agent part of the model we create. These elements will be discussed in the section entitled Approach, after introducing works in the field of semantics and MABS in the section entitled Related Works.

2 Related work

Improving data structure in the context of MABS is not new. The work presented here suggests that semantic modeling is the key to information management for this field of research. In [6], authors defined a taxonomy for an agent from a list of approaches made in the field of MABS (Multi-Agent System). The problem with this proposal is that many approaches have the different agents' definitions which causes conflicts between these definitions. Compared to this proposal, the objective of our method is to specify and model: the definition of an agent. It is possible to fit a large

number of definitions, while limiting to a minimum specific constraints to certain areas. Semantics are the key point of this generic definition, as each expert can bring its own domain knowledge to each of the characteristics of a MABS. [4] focuses on the description of the interactions in an ontology. Goals are modeled as states of the environment. These goals are reached by means of inference based on the related ontology. Although the approach is interesting on this point, the contribution of semantics is limited to interactions including all MABS concepts. In [7], the work involves using an ontology to store the management of the agent's knowledge. Several specific features of ontologies are used (inferences, class hierarchy, queries, etc.). However, only the part affected to the agent's knowledge has been enhanced by the use of semantics. Compared to [7] Our approach applies semantics to all elements of a MABS : environment, agents and simulation. Last but not least, [5] describes a more complete approach. For managing the three basic elements of a multi-agent system : agents, environment and interactions. This approach relies on our ontology to represent the knowledge to lead a person to manipulate an object in a hazardous environment. It models the interactions of objects, but also the results produced by an interaction. This approach is also focused on training agents in a virtual environment. The problem with this approach is that the population process of the ontology is long, because for each object, you must manually specify everything that allows interaction (states, interactions, transitions, etc.). In our approach, it is not necessary to define this information, as it is already contained in ontology concepts related to the environment. Each object already has its own knowledge of interactions. Objects are auto-generated to create the environment. For each object, one has to define its main interactional characteristics. In the end, we also take into consideration all the concepts of simulation, concepts that lack in the presented work. As indicated in the introduction, works on data structure in the MABS field suggest that improvements require the creation of a semantic model. Our model is discussed in the next chapter.

3 Approach

All the above presented models don't consider the ontology as the central point for managing all data inherent to a simulation applied to MABS. Each approach addresses only a specific element of a MABS, that is either the agent, the simulation or the environment. Combining the benefits of each of these approaches allows a global semantic model. If information about the MABS is sometimes managed successfully, problems arise when having to manage the simulation itself: logs, characteristics of simulation, etc. In our proposal, the ontology is the core of the information. All that is used or produced by the simulation as a whole (and by MABS extension) is modeled in the ontology. This allows greater flexibility of simulation and / or information (re)use. The simulation results, whatever their forms (3D modeling, knowledge, decisions, etc..) can be (re)used at any time during the simulation or other processing. This ontological foundation helps to provide a consistent basis for heterogeneous

information, from both specific concepts related to contributing experts, and to the use of simulations and MABS. This allows each project expert to manage their own information without having to understand the whole project.

We propose a new methodology to create a MABS, mostly based on: automatic generation of the physical informed environment and self built smart agents. This feature provides the process of creating and managing a MABS. Our approach addresses four elements of a MABS : environment, agents, interactions and simulations.

For the first part, we propose a semantically aware environment automatically generated from the IFC standard [9], standard used in the building industry. The IFC standard includes both the geometric description of the environment and the semantic information associated with objects from the environment. A part of our work is to filter and classify useful concepts from IFC standard with virtual simulation. Agents, defined in previous works [1], and also generated automatically from our model, are used in two stages. Firstly, we address the issues raised by agents that are unable to solve complex situations. As these agents are by definition autonomous, they need four basic characteristics: movement, perception, interaction and reasoning. In order to increase their knowledge, we force these agents to face simple situations. This results in an improved agents ability to face more complex behaviors. These agents will face simple situations to progress in knowledge that results in more complex behaviors. Secondly, we place these agents in real life simulation in environments based on real building plans. To enable them to interact with the environment, we choose to use the concept of Smart Object [3]. The integration of this concept will be discussed in a future paper. The scope of this paper is limited to the model for the environment. We planned four steps to define the environment part of the model:

- The first step is the geometric modeling of the environment.
- The second is the producing of a BIM semantic model.
- The next is to define the framework interactions' between agents and their environment.
- Finally, it remains the integration of the definition of this informed environment model as an environment in a MABS (including agents, simulation elements and environment).

The first two steps can be generated automatically. Based on the work of [9], using the IFC standard in BIM projects permits us to generate our semantically aware environment. In this work, the data contained in the IFC are translated and modeled into an ontology. We will not create a model from scratch but we will use the concept of modular ontologies [8]. This way, we are able to include all IFC ontology concepts necessary for modeling our environment. As mentioned above, the work in these two steps is based on the understanding of IFC and extraction elements. With the use of this standard, we have the advantage of working on a tool already used in industry.

4 Conclusion

In the last section, we outlined the steps necessary to build our ontology and the need to define semantic knowledge a MABS. Future works will be addressing the last two steps : our environment data of the model must incorporate a broader ontology, which includes MABS concepts. New bricks of interaction must be added to the MABS structure in our model. Last but not least, a learning process must be implemented to give life to the agents.

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References

1. Béhé, F., Durif, T., Nicolle, C., Galland, S., Gaud, N., Koukam, A.: Ontology-based multiagent systems using Inductive Recommendations - A new approach to qualify building use during the Design phase. In: 12th International Conference on Design & Decision Support Systems in Architecture and Urban Planning. Eindhoven, Pays-Bas (Aug 2012)
2. Bernstein, P.G., China, F.: Building information modeling. *Structural Engineer*(Atlanta, Ga) 6(7), 18–21 (2005)
3. Cea, A., Dobre, D., Bajic, E.: Ambient services interactions for smart objects in the supply chain. In: *Service Systems and Service Management, 2006 International Conference on.* vol. 1, pp. 822–827. IEEE (2006)
4. Chang, P.H.M., Chien, Y.H., Kao, E.C.C., Soo, V.W.: A knowledge-based scenario framework to support intelligent planning characters. In: *Intelligent Virtual Agents.* pp. 134–145. Springer (2005)
5. Edward, L., Amokrane, K., Lourdeaux, D., Barthes, J.P.: An ontology for managing a virtual environment for risk prevention. In: *Integrated Intelligent Computing (IChIC), 2010 First International Conference on.* pp. 62–67. IEEE (2010)
6. Franklin, S., Graesser, A.: Is it an agent, or just a program?: A taxonomy for autonomous agents. In: *Proceedings of the Workshop on Intelligent Agents III, Agent Theories, Architectures, and Languages.* pp. 21–35. ECAI '96, Springer-Verlag, London, UK, UK (1997)
7. Holmes, D., Stocking, R.: Augmenting agent knowledge bases with owl ontologies. In: *Aerospace conference, 2009 IEEE.* pp. 1–15. IEEE (2009)

8. Stuckenschmidt, H., Parent, C., Spaccapietra, S.: Modular Ontologies: Concepts, Theories and Techniques for Knowledge Modularization, vol. 5445. Springer (2009)
9. Vanlande, R., Nicolle, C., Cruz, C.: IFC and Buildings Lifecycle Management. *Automation in Construction* (18), 70–78 (Jan 2008)