EXPLAIN_MAS: An Agent Behavior Explanation System

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Abstract. Agent-Based Simulations are well adapted to model complex social systems in various domains. The simulation is considered as an efficient way to predict, to explore and to test hypothesis for problems that cannot be reproduced in the real world. We are convinced and we fully believe that the simulation of complex systems requires the development and the execution of a complex Multi-Agent System (MAS). To face this complexity, users need to understand how such a complex MAS operates. This paper focuses on the explanation of agents' behaviors and their way to act and interact. For this purpose, we propose to associate the MAS with a Knowledge Based System for Explanation (KBSE) called EXPLAIN_MAS.

Keywords: Agent behavior · Reasoning explanation · Causal map · Simulation

1 Introduction

Multi-Agent Systems (MAS) have, on the one hand, the traditional advantages of the resolution of problems as modularity, parallelism and reliability. On the other hand, they inherit the attractive features of the artificial intelligence as the symbolic treatment of knowledge. In addition, they support sophisticated scenario of interactions (cooperation, coordination, negotiation). These aspects have classified MAS as complex systems marked by the lack of a global control. In fact, agents use their own knowledge, their environment perceptions and their interactions to reach their goals. So, we consider that it is crucial to elucidate, to interpret and to deal with the proceeding of the intelligent resolution of agents in a dynamic, complex, and open system. In order to deal with this issue, first, we focused on the explanation in knowledge based systems particularly expert systems. Second, we reviewed the existing works in MAS area. In this context, there are two directions that have underlined these works: The auto-explanation [1] and the modular one [2]. We think that the presented directions have limits. In fact, the auto-explanation starts with the design and the development of the MAS, so it could not be applied in already developed systems. Then, it affects the system performance by overloading the agent; each agent should resolve a problem and at the same time deal with the explanation process. The proposed approaches in the second direction depend on the application domain and the development platform. Furthermore, explanation mechanisms in expert systems cannot be applied directly in MAS considering their features (parallelism, interaction, etc.). In order to overcome

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the above limits, we are realizing a separate modular explanation system. This system is dynamic and independent of the functionality of the system to explain, and the type of involved agents.

2 Main Purpose

We propose in this paper an intelligent approach. This approach consists in three principal modules: an observation module, a modeling module and an interpretation one. The observation module presents the knowledge acquisition phase. It detects agents' activities and collects their execution context in what we called an explanation structure presented as the tuple <K, A, G, R> (Knowledge, Action, Goal, Relation). The tuple attributes point out the explanatory knowledge. These knowledge describe the main reasoning concepts for each agent "i″ at a moment "t" in the tuple $<K_i(t), A_i(t), G_i(t), R_i(t)>$ [3]. We consider that the explanatory knowledge could not reflect an explanation of agent performed actions, they are deprived of a clear and a semantic explanation. Consequently, we identify the causal links between these knowledge attributes to elucidate the cause/effect relationships among visualized events. So, we proceed according to different levels of construction in order to build connected causal maps in what we call an Extended Causal Map (ECM) [3]. These levels denote several types of causal links. The first level presents a **temporal** one. It describes a causal graph where the concepts are the reasoning states, RS_i. These concepts express the detected agents' behaviors while the graph arrows $(t_i,\ t_{i+1})$ show the alteration between behaviors. Each observed behavior depicted in the graph concept is represented in our case with the explanatory knowledge collected in the tuple <K, A, G, R>. Therefore, from this level we generate a second level, labeled **horizontal level**, that indicates the causal relations between the tuple attributes. Furthermore, we recognize additional causal links via the temporal relation depicted between RS_i and RS_{i+1}that refer to the detected behaviors of, on the one hand, the same agent, and on the other hand, of different agents. So, we consider that there are causal relations between explanatory knowledge collected at the moment t_i in the tuple $<K_i(t), A_i(t), G_i(t), R_i(t)>$ and the ones collected at the moment t_{i+1} in the tuple $<K_i(t_{i+1}), A_i(t_{i+1}), G_i(t_{i+1}), R_i(t_{i+1})>$ for the same agent. These relationships outline an **internal vertical level** in the ECM. This level indicates the causal relations between the actions performed by the agent and its satisfied goals. Then, we note that the relation between the behaviors of different agents of the MAS depends on the interaction process elaborated between these entities. We remind that each performed communication act is detected by the observation module, and its execution parameters are stored in the attributes R and A. So, we focus on these attributes for each agent at different moments to describe and analyze the established interactions. We create these causal maps in what we call an **external vertical level** based on the performatives of the agent communication language. This level presents the causal links between the explanatory knowledge acquired at the moment "t" of the agent "i", $<K_i(t), A_i(t), G_i(t), R_i(t)>$, and the ones acquired at a moment " t' "of the agent "j", $<K_j(t'), A_j(t'), G_j(t'), R_j(t')>$. Further, a knowledge representation model as a graph could provide a visual interpretation in terms of a set of relationships between concepts. Such interpretation is easier if the graph has a limited number of nodes and arrows. This is not the case of our ECM elaborated for complex systems like MAS. So, we propose to associate this causal map with an interpretation formalism to deduce a knowledge for explanation. We define the CAUMEL language [4] based on the first-order and the temporal logics.

3 Demonstration

Our work has been validated on a MAS simulation of large scale emergency rescue SimGenis [3]. The interface depicted in the figure 1 shows the required tabs to configure this application. When the simulation is launched, the explanation is triggered.

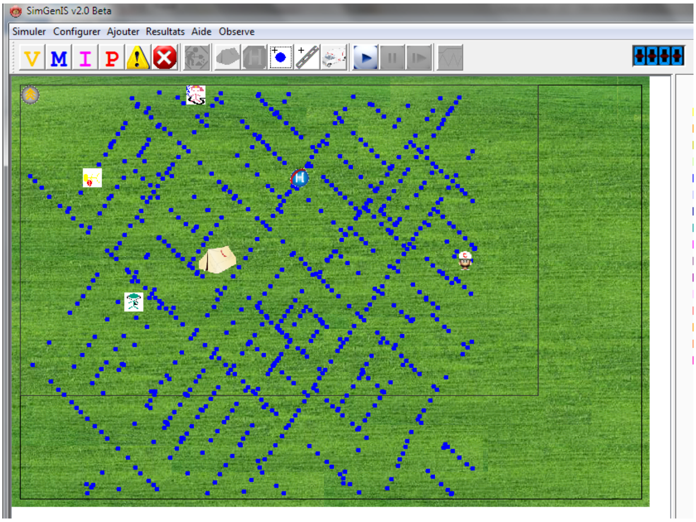

Fig. 1. SimGenis interface

First, each action performed by agents is observed and the explanatory knowledge are acquired in real time. The observation module is developed using the aspect-oriented programming with the AspectWerkz[1] tool. Then, the appropriate causal map is built according to the different levels (temporal, horizontal, internal vertical, external vertical). We present in the figure 2 some 3D causal maps generated, during the SimGenis execution. Eventually, each produced map is interpreted and translated to predicates using CAUMEL. In the second part of the figure 2, we point out some of these predicates. The interface contains a narrator agent to report the explanation process.

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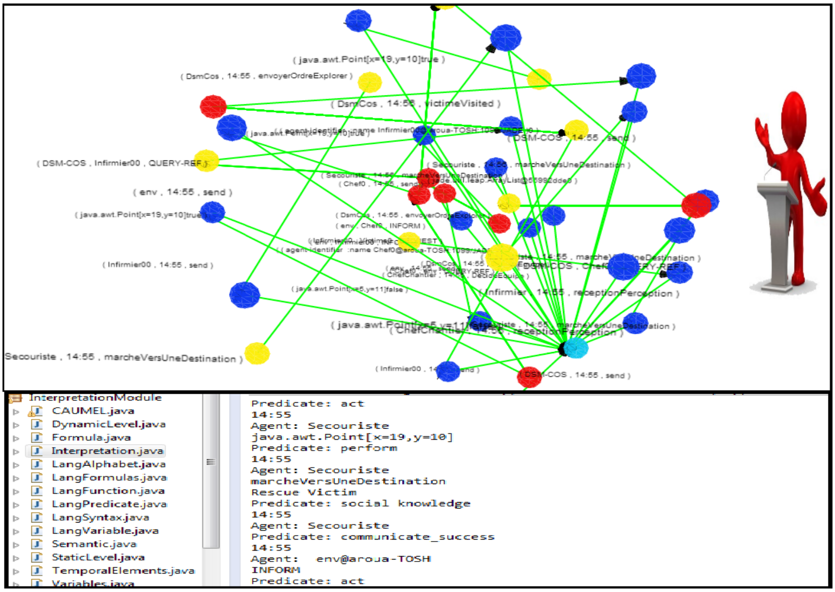
[1] http://aspectwerkz.codehaus.org/



```
Predicate: act
14:55
Agent: Secouriste
java.awt.Point[x=19,y=10]
Predicate: perform
14:55
Agent: Secouriste
marcheVersUneDestination
Rescue Victim
Predicate: social knowledge
14:55
Agent: Secouriste
Predicate: communicate_success
14:55
Agent:  env@aroua-TOSH
INFORM
Predicate: act
```

Fig. 2. Causal maps

4 Conclusion

In this paper, we dealt with an online explanation of agent behaviors during the MAS execution. For this purpose, we developed a knowledge based system composed of three modules. The observation module presents a knowledge acquisition phase. The modeling module describes the knowledge representation phase and the interpretation module corresponds to the interpretation phase. Our explanation system EXPLAIN_MAS is validated using a large scale emergency rescue MAS.

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