Virtual Customers in an Agent World

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Abstract The relevance of multi-agent systems (MAS) has been demonstrated in computer simulations or video games where many autonomous entities interact in a complex and dynamic environment. Serious Games (SG) are a new discipline situated at the edge of computer simulation and games. We advocate that a certain category of SG, where the player is immersed in a 3d environment, represents a particularly interesting testbed for MAS, for they introduce novel and inspirational problematics for the community. In this paper, we explore the challenges posed by these immersive SG to the MAS approach. Particularly, we demonstrate that the IODA interaction-oriented MAS approach, answers these new problematics with efficacy. We illustrate our discussion with a SG project developed in our team.

1 Introduction

A serious game (SG) is a game purposed at teaching, training or raising awareness of a specific theme (cultural heritage, ecology, health, etc.) in learners (equally referred to as players) by offering them a compelling and engaging experience. In this paper, we will suppport our assertions through an immersive 3d SG developed in our team, called FORMAT-STORE, aimed at training undergraduate students to the management of a convenience store and customer relationship (CRM). The features of this SG, and the solutions proposed to address the issues reported below, are described in [4]. Unlike traditional approaches to CRM games, where problematised situations are explored within a virtual interview between the player and one virtual agent (the *Banque Cantonale Vaudoise* project developed by Daesign[1], *The Sales Game*

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[1] `http://www.daesign.com`

from PIXELearning[2], *Knowledge Drive* developed by Caspian Learning[3] for Volvo Car UK), the approach promoted by FORMAT-STORE considers the immersion of the learner in a virtual replica of a store populated by artificial customers. Daily activities of a salesperson and customer relations management constitute the core of the learning objectives. The main research problematic of FORMAT-STORE is the design of a multiagent crowd of intelligent, adaptive and interacting customers. Not only do MA simulations constitute a relevant answer to our problematic, as we intend to demonstrate, but we advocate that serious games in return represent a challenging testbed for MAS. In this paper we show which aspects of an immersive SG are of interest for the MA community, what methodology is likely to provide an adapted answer and finally what improvements are brought by a MA simulation to an immersive SG.

2 Specific aspects of a SG from the MAS perspective

Depending on the application domain of a MA simulation, several characteristics are key. An immersive SG represents a demanding exercise where factors like human integration and *mise en scène* are added to the more traditional need for realism.

As a first mandatory characteristic, the simulation must be **participatory** – e.g. integrate the human element. The player interacts in an unpredictable fashion, with a modality and a temporality different from the other autonomous agents. On the other hand, for test purposes, the simulation should be runnable without the player. Ultimately, player and agents should be seamlessly interchangeable: this would ensure 1) that the techniques used for human integration are generic and 2) that the behaviours given to the artificial agents are realistic enough and cannot be distinguished from a human-played behaviour at first sight. One consequence of the integration of a human player is the necessity of a **flexible evaluation**: the game should be able to take into account the reactions and performances of human participants, in order to automatically adapt the difficulty level and the selection of pedagogic issues. Finally, the simulation must be **staged**, in spite of the autonomous nature of the agents, for the content to be presented in an engaging and contextualised fashion.

Other factors, albeit not specific to a SG, are crucial to guarantee the success of a simulation. The design process must be **interactive** enough for domain experts to participate, and **incremental** to allow for the reviewability of the simulation model. Therefore, the behaviours represented in the model must be **understandable** by said domain experts, who are often not computer scientists nor media experts. Finally, the behaviours themselves once expressed in the simulation must be 1) **realistic**, 2) **adaptive**, since a MA simulation is highly dynamic, let alone the presence of the player and 3) **modular**, in order to accommodate abilities of different complexity

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[2] http://www.pixelearning.com/services-the_sales_game.htm

[3] http://www.caspianlearning.co.uk/

(moving *versus* pathfinding *versus* conversational abilities for example) within a unique component.

Designing a MA simulation for an immersive SG requires a methodology that can account for each of the above mentioned points. The IODA methodology is an appropriate answer.

3 IODA: An interaction-oriented design methodology

IODA is developed since 2001 with the aim to propose a simple to use MA methodology, yet powerful in terms of attainable complexity of the simulations. IODA [2, 1] is an interaction-oriented design approach [5], whose originality is to make each interaction a concrete software element and to offer a unified design process of the MA simulation. As a methodology, IODA brings together several principles guiding the design of the MA simulation, all of which are summarized in the following sections. The concrete implementation of a IODA model is then enabled by JEDI, a Java-based API offering a computational counterpart to each of these principles.

3.1 Everything is agent

Although IODA is an interaction-oriented methodology, the starting point of designing a simulation consists in identifying the participating agents. What traditionally defines an agent in a MAS is a minimum degree of behavioural autonomy and the subsequent ability to trigger autonomously an action or an interaction. Historically, “living” characters in a virtual simulation are considered as agents whereas “inanimate” objects like trees, furniture or items are not.

The first recommendation of the IODA methodology is to consider every object in the environment as an agent [3]. This provides a homogeneous representation of all entities involved in a simulation model. Agents are related to agent families through a “is-a” relationship.

3.2 Interaction reification

In a similar way, as every entity in the simulation is represented by an agent family, any behaviour can be described by one or several interactions in IODA. Unlike other MAS approaches, where an interaction is virtually expressed in the behaviour of two agents interacting together, all interactions in IODA are reified as part of a software library.

An interaction is a **rule** involving two agents: it is performed by a source agent and undergone by a target agent. It is composed of two parts, a Boolean condition testing if the interaction can be triggered, and an action part containing the corresponding sequence of actions. Both these functions rely on generic primitives, left for implementation inside the agents or reused from a template library.

As a consequence, IODA exhibits two unique features. Firstly, **the interactions are reusable** from one agent family to another and from one simulation to another (as long as the semantics of those interactions is kept unchanged). Each can be allocated to any agent in a "plug and play" fashion, provided the agent implements the primitives. The other advantage of interactions reification is the ability for all the agents to be processed by a **generic engine** through a single iteration loop, irrespective of the nature of each agent (cf. section 3.4 dedicated to action selection).

3.3 The interaction matrix

Owing to this dissociation between entities (agents) and abstract behaviours (interactions), the description of the actual behaviour for each agent consists in allocating interactions to agent families, by means of an **interaction matrix**.

An interaction matrix is a set of tuples of the form (S,T,I,p,d) where S and T are agent families, I an interaction, p a priority level and d a limit distance. Such a tuple denotes the ability for any agent from the family S to be the source of (i.e. *perform*) an interaction I with a target agent from the family T (which *undergoes* I), with a priority level p (from the point of view of the source agent), provided the distance between the source and target agent is less or equal than d (depending on the metric of the environment). In case of reflexive interactions (when the target is the source itself), we use the simplified notation (S,I,p). The priority level is used by the source agent to sort between the realisable interactions when several compete for a given agent at a given time (by default, priorities are static and result from the experts' knowledge).

In practice, the interaction matrix is usually specified through a Source/Target table as shown in [4]. Thus, the main advantage of the interaction matrix is to be easily written and/or naturally read by a non-computer scientist, although the implementation of the primitives still involves a computer scientist (see section 3.2). Despite its apparent simplicity, the interaction matrix describes the behaviour of each agent exhaustively. Besides, once exploited by the action selection mechanism presented in the next section, the matrix is functionally equivalent to any type of behaviour description.

3.4 Action selection

The expression of the matrix into a behaviour for each agent is achieved by an action selection mechanism.

Traditionally, the action selection consists of an internal perception→decision→ action loop, operated by the agent itself following the principle of behavioural autonomy. Evaluating the perception of an agent consists in making the inventory of all the other agents in its local neighbourhood. The neighbourhood is given according to a metric defined in the environment, such as the Euclidean distance or acquaintances in a social network.

In classical approaches, perceptions are processed by a reactive, cognitive or hybrid architecture so as to select the appropriate actions. The interaction-oriented nature of IODA simplifies this process. At each time step – time is discrete in IODA – each agent considers all the possible interactions according to the interaction matrix and the other agents in the neighbourhood. Each interaction is then considered realisable if the distance between the agent and the target is below the interaction limit distance and if the preconditions of the interaction are met. If several interactions are realisable at the end of this process, the agent only retains the one with the highest priority.

Owing to an interaction-oriented methodology and the homogeneity of the action selection mechanism, IODA offers a simple and intuitive way to describe the behaviours in a MA simulation. Yet, complex behaviours can be obtained, as illustrated by the implementation of the serious game FORMAT-STORE.

4 Implementation of FORMAT-STORE

Implementation details of FORMAT-STORE are provided in [4]. The game is built on a JEDI-clone simulation engine which implements IODA models.

The example of FORMAT-STORE shows that IODA is an appropriate answer to the specificities of immersive SG, as listed above:

Human in the loop: The human player controls the vendor agent through a web interface, which sends messages to the agent so as to trigger the appropriate interaction. A scenario can be easily split into several successive interactions. In addition, a game manager adapts the parameters (e.g. difficulty level, events) of the simulation to the performances of the player.

Design process: The intelligibility of the simulation model directly results from the dissociation made by IODA between declarative (agents, interactions) and procedural elements. Thus, the model can be built step by step on an empirical basis, and reviewed as well if needed.

Behaviours: Realistic behaviours are ensured by 1) coherence and 2) variety. Coherence results from the explicit introduction of expert knowledge in the specification of the interactions, enabling an a priori and a posteriori assessment of the behaviour by the experts. Variety is ensured by several mechanisms: among them, similar agents can participate in different interactions, depending on their state and situation; also, the condition and action primitives of a same interaction can be written differently so as to represent customer profiles: thus a same interaction can be performed under several modalities.

5 Conclusion

We have demonstrated in this paper that serious games raise game-, pedagogy- or simulation-related problematics turning them into a challenge to the classical approaches of MA simulation. Although each problematic individually has already been addressed by the MA community, their combination represents a test for what quality among modularity, expressiveness, model reworking and human integration belong to a MA approach or not. Through our own implementation experience of a SG, we have illustrated these difficulties and shown how the interaction-oriented methodology IODA, designed for more classical simulations, was particularly adapted to answer the SG problematics, owing to a separation between the entities and the behaviours. We have also shown how to take into account the human player in a plug-and-play fashion, easily replaced by an autonomous agent, and *vice versa*. This versatility suggests that immersive SG could constitute a kind of Turing test for MA simulations and the definition of realistic behaviours.

Acknowledgements

The FORMAT-STORE project, designed in collaboration with the game studio Idées-3Com[4] and the business school ENACO[5], is supported by the French ministry of Economy, Finances and Industry under the “2009 Serious Game” scheme.

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[4] `http://www.idees-3com.com`

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