Applying the AdapTIVE Model in Games

CÁSSIA TROJAHN DOS SANTOS[1]
FERNANDO SANTOS OSÓRIO[2]

[1]Universidade de Évora - Departamento de Informática
cassia.ts@gmail.com

[2]Universidade do Vale do Rio dos Sinos – Programa de Pós-Graduação em Computação Aplicada
fosorio@unisinos.br

Abstract

This paper presents the model and application of the AdapTIVE (Adaptive Three-dimensional Intelligent and Virtual Environment) in games. The AdapTIVE is a virtual environment which has its structure customized according to users' interests, preferences, and behaviors. We present the potential application of the AdapTIVE to create highly interactive games that adapt to user.

Palavras Chave: intelligent environments, user model, adaptive games

1 Introduction

A recent effort to make computer games more engaging and interesting consists in the incorporation of Artificial Intelligence techniques. Particular attention is given to games that react to players and provide different challenges and situations based on users' actions, interests, and preferences. According to Lent [1], systems that can adapt to, or learn from individual players and their own history have the potential to tailor gaming experiences and improve replay ability.

The game should observe the player's behavior, create a model of what aspects of the game the player knows and does not know (yet), and offer choices to the player, which are designed to keep him or her motivated [2]. For example, the game can adjust difficulty levels to match a player's abilities fairly simply. As the player acquires more expertise the pace and difficulty can ramp up accordingly.

In this paper we suggest to adapt the AdapTIVE model [3] to be applied in games. The AdapTIVE is a virtual environment which has its structure customized according to users' interests, preferences, and behaviors. We present the model and potential application of the AdapTIVE to create highly interactive environments to games. The AdapTIVE was validated in distance learning [4] and e-commerce [5] applications, meantime the main properties of this model are very promising if they are applied in entertainment and games applications.

The paper is organized as follow. In section 2, the AdapTIVE model is presented. Section 3 presents the main issues on using AdapTIVE in games. Section 4 presents the final remarks and the future works.

2 AdapTIVE Model

Initially the AdapTIVE model was developed to be used mainly in Distance Learning and E-Commerce applications (e.g Virtual University, Virtual Library, Virtual Bookstore). The environment consists of the representation of a 3D world, accessible through the Web, used to make content available, which are organized into content categories (i.e. virtual rooms). In the environment there is support for two types of users: consumer and provider. The users are represented by avatars, they can explore the environment searching relevant content and can be aided by the intelligent agent, in order to navigate and to locate information. User models are used in the environment adaptation. Contents are added or removed by the provider. Each content contains a content model. The provider, aided by the automatic content categorization process, acts in the definition of this model. From the content model, the spatial position of each content in the environment is defined. The representation of the contents in the environment is made by 3D objects and links to the data (e.g., text document, web page). Different 3D structures that form the environment can be created, according to the user and content models. The environment adaptation involves its reorganization, in relation to the arrangement of the contents and aspects of its layout (e.g. use of different textures and colors, according to user's preferences). In this paper, we focus the user modeling process of the AdapTIVE model, which can be adjusted to create games that adapt to user.

2.1 User Modeling Process

An user model contains information about the users' interests, preferences and behaviors (actions in the environment). In order to collect the data used in the composition of the model, the explicit and implicit approaches [6, 7] can be used. The explicit approach is adopted to acquire the user's preferences compounding an initial user model and the implicit one is applied to update this model. In the explicit approach, a form is used to collect fact data (e.g., name, gender, preferences for colors). In the implicit approach, the monitoring of user navigation in the environment, his actions and interactions with the intelligent agent are made. These data are used to update the initial user model.

The process of updating the user model is based on rules and certainty factors (CF) [8]. The rules allow to infer conclusions (hypothesis) from antecedents (evidences). To each conclusion, it is possible to associate a CF, which represents the degree of belief associated to corresponding hypothesis. Thus, the rules can be described in the following format: IF Evidence (s) THEN Hypothesis with CF = x degree. The CFs associate measures of belief (MB) and disbelief (MD) to a hypothesis (H), given an evidence (E). A CF=1 indicates total belief in a hypothesis, while CF=-1 corresponds a total disbelief.

The calculation of the CF is accomplished by the formulas (1), (2) and (3), where P(H) represents the probability of the hypothesis, and P(H|E) is the probability of the hypothesis (H), given that some evidence (E) exists. In the AdapTIVE model, the initial value of P(H) is determined by the explicit collection of data and it may vary during the process of updating the model (based on threshold of increasing and decreasing belief), where P(H|E) is obtained from the implicit approach. In a general way, the evidences are related to the environment places visited and to the requested and accessed contents by the user. They are used to infer the hypothesis of the user's interest, from the rules and corresponding CFs. However, it must be addressed that different applications involve different evidences. In a virtual store, for instance, the evidences related to the visited environment places, information about products requested to the intelligent agent, and products bought must be considered. In games, places were the player usually goes, the rewards he gets and the punishments he face it can be used to compose the user model.

$$CF = \frac{MB - MD}{1 - MIN(MB, MD)} \tag{1}$$

$$MB = \begin{cases} 1 & \text{if } P(H) = 1 \\ \dfrac{MAX[P(H|E), P(H)] - P(H)}{1 - P(H)} & \text{otherwise} \end{cases} \tag{2}$$

$$MD = \begin{cases} 1 & \text{if } P(H) = 0 \\ \dfrac{MIN[P(H|E), P(H)] - P(H)}{0 - P(H)} & \text{otherwise} \end{cases} \tag{3}$$

In order to update the model, a rule is associated to each evidence, the combination of the rules is made, and the resultant CF is calculated – formula (4) – where two rules with CF1 and CF2 are combined. Each n sessions (adjustable time window), the evidences are verified, the inferences with the rules are made, and the CFs corresponding to the hypothesis are updated. By sorting the resulting CFs, it is possible to establish a ranking of user's interest. Therefore, it is possible to verify the changes in the initial model (obtained from the explicit data collection) and, thus, to update the user model. From this update, the reorganization of the environment is made (i.e. changing the position of the objects, increasing or decreasing the difficulty of the game).

$$CF = \begin{cases} CF1 + CF2\,(1 - CF1) & \text{if both} > 0 \\ \dfrac{CF1 + CF2}{1 - MIN\,(|CF1|,|CF2|)} & \text{if one} < 0 \\ CF1 + CF2\,(1 + CF1) & \text{if both} < 0 \end{cases} \quad (4)$$

3 Using AdapTIVE in Games

Our motivation to the proposition of the application of AdapTIVE in games was based on the following main ideas: i) The 3D games offer to user a more attractive interaction and possibilities, and they are situated in an 3D environment populated with avatars and agents as in the other AdapTIVE implemented applications; ii) After playing the game several times, the player comes to know exactly all details of the environment and how/when the opponents (not so intelligent and not so autonomous agents) will act [9]. In order to overcome some traditional game limitations we can exploit the AdapTIVE model facilities adapting the environment and the position of the objects and agents that are placed into; iii) The development of new games that can react to players and provide different challenges and situations based on users' models (considering users' actions, interests, and preferences) could create more attractive games and a new experience every time the user plays the game [10]; iv) The use of intelligent opponents (agents) that know the environment and the user model, can make the interaction even more interesting.

We can adjust the difficulty level of a game more precisely according to the user behavior in the game (increasing or decreasing the "intelligence" of the agent and/or simplifying or making more difficult the game through changes in the environment). As the game continues and the player acquires more expertise, the difficulty can ramp up accordingly.

We can suppose an application of the AdapTIVE model in a computer game inspired on a "Dungeons and Dragons" game situated in a 3D environment (labyrinth). In this kind of games, we have some rewards (swords, weapons, health bonus, treasures, and other good things) and also some punishments (traps, monsters, dangerous places, and other bad things) that are spread over the game board, and in our case, distributed in a 3D labyrinth composed of several rooms and chambers. The players can explore the labyrinth, searching for rewards and avoiding the punishments/dangers.

The AdapTIVE model can be used to model the player behavior, identifying places were the player usually goes, the rewards he gets (or he doesn't gets) and the punishments he face it (or he doesn't face it). So, as a first example, we can apply rules like those:

"**IF** *player visits Room1* **THEN** *access to Room1 is easy* **with CF**=*x*"

"**IF** *player gets Reward1 placed into Room1* **THEN** *access to Room1 is easy* **with CF**=*x*"

"**IF** *player (not visit Room2) and (not get Reward2)* **THEN** *access to Room2 is difficult* **with CF**=*x*".

These rules can help to build an ordered list of easy and difficult access places, classified according to the way each player acts in the game.

In another example, we can imagine monsters (intelligent agents) that move across the labyrinth, and using the AdapTIVE model, the places they visit can be modified in order to direct them to go to places where the player usually goes, getting the game harder, or avoiding these places, getting the game easier. We can also change automatically the placement of rewards and punishments (and add/substract more rewards and punishments) in order to facilitate or difficult the game, based on a specific player behavior model.

Moreover, the AdapTIVE model proposes the use of a very simple AI mechanism, based on rules and CF, used to represent and adapt users' models and environment. This model has low computational costs, something very important when you are designing a high performance 3D game. Moreover, it is flexible where new rules can be added, allowing to adapt the model to different games.

We started the implementation of a game, which is situated in a 3D labyrinth composed of several rooms (Figure 1). In these rooms, we have rewards (i.e. weapons and health bonus) and some punishments (i.e. monsters). The players explore the labyrinth, searching for rewards and avoiding the punishments. Initially, some rewards and punishments are presented to all players. According to the navigation of each user, the position and number of these goods can be changed (Figure 2). Basically, we can create rules based on the user navigation, in order to update the user model.

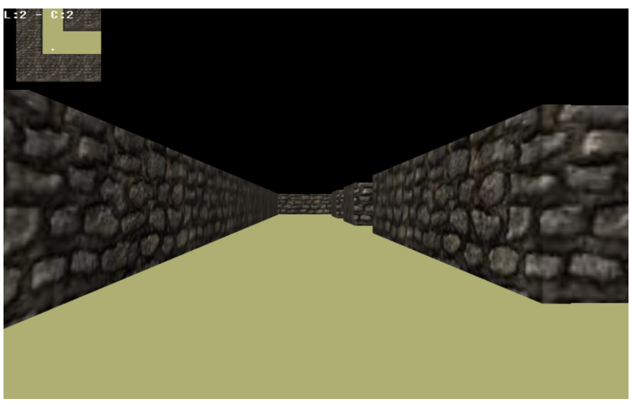

Figure 1 – 3D game labyrinth (front view).

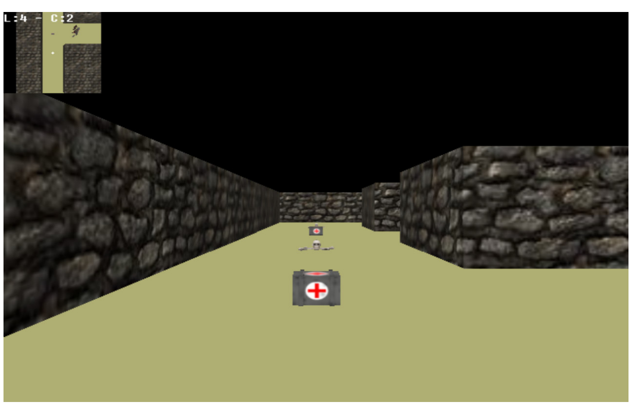

Figure 2 – Labyrinth with some rewards.

4 Final Remarks

The AdapTIVE model can be applied in different domains, especially where the use of user and content models, intelligent agents and virtual environments is promising, like in games. We suggest deals with the acquisition of users' models in 3D games, using these models to create adaptive games. As future works, we want to continue the implementation of the game environment using AdapTIVE model, as main ideas indicated in Section 3.

5 References

[1] Lent, M. *AI For Adaptive Opponents, Teammates and NPCs*. Game Developers Conference, San Francisco, CA, March 2005.

[2] Beal, C.; Beck, J.; Westbrook, D.; Atkin, M.; Cohen, P. *Intelligent modeling of the user in interactive entertainment.* Proceedings of the AAAI Spring Symposium on Artificial Intelligence and Interactive Entertainment, 2002.

[3] Santos, C. and Osório, F.: *Integrating Intelligent Agents, User Models and Automatic Content Categorization in a Virtual Environment*. Proceedings of the 7th International Conference on Intelligent Tutoring Systems, Alagoas, Brazil, September, Springer Verlag, 2004, p.128 - 139.

[4] Santos, C. and Osório, F.: An Intelligent and Adaptive Virtual Environment and its Application in Distance Learning. Advanced Visual Interfaces, Italy, May, ACM Press, 2004.

[5] Santos, C. and Osorio, F.: *AdapTIVE: An Intelligent Virtual Environment and its Application in E-Commerce*. Proceedings of the 28th Annual International Computer Software and Applications Conference. Los Alamitos: IEEE Computer Society Press, p.468 – 473, 2004.

[6] Papatheodorou, C.: *Machine Learning in User Modeling*. Machine Learning and Applications. Lecture Notes in Artificial Intelligence. Springer Verlag, 2001.

[7] Pazzani, M. and Billsus, D.: *Learning and Revising User Profiles: The identification on Interesting Web Sites*. Machine Learning, 27(3), 313-331, 1997.

[8] Giarratano, J. and Riley, G.: Expert Systems – Principles and Programming. 3 ed., PWS, Boston, 1998.

[9] Fogel, D. Evolutionary Entertainment with Intelligent Agents. IEEE Computer, June 2003, p. 94-96.

[10] Paulson, L. D. Using AI Games that Adapt to Users. IEEE Computer, July 2003.