Potential Applications of the AdapTIVE Model: Distance Learning, E-Commerce and Games

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Abstract: This paper presents the model and applications of the AdapTIVE (Adaptive Three-dimensional Intelligent and Virtual Environment) in several domains, such as learning and entertainment. The AdapTIVE is a virtual environment which has its structure and presentation (spatial organization) customized according to users' interests and preferences. This reorganization is based on the user and contents models, that can be automatically updated by the system. An intelligent agent assists users during the navigation in the environment and retrieval of relevant information. We present the potential application of the AdapTIVE to create highly interactive environments to Distance Learning, E-Commerce and Games.

Key words: intelligent virtual environments, virtual agents, distance learning, e-commerce, games.

1- Introduction

Virtual Environments (VEs) becomes an attractive alternative for the development of more realistic and interesting interfaces for the user. In VEs, according to [1], the user is part of the system, an autonomous presence in the environment. He is able to navigate, to interact with objects and to examine the environment from different points of view. According to [2], the 3D paradigm is useful mainly because it offers the possibility of representing information in a realistic way, while it organizes content in a spatial manner. In this way, a larger intuition in the visualization of the information is obtained, allowing the user to explore it in an interactive way, more natural to humans. Nowadays, the use of intelligent agents in VEs has been explored. These agents when inserted in virtual environments are called Intelligent Virtual Agents (IVAs) [3]. They act as users' assistants in order to help to explore the environment and to locate information [4,5,6,7], being able to establish a verbal communication (e.g., using natural language) or non verbal (through body movement, gestures and face expressions) with the user. The use of these agents has many advantages: to enrich the interaction with the virtual environment [8]; to turn the environment less intimidating, more natural and attractive to the user [4]; to prevent the users from feeling lost in the environment [9].

At the same time, the systems capable of adapting its structure from a user model have received special attention on research community. According to [10], a user model is a collection of information and suppositions on individual users or user groups, necessary for the system to adapt several aspects of its functionalities and interface. The adoption of a user model has been showing great impact in the development of filter systems and information retrieval [11,12], electronic commerce [13], learning systems [14], adaptive interfaces [15,16] and games [33]. These systems have already proven to be more effective and/or usable that non adaptive ones [17,36]. However, the research effort in adaptive systems has being focused in the adaptation of traditional 2D/textual environments. Adaptation of 3D VEs is still few explored, but considered promising [18,19].

Moreover, in relation to organizing content in VEs, the grouping of the contents, according to some semantic criterion, is interesting and sometimes necessary. An approach to organize contents consists in the automatic content categorization process. This process is based on machine learning techniques and comes being applied in general context, such as web pages classification (see e.g, [20]). However, it can be adopted in the organization of content in VE context.

This paper presents the model and applications of the AdapTIVE (Adaptive Three-dimensional Intelligent and Virtual Environment) in several domains, such as learning and entertainment. The AdapTIVE is a virtual environment which has its structure and presentation (spatial organization) customized according to users' interests and preferences. This reorganization is based on the user and contents models, that can be automatically updated by the system. An intelligent agent assists users during the navigation in the environment and retrieval of relevant information. We present the potential application of the AdapTIVE to create highly interactive environments to Distance Learning, E-Commerce and Games.

The paper is organized as follow. In section 2, the AdapTIVE model is presented and its main components are detailed. In section 3, the applications of the AdapTIVE in Distance Learning and E-Commerce are detailed, and the possible extensions to apply AdapTIVE in Games are also presented. Finally, section 4 presents the final remarks and 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 (Figure 1) consists of the representation of a three-dimensional world, accessible through the Web, used to make content available, which are organized into content categories. 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.

The user models are used in the environment adaptation and are managed by the user model manager module. The contents are added or removed by the provider through the content manager module and stored in a content database. 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 three-dimensional objects and links to the data (e.g., text document, web page).

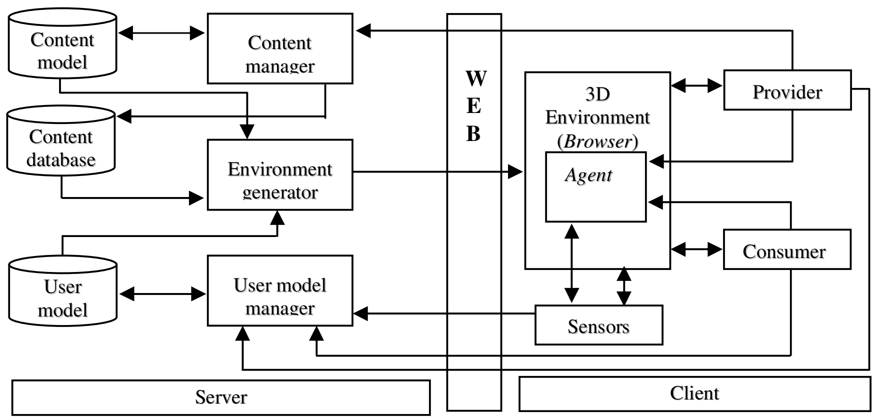


Figure 1 – AdapTIVE Model Scheme

The environment generator module is the responsible for the generation of different three-dimensional structures that form the environment and to arrange the information in the environment, 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 preference). In the following sections are detailed the main components of the environment: user model manager, content manager, and intelligent virtual agent.

2.1 – User Model Manager

This module is responsible for the initialization and updating of user models. The user model contains information about the users' interests, preferences and behaviors. In order to collect the data used in the composition of the model, the explicit and implicit approaches [21,22] are 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, areas of interest and preferences for colors).

In the implicit approach, the monitoring of user navigation in the environment, his actions and interactions with the agent are made. Through this approach, the environment places visited by the user and the requested (through the search mechanism) and accessed (clicked) contents are monitored. 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) [23,24]. 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 (i.e. the interest in some area), and P(H|E) is the probability of the hypothesis (H), given that some evidence (E) exists. In the environment, the user's initial interest in a given area – 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.

The evidences are related to the environment areas visited and to the requested and accessed contents by the user. They are used to infer the hypothesis of the user's interest in each area, from the rules and corresponding CFs. However, it must be addressed that different applications may involve different evidences, as indicated in Section 3. In a virtual store, for instance, the evidences related to the products bought by the user must be also considered.

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

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

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

In a general way, to update the model the main rules (4), (5), (6), and (7) can be used. The rules (4), (5) and (6) are used when evidences of request, navigation, and access exist. In this case, the combination of the rules is made and the resultant CF is calculated – formula (8) – where two rules with CF1 and CF2 are combined. The rule (7) is used when does not exist any evidence, indicating total lack of user interest in the corresponding area.

IF request THEN interest in Y with CF = x (4)
IF navigation THEN interest in Y with CF = x (5)
IF access THEN interest in Y with CF = x (6)
IF (not request) and (not navigation) and (not access) (7)
THEN interest in Y with CF = x (where x<0)

$$CF = \begin{cases} CF1 + CF2\,(1 - CF1) & \text{if both} > 0 \\ \frac{CF1 + CF2}{1 - MIN\,(|CF1|,|CF2|)} & \text{if one} < 0 \\ CF1 + CF2\,(1 + CF1) & \text{if both} < 0 \end{cases} \quad (8)$$

Each n sessions (adjustable time window), for each area, the evidences (navigation, request, and access) are verified, the inferences with the rules are made, and the CFs corresponding to the hypothesis of interest are updated. By sorting the resulting CFs, it is possible to establish a ranking of user's areas of 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 - contents that correspond to the areas of major user's interest are placed, in a visualization order, before the contents which are less interesting (easier access). It must be addressed that each modification in the environment is always suggested to the user and accomplished only under user's acceptance.

The motivation to adopt rules and CFs is based on the following main ideas. First, it is a formalism that allows to infer hypothesis of the user's interests in the areas from a set of evidences (e.g., navigation, request, access and buy), also considering a degree of uncertainty about the hypothesis. Second, it doesn't require to know a priori set of probabilities and conditional tables, as it occurs with the use of the Bayesian Nets, an other common approach used in user modeling. Third, it doesn't require the pre-definition of user categories, as in the techniques based on stereotypes. Moreover, it has low computational cost, is intuitive and robust. All these aspects are relevant in user modeling.

2.2 – Content Manager

This module is responsible for insertion and removal of contents, and management of its models. The content models contain the following data: category (among a pre-defined set), title, description, keywords, type of media and corresponding file. From content model, the spatial position that the content will occupy in the environment is defined. The contents are also grouped into virtual rooms by main areas (categories). For textual contents, an automatic categorization process is available, thus the category and the keywords of the content are obtained. For non textual contents (for instance, images and videos), textual descriptions of contents can be used in the automatic categorization process.

An automatic categorization process is formed by a sequence of stages: (a) document base collection; (b) pre-processing; and (c) categorization. The document base collection consists of obtaining the examples to be used for training and test of the learning algorithm. The pre-processing involves, for each example, the elimination of irrelevant words (e.g., articles, prepositions, pronouns), the removal of affix of the words and the selection of the most important words, used to characterize the document. In the categorization stage, the learning technique is then determined, the examples are coded, and the classifier learning is accomplished. After these stages, the classifier can be used in the categorization of new documents.

In a set of preliminary experiments (details in [25]), the decision trees [26] showed to be more robust than the artificial neural networks [27] and were selected for use in the categorization process proposed in the environment. In these experiments, the pre-processing stage was supported by an application, extended from a *framelet* (see [28]), whose kernel contemplates the basic flow of data among the activities of the pre-processing stage and generation of scripts submitted to the learning algorithms. The tools used for training the categorization algorithms, decision trees and artificial neural network, were C4.5 [26] and Neusim (Neural Simulator [29]).

After applying the learning algorithm, the "learned model" – rules extracted from the decision tree – is connected to the content manager module, in order to use it in the categorization of new documents. Thus, when a new document is inserted in the environment, it is pre-processed, has its keywords extracted and is automatically categorized and positioned in the environment.

2.3 – Intelligent Virtual Agent

The virtual agent assists users during navigation and retrieval of relevant information. It has the following characteristics: perception of the environment, ability to interact, user/content knowledge, certain degree of reasoning and autonomy and graphic representation. The agent's architecture reflects the following modules: knowledge base, perception, decision and action. The agent's knowledge base stores the information that it holds about the user and the environment. This knowledge is built from two sources of information: external source and perception of the interaction with the user. The external source is the information about the environment and the user, and they are originated from the environment generator module. A perception module observes the interaction with the user, and the information obtained from this observation is used to update the agent's knowledge. It is through the perception module that the agent detects the requests from user and observes the user’s actions in the environment. Based on its perception and in the knowledge that it holds, the agent decides how to act in the environment. A decision module is responsible for this activity. The decisions are passed to an action module, responsible to execute the actions (e.g., animation of graphic representation and speech synthesis).

The communication between the agent and the users can be made in three ways: in a verbal way, through a pseudo-natural language and speech synthesis, and non verbal way, by the agent's actions in the environment. The dialogue in pseudo-natural language consists of a certain group of questions and answers and short sentences, formed by a verb that corresponds to the type of user request and a complement, regarding the object of user interest. During the request for helping to locate information, for instance, the user can indicate (in textual interface) Locate <content>. The agent's answers are suggested by its own movement through the environment (moving towards the information requested by the user), by indications through short sentences, and by text-to-speech synthesis. In the interaction with provider, during the insertion of content, he can indicate Insert <content>, and the agent presents the data entry interface for the specification, identification and automatic categorization of the content model.

Moreover, a topological map of the environment is kept in the agent's knowledge base. In this map, a set of routes for key-positions of the environment is stored. In accordance with the information that the agent has about the environment and with the topological map, it defines a set of routes that must be used in the localization of determined content or used to navigate until determined environment area. Considering that the agent updates its knowledge for each modification in the environment, it is always able to verify the set of routes that leads to a new position of a specific content.

3- Applications of the AdapTIVE Model

The AdapTIVE model was applied to create highly interactive environments to Distance Learning, E-Commerce and we suggest that it can be adapted to be applied in Games. In this section, these applications are commented.

3.1 – An Environment for Distance Learning

The AdapTIVE was initially validated with a prototype of an environment for distance learning [30,31], used to make educational content available. In the prototype, a division of the virtual environment is adopted according to the areas of the contents. In each area a set of sub-areas can be associated. The sub-areas are represented as subdivisions of the environment. In the prototype the following areas and sub-areas were selected: Artificial Intelligence (AI) – Artificial Neural Networks, Genetic Algorithms and Multi Agents Systems; Computer Graphics (CG) – Modeling, Animation and Visualization; Computer Networks (CN) – Security, Management and Protocols; Software Engineering (SE) – Analysis, Patterns and Software Quality. A room is associated to each area in the environment and the sub-areas are represented as subdivisions of rooms. Figures 2 and 3 show screen-shots of the prototype that illustrate the division of the environment in rooms and sub-rooms. As we can see in screen-shots, a system version in Portuguese is presented, where the description “Inteligência Artificial” corresponds to “Artificial Intelligence”.

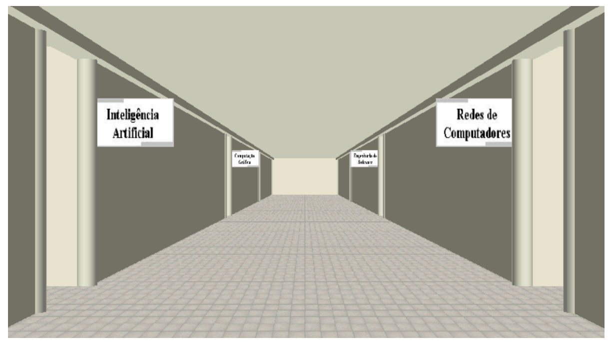


Figure 2 – Rooms of the environment.

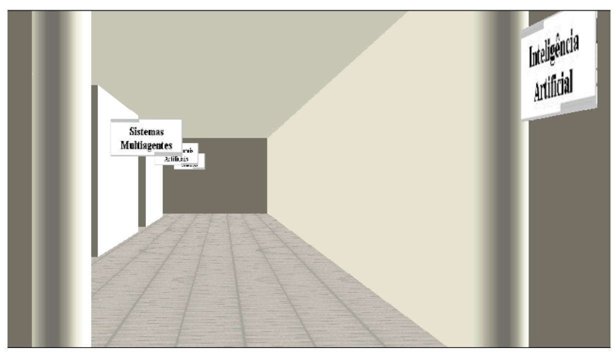


Figure 3 – Sub-rooms of the environment.

According to the user model, the reorganization of this environment is made: the rooms that correspond to the areas of major user's interest are placed, in a visualization order, before the rooms which contents are less interesting. The initial user model, based on explicit approach, is used to structure the initial organization of the environment. This involves also the use of avatars according to gender of user and the consideration of users’ preferences by colors. As the user interacts with the environment, his model is updated and changes in the environment are made. After n sessions (time window), for each area, the evidences of interest (navigation, request and access) are verified, in order to update the user model.

For instance, with a user, who is interested about Artificial Intelligence (AI), is indifferent to contents related to the areas of Computer Networks (CN) and Computer Graphics (CG), and does not show initial interest about Software

Engineering (SE), the initial values of the CFs, at the beginning of the first session of interaction (without evidences), would be respectively 1, 0, 0 and -1. After doing some navigations (N), requests (R) and access (A), presented in the graph of Figure 4, the CFs can be reevaluated. According to Figure 4, it is verified that the CN area was not navigated, requested and accessed, and on the other side, the user started to navigate, to request, and to access contents in SE area. As presented in the graph of Figure 5, an increase of the CFs values had been identified as related to the SE area. In that way, at end of the seventh session, the resulting CFs would be 1, -1, 0.4 and 0.2 (AI, CN, CG, SE, respectively). By sorting the resulting CFs, it would be possible to detect an alteration in the user model, whose new ranking of the interest areas would be AI, CG, SE, CN.

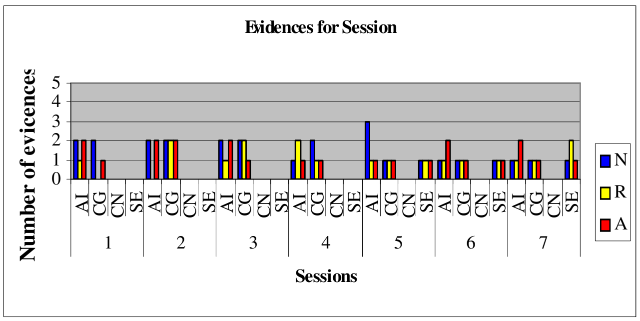


Figure 4 – Number of navigations (N), requests (R) and access (A) of each area, for session.

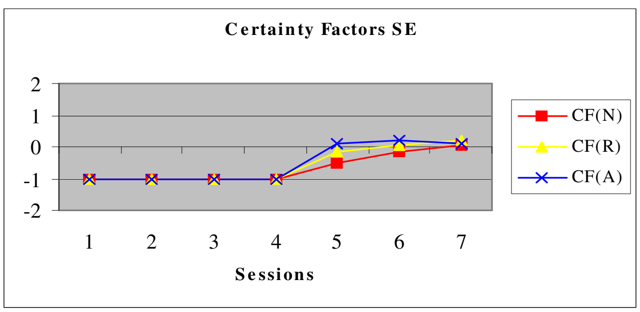
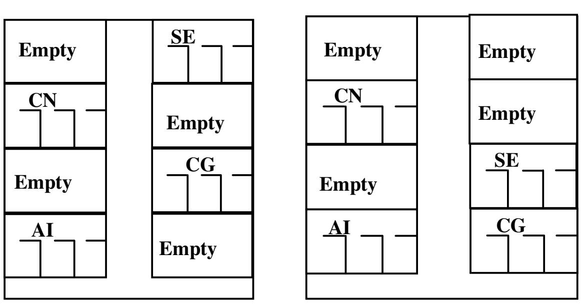


Figure 5 – CFs corresponding to evidences of the SE area.

Figures 6(a) and 6(b) represent an example of the organization of the environment (2D view) before and after a modification in the user model, respectively, as the example above.



(a) (b)

Figure 6 – (a) Organization of the environment according to initial user model; (b) organization of the environment after the user model changes.

On the other side, in relation to contents in the environment, the following file types are supported: *.txt, *.html, *.doc, *.pdf, *.ppt, *.jpg, *.bmp, *.wrl (VRML), *.avi, *.wav e *.au. The types that correspond to 2D and 3D images (*.bmp, *.jpg and *.wrl) and videos (*.avi) are represented directly in the 3D space. The other types (*.txt, *.html, *.doc, *.pdf and *.ppt) are represented through 3D objects and links to content details (visualized using the corresponding application/plug-in). Moreover, the sounds (*.au and *.wav) are activated when the user navigate or click on some object.

In relation to manipulation of contents in the environment, the provider model describes his main expertise areas and is used to indicate the area (e.g., Artificial Intelligence) that the content being inserted belongs, and the automatic categorization process indicates the corresponding sub-area (e.g., Artificial Neural Nets), or either, the sub-room where the content should be inserted. In this way, the spatial disposal of the content is made automatically by the environment generator, on the basis of its category. In the prototype, thirty examples of scientific papers, for each sub-area, had been collected from the Web, and used for learning and validation of the categorization algorithm. In the stage of learning, experiments with binary and multiple categorizations had been carried through [25]. In the binary categorization, a tree is used to indicate if a document belongs or not to the definitive category. In the multiple categorization, a tree is used to indicate the most likely category of one document, amongst a possible set. In the experiments, the binary categorization presented better results (less error and, consequently, greater recall and precision), being adopted in the prototype. In this way, for each sub-area, the rules obtained from decision tree (C4.5) were converted to rules of type IF - THEN, and associated to content manager module.

Moreover, in relation to communication process between the agent and the users, they interact by a dialog in pseudo-natural language, as commented in section 2.1. The user can select one request to the agent in a list of options, simplifying the communication. The agent's answers are showed in the corresponding text interface window and synthesized to speech. Figures 7, 8, and 9 illustrate, respectively: a request of the user for the localization of determined area and the movement of the agent, together with a 2D environment map, used as an additional navigation resource; the localization of an sub-area by the agent; the user visualization of a content and the visualization of details of it, after selection and click in a specific content description.

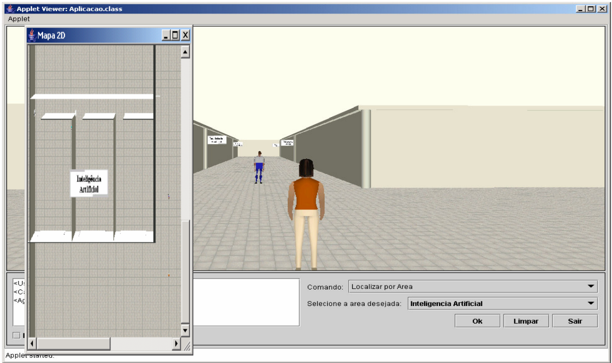


Figure 7 − Request of the user.

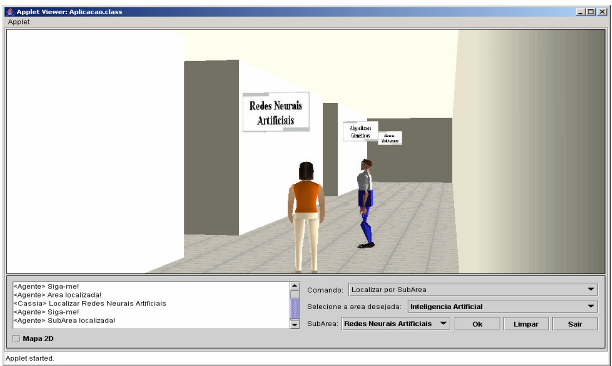


Figure 8 − Localization of a sub-area.

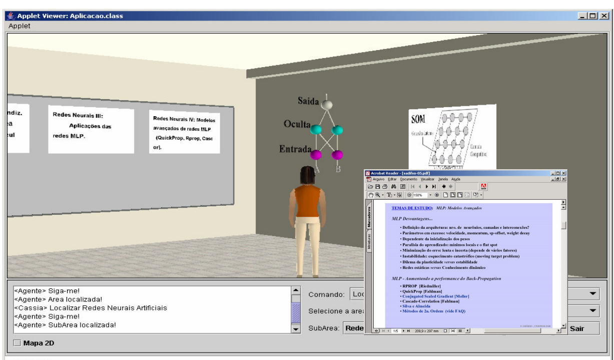


Figure 9 − Visualization of contents.

3.2 – A Virtual Bookstore

Other potential application to the AdapTIVE is e-commerce environments [32]. Our motivation to develop this environment was based on the following main ideas. First, the three-dimensional virtual stores offer to user a more natural and attractive interaction, so he is able to navigate through a virtual store and visualize products in a more realistic way compared to 2D interfaces. Second, the possibility to arrange stores and their products, according to the users' preferences and needs (impracticable in a real environment), facilitates the access to products and increases user's satisfaction level. Third, the use of intelligent assistants that establish a dialogue with the users and offer help to locate products, or offer information about the same ones, can make the interaction even more interesting. Moreover, in relation to acquisition of users' characteristics in a three-dimensional environment, according to [18], unlike 2D e-commerce sites, where it is often assumed that every product in a downloaded page has been seen, a 3D environment allows one to track better what products the consumer is seeing, by verifying that two condition hold: (a) the consumer has to be near enough to the product in the 3D space, and (b) the virtual head of the consumer must be oriented towards the product.

In the prototype, a virtual bookstore was implemented and a division of the virtual environment is adopted according to the areas of the contents (book categories). In each area a set of sub-areas can be associated. The sub-areas are represented as subdivisions of the environment. The following areas and sub-areas were selected: Culinary – Drinks and Foods; Computer Science – Programming, Applications and Hardware; Literature – Biographies, Story and Romance; Business – Economy, Management and Marketing; and Health – Exercises and Fitness, Homoeopathy and Nutrition.

A room is associated to each area in the environment and the sub-areas are represented as subdivisions of rooms. Figures 10 and 11 show screen-shots of the prototype that illustrate the division of the environment in rooms and sub-rooms. In screen-shots, a system version in Portuguese is presented, where the description "Informática" corresponds to "Computer Science".

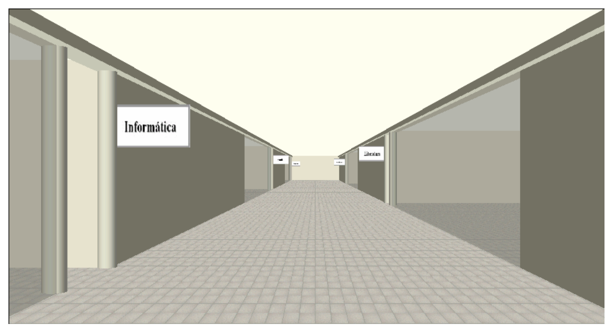


Figure 10 – Rooms of the environment.

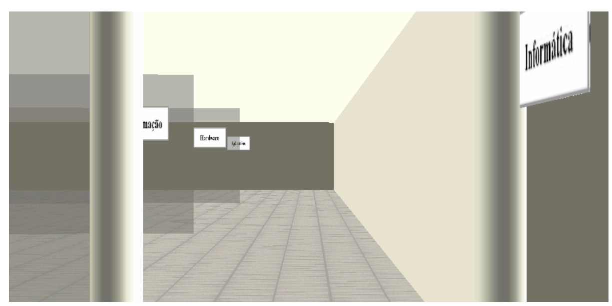


Figure 11 – Sub-rooms of the environment.

According to the user model, the reorganization of this environment is made: the rooms that correspond to the areas of major user's interest are placed, in a visualization order, before the rooms which contents are less interesting. The initial user model, based on explicit approach, is used to structure the initial organization of the environment. Figures 12 and 13 represent examples of the initial environment adaptations. In the environment of Figure 12, the user (female gender) has interest by Computer Science area and use clean color; in the environment of Figure 13, the user (male gender) has interest by Health area (indicated as "Saúde" in Portuguese) and use dark color. As the user interacts with the environment, his model is updated and changes in the environment are made. After n sessions (time window), for each area, the evidences of interest (navigation, request, access and buy) are verified and CFs are calculated, in order to update the user model.

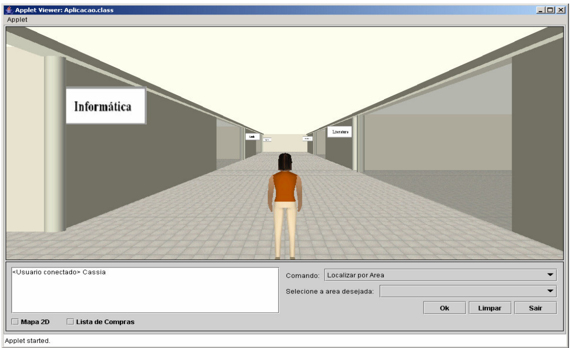


Figure 12 – User with interest in Computer Science area.

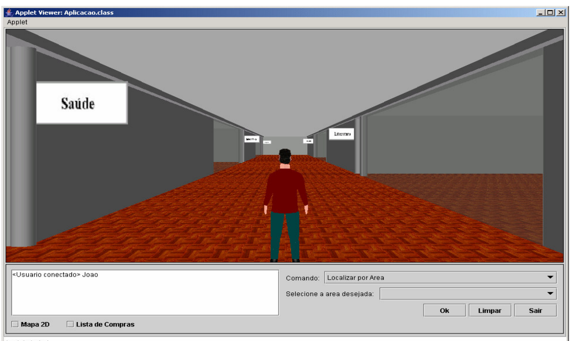


Figure 13 – User with interest in Health area.

On the other side, in relation to contents in the environment, the books are represented through 3D objects with the book cover and links to its descriptions. When the user clicks one time on the object, he can visualize the description of corresponding book (e.g., brief description, price, edition, editor, number of pages). The full book descriptions are informed by provider and they are used by the automatic categorization process. The brief descriptions are obtained through a form, where the provider can also activate the automatic categorization process. Figure 14 shows representations of books in the environment.

Figure 14 – Books in the virtual store.

In relation to manipulation of contents in the environment, the provider model is used to indicate the area (e.g., Computer Science) that the content being inserted belongs, and the automatic categorization process indicates the corresponding sub-area (e.g., Programming), or either, the sub-room where the content should be inserted. In this way, the spatial disposal of the content is made automatically by the environment generator, on the basis of its category. In the prototype, thirty examples of book descriptions, for each sub-area, had been collected from the Web, and used for learning and validation of the categorization algorithm. In the stage of learning, experiments with binary and multiple categorizations had been carried through. The binary categorization presented better results (less error and, consequently, greater recall and precision), being adopted in the prototype. In this way, one book can be categorized (and placed) in more than one category at the same time. For each sub-area, the rules obtained from decision tree (C4.5) were converted to rules of type IF – THEN, and associated to content manager module.

In relation to the action of buy books, when the user clicks two times on 3D objects, the corresponding book is added in a buy list. This list stays always available for the user and he can also remove items.

The communication process between the virtual agent and the users is made by a dialog in pseudo-natural language, as commented in Section 2.1. The user can select one request to the agent in a list of options, simplifying the communication. The agent's answers are showed in the corresponding text interface window and synthesized to speech. Figures 15, 16, 17 and 18 illustrate, respectively: a request of the user for the localization of determined category of books and the movement of the agent, together with a 2D environment map, used as an additional navigation resource; the localization of an category by the agent; the user visualization of books and visualization of details, after selection and click in a corresponding 3D object; and the user's buy list.

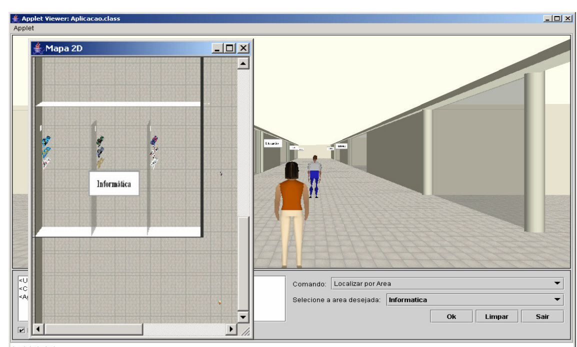


Figure 15 – Request of the user.

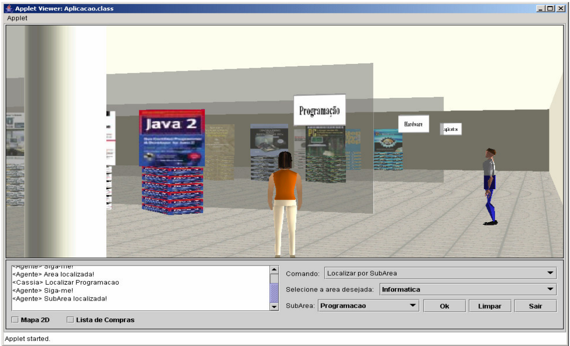


Figure 16 – Localization of the category by the agent.

Figure 17 – Visualization of book details.

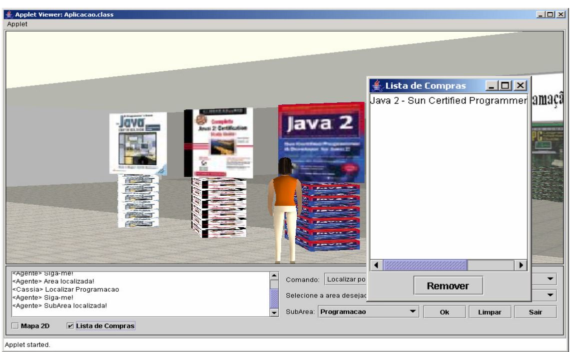


Figure 18 – User's buy list.

Moreover, bought books are stored in a special room, as Figure 19 shows. This room is used to store a history of the user's buys.

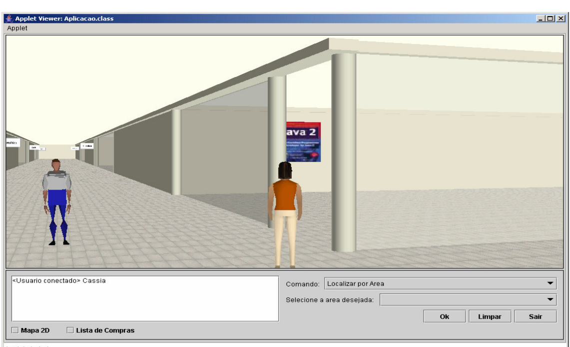


Figure 19 – Special room of bought books.

It must be addressed that the prototype was implemented using Java3D[1], VRML[2], MySQL[3] and JSAPI[4]/IBM ViaVoice[5].

3.3 – Games

The AdapTIVE was validated in distance learning and e-commerce applications, meantime the main properties of this model are very promising if they are applied in entertainment and games applications. Our motivation to the proposition of this application of AdapTIVE in games was based on the following main ideas: i) The three-dimensional 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 [34]. 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 [36]; 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). The game should observe the player's behavior, create a model of what aspects of the game the player knows and not know (yet), and offer choices to the player that are designed to keep hi or her motivated and engaged [33]. As the game continues and the player acquires more expertise, the pace and 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 good 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

[1]http://java.sun.com/products/java-media/3D
[2]www.web3d.org
[3]www.mysql.com
[4]http://java.sun.com/products/java-media/speech/index.jsp
[5]http://www-306.ibm.com/software/voice/viavoice/

ewards 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 in order to facilitate or difficult the game, based on a specific player behavior model.

Moreover, the AdapTIVE model proposes the use of a simple mechanism, based on rules and CFs, used to represent and adapt users' models and environment, where this model has low computational costs, something very important when you are designing a high performance 3D game.

4- Final Remarks

This paper presented the model and applications of the AdapTIVE (Adaptive Three-dimensional Intelligent and Virtual Environment) in several domains, such as learning and entertainment. The resources of Virtual Reality are explored, seeking to increase the interactivity degree between the users and the environment. The spatial reorganization possibilities and the environment customization, according to the modifications (addition and removal) in the available contents and the user models were presented. Besides, an automatic content categorization process that aims to help the specialist of the domain (provider) in the information organization in this environment was also shown. It was described an intelligent agent that knows the environment and the user, acts assisting him in the navigation and location of information in this environment.

We applied our approach on distance learning and e-commerce environments. This way, the AdapTIVE architecture 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. Moreover, a standout of this work is that it deals with the acquisition of users' characteristics in a three-dimensional environment. Most of the works related to user model acquisition and environment adaptation are accomplished using 2D interfaces. A great portion of these efforts in the construction of Virtual Environments don't provide the combination of user models, assisted navigation and retrieval of information, and, mainly, don’t have the capability to reorganize the environment, and display the contents in a three-dimensional space. Usually, only a sub-group of these problems is considered. This work extends and improves these capabilities to 3D environments.

As future works, many possibilities exist. First, the use of techniques related to natural language processing in the communication between the agent and the users could be made. Second, the environment could be extended to support the multi-user interaction. In the specific case of the virtual bookstore, the brief book descriptions could be obtained from the automatic summarization process, using as base its full descriptions. Third, we want to implement a game environment using AdapTIVE model, as main ideas indicated on Section 3.3.

5- References

[1] Avradinis, N.; Vosinakis, S.; Panayiotopoulos, T.: Using Virtual Reality Techniques for the Simulation of Physics Experiments. 4th Systemics, Cybernetics and Informatics International Conference, Orlando, Florida, USA, July, 2000.

[2] Frery, A.; Kelner, J.; Moreira, J., Teichrieb, V.: Satisfaction through Empathy and Orientation in 3D Worlds. CyberPsychology and Behavior, 5(5), 451-459, 2002.

[3] Aylett, R. and Cavazza, M.: Intelligent Virtual Environments - A state of the art report. Eurographics Conference, Manchester, UK, 2001.

[4] Chittaro, R.; Ranon, R.; Ieronutti, L.: Guiding Visitors of Web3D Worlds through Automatically Generated Tours. Proceedings of the 8th Conference on 3D Web Technology, ACM Press, New York, March, 2003.

[5] Milde, J.: The instructable Agent Lokutor. Workshop on Communicative Agents in Intelligent Virtual Environments, Spain, 2000.

[6] Nijholt, A. and Hulstijn, J.: Multimodal Interactions with Agents in Virtual Worlds. In: Kasabov, N. (ed.): Future Directions for Intelligent Information Systems and Information Science, Physica-Verlag: Studies in Fuzziness and Soft Computing, 2000.

[7] Panayiotopoulos, T.; Zacharis, N.; Vosinakis, S.: Intelligent Guidance in a Virtual University. Advances in Intelligent Systems - Concepts, Tools and Applications, 33-42, Kluwer Academic Press, 1999.

[8] Rickel, J.; Marsella, S.; Gratch, J.; Hill, R.; Traum, D.; Swartout W.: Toward a New Generation of Virtual Humans for Interactive Experiences. IEEE Intelligent Systems, 17(4), 2002.

[9] Rickel, J. and Johnson, W.: Task-Oriented Collaboration with Embodied Agents in Virtual Worlds. In J. Cassell, J. Sullivan, S. Prevost, and E. Churchill (Eds.), Embodied Conversational Agents, 95-122. Boston: MIT Press, 2000.

[10] Kobsa, A.: Supporting User Interfaces for All Through User Modeling. Proceedings of HCI International, Japan, 1995.

[11] Billsus, D. and Pazzani, M.: A Hybrid User Model for News Story Classification. Proceedings of the 7th International Conference on User Modeling, Banff, Canada, 99-108, 1999.

[12] Lieberman, H.: Letizia: An Agent That Assist Web Browsing. International Joint Conference on Artificial Intelligence, Montreal, 924-929, 1995.

[13] Abbattista, F.; Degemmis, M; Fanizzi, N.; Licchelli, O. Lops, P.; Semeraro, G.; Zambetta, F.: Learning User Profile for Content-Bases Filtering in e-Commerce. Workshop Apprendimento Automatico: Metodi e Applicazioni, Siena, Settembre, 2002.

[14] Self, J.: The defining characteristics of intelligent tutoring systems research: ITSs care, precisely. International Journal of Artificial Intelligence in Education, 10, 350-364, 1999.

[15] Brusilovsky, P.: Adaptive Hypermedia. User Modeling and User-Adapted Interaction, 11, 87-110, Kluwer Academic Publishers, 2001.

[16] Perkowitz, M. and Etzioni, O.: Adaptive Web Sites: Automatically synthesizing Web pages. Fifteen National Conference in Artificial Intelligence, Wisconsin, 1998.

[17] Fink. J. and Kobsa, A.: A Review and Analysis of Commercial User Modeling Server for Personalization on the World Wide Web. User Modeling and User Adapted Interaction, 10(3-4), 209-249, 2000.

[18] Chittaro L. and Ranon R.: Adding Adaptive Features to Virtual Reality Interfaces for E-Commerce. Proceedings of the International Conference on Adaptive Hypermedia and Adaptive Web-based Systems, Lecture Notes in Computer Science 1892, Springer-Verlag, Berlin, August, 2000.

[19] Chittaro, L. and Ranon, R.: Dynamic Generation of Personalized VRML Content: A General Approach and its Application to 3D E-Commerce. Proceedings of 7th Conference on 3D Web Technology, USA, February, 2002.

[20] Sebastiani, F.: Machine learning in automated text categorization. ACM Computing Surveys, 34(1), 1-47, 2002.

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

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

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

[24] Nikolopoulos, C.: Expert Systems – Introduction to First and Second Generation and Hybrid Knowledge Based Systems. Eds: Marcel Dekker, New York, 1997.

[25] Santos, C. and Osorio, F. : Técnicas de Aprendizado de Máquina no Processo de Categorização de Textos. Internal Research Report (http://www.inf.unisinos.br/~cassiats/dissertacao), 2003.

[26] Quinlan, R. C4.5: Programs for Machine Learning. Morgan Kaufmann, Sao Mateo, California, 1993.

[27] Haykin, S. Redes Neurais: Princípios e Prática. 2 ed. Bookman, 2001.

[28] Pree, W. and Koskimies, K.: Framelets-Small Is Beautiful, A Chapter in Building Application Frameworks: Object Oriented Foundations of Framework Design. Eds: M.E. Fayad, D.C. Schmidt, R.E. Johnson, Wiley & Sons, 1999.

[29] Osorio, F. and Amy, B. 1999. INSS: A hybrid system for constructive machine learning. Neurocomputing 28: 191-205.

[30] 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.

[31] 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.

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

[33] Beal, C.; Beck, J.; Westbrook, D.; Atkin, M.; Cohen, P. Intelligent modeling of the user in interactive entertainment. AAAI Stanford Spring Symposium.

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

[35] Fogel, D.B.; Hays, T.J.; Johnson, D.R. A platform for evolving characters in competitive games. Proceedings of 2004 Congress on Evolutionary Computation, IEEE Press, Piscataway, NJ, p. 1420-1426.

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