Lizeth: Agent Mediated E-Commerce in a Virtual Environment

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Abstract

The explosion of the Internet, and most recently e-commerce, has caused great interest in agent technologies. The development of virtual environments has also increased in the last few years. A growing number of real-time applications use graphics with photorealistic quality, especially in the field of training, but also in the areas of design and ergonomic research.

We describe an attempt to develop a framework that provides customers with multimedia information and interactive experiences within a virtual shopping environment. The application presented consists on a virtual visit to a music-store where the user is guided by an intelligent agent named Lizeth which responds in real-time to user's requests with precise information about music, artist's biographies, prices and related products to help the user to make decisions.

The potential of UML and the Java programming language is discussed to show their application in the field of intelligent agents as mediators on shopping processes. We conclude that the proposed framework leads to the creation of applications with a potentially significant impact in the development of e-commerce systems embedded in virtual environments.

Keywords:

Knowledge-Bases (KB), Intelligent Agents, Electronic Commerce, Virtual Environments, VRML

Introduction

The use of intelligent agent technologies in the field of e-commerce has been recognized as a revolutionary tool. Over the last eight years, the Internet has gone through a transformation process, specially in the services which it can provide. It has expanded from a simple publishing tool to a fully integrated set of powerful services and applications. As new and more sophisticated applications are built around the Internet the user interfaces have become a key element. These changes can be grouped into different web site generations[1].

The latest research on AI has shown the capabilities of web-agents, such as Letizia [2], an agent that helps the user make faster searches by analyzing the user's navigation history. Also, a multiagent infrastructure framework was presented in [3]. This framework enables searching and interoperation between agents. A similar application is AVATARS [4], which tries to simulate communicative interface agents inside a conversational environment. However these agents are not able to simulate the human communication through body movements. This problem was addressed using Knowledge-Bases to show such behavior. The agent perceives an action and has an predefined reaction to it. Hannoun et al. [5] stated that for each agent, the organization is viewed as a normative set of rules that constrains the agents' behavior.

The development of virtual environments has increased in the last few years. A growing number of real-time applications need graphics with photo realistic quality, especially in the field of training (virtual operation, driving and flight simulation), but also in the areas of design and ergonomic research [6].

E-Commerce and Agents

Due to their characteristics, agents can be used as assistants and electronic mediators in virtual environments.

In order for an agent involved in a shopping environment to offer a more realistic experience it would have to include features like multiple attributes negotiation, similar product suggestion, correlated product suggestion, negotiation costs and learning.

Next, we will analyze two key issues in the design of agents working in a virtual environment like a music store.

Agent design problem

Nowadays one of the main interests is to build agents that can autonomously act on our behalf to accomplish a task within a complex and unpredictable environments. The agent design problem may be stated as follows :

"Given an environment, together with a specification of a task, is it possible to construct an agent that can be guaranteed to successfully accomplish the task in the environment?" [16]

Wooldridge et al. [16] had presented a model to frame systems composed of an agent situated in an environment. In this work this can be stated as follows: the agent (virtual assistant) interacts with the environment by performing actions upon it, and the environment (virtual shop and the user) responds to this actions with changes in state.

The environment may be in any of a finite set $E = \{e,e',\ldots\}$ of instantaneous states. The agents can execute a repertoire of possible actions, which transform the state of the environment. Let $Ac = \{\alpha,\alpha',\ldots\}$ the finite set of actions.

A run, r, of an agent in an environment can be seen as the sequence of interleaved environment states and actions :

$$r : e_0 \xrightarrow{\alpha_0} e_1 \xrightarrow{\alpha_1} e_2 \xrightarrow{\alpha_2} \ldots \xrightarrow{\alpha_{u-1}} e_u \ldots$$

The previous definitions are very important, they need to be carefully considered in the specification of the capabilities and goals of the agent because they define the complexity of the agent's strategy to achieve its objectives.

Knowledge in e-commerce systems

The system presented in this paper is based on the vast knowledge that already exists about the business domain and the knowledge acquired from the sellers, buyers, and transactions. Based on these knowledge, an information model is used to represent the experience through a knowledge base system.

Evaluation of Lizeth's knowledge bases : The KAMET methodology

The Knowledge Acquisition Methodology, KAMET [11], is a dynamic, compact, and versatile tool to model complex KBS. The first version of KAMET [12,13,14] included a life cycle model with two main phases: one to asses the knowledge involved in the project, and one to model and process that knowledge. Since its outset KAMET was designed to manage knowledge acquisition (KA) from multiple knowledge sources (KS), with a mechanism to achieve KA in an incremental fashion, and in a cooperative environment (See Figure 1).

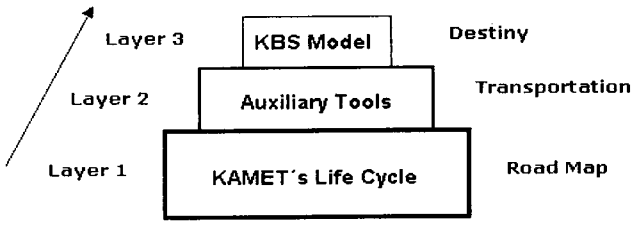

Figure 1 – Abstract layers of the KAMET methodology

In this system, we sketch our evaluation process using this methodology in order to obtain a reliable, and complete product.

Overview of Lizeth

The agent described can be classified as an hybrid one because it shows both characteristics of a reactive and an interface agent [15]. Lizeth pretends to be a user's personal assistant during the visit to a web site and can advise the user based on the knowledge it has to make a more enjoyable visit.

The definition of Knowledge-Bases serve as the basis for some inference mechanisms including rule-based reasoning that provides answers to user's questions related to information about any CD title. Lizeth has the ability to communicate with the Knowledge-Bases in order to search for knowledge about the situation. The communication works using an agent communication language like KQML. It is the facto standard for agent communication languages. The proposed agent uses personal profile information to offer the users tailored content, goods, and services that match their preferences while protecting their privacy.

Negotiation parameters

The following parameters are used for the agent's negotiation and to specify it's goals:

- Latest date to sell the CD.
- Desired price.
- Lowest/highest acceptable price.
- Negotiation strategy.

Based on the above parameters, Lizeth interacts with the user aiding him in making the best decision when buying a CD. Lizeth's mental state is structured using the BDI model formed by three main components: *Belief*, *Desire* (or *Goal*), and *Intention*.

System design

The presented system is described using UML (Unified Modeling Language). UML allows to capture information about the static structure of the web page and the dynamic behavior of Lizeth. The system is modeled as a collection of objects that interact performing actions oriented to user's benefits.

Lizeth is designed to run the intelligence of the e-commerce system. Its structure is basically a library of behaviors implemented as objects. The sensing process and the action primitives of the architecture are implemented through the methods of eigth classes. Each class is based on a knowledge-base representing attributes of the web site's environment.

The following needs were established for Lizeth's behavior:

- The user actor needs the system to register his visit.
- After the user's registration, multiple KB must be loaded to describe the user's profile, including Lizeth's behavior that must be adopted through the rest of the visit.
- The agent actor needs the system to select the corresponding actions according to the user's request.
- The virtual store actor is responsible for the creation of the music catalog that the user wants to purchase, and for the maintenance of all information about the music and the artists.

Table 1 shows a list of the system's use cases.

Table 1 – Use cases

Use cases
Register the visit
Navigate through the virtual store
Select type of music
Get information from disc
Create catalog of music
Maintain information from virtual site
Maintain information from user

Next, we present an overview of the use case : Navigate through the virtual store, to explain the way the user can select a CD.

Two main actors are involved in this process: Lizeth and the user; a secondary actor: the virtual stores' environment, and one use case: Navigate through the store. The UML diagram presented in figure 2 shows the use case where the user navigates around a specific view of the virtual store. Lizeth is embedded to assist the visitor. Every action performed by the user is monitored by the agent's sensors. These elements allow Lizeth to identify those set of actions that must be executed, according to the involved knowledge bases. Additionally, if the user doesn't make any movement, Lizeth is able to activate an autonomous action to gain the user's attention and to suggest any other movement.

Figure 2 – Store's use case diagram

Lizeth begins with the selection of music when it is required to perform an action mapped on its KB's (see figure 3). These KB will support the perceptions and the possible actions that the agent obtains from the user.

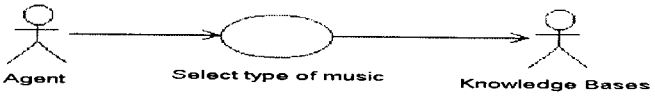

Figure 3 – Select type of music use case

The class diagram that corresponds to the use case "Navigate through the virtual store" is shown in figure 4.

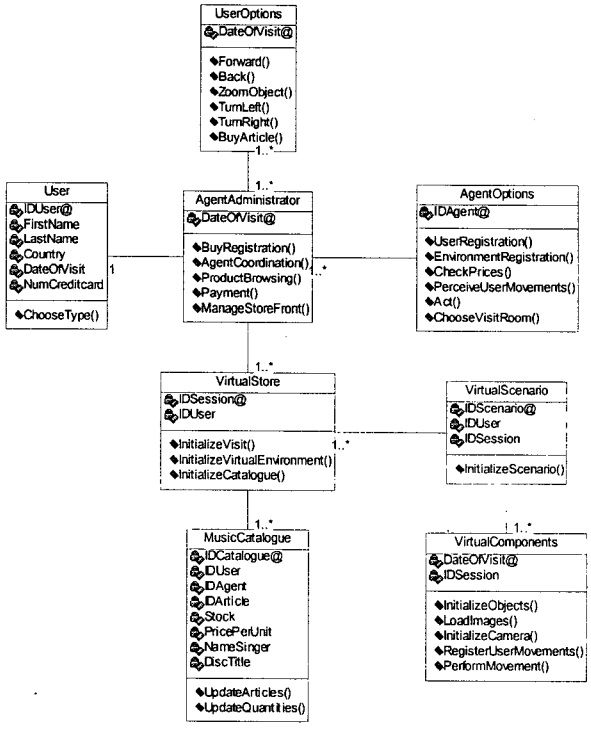

Figure 4 – Class diagram

The class diagram works as follows. The class AgentAdministrator monitors the user's actions and coordinates the action that was required from Lizeth. This class improves the system's performance and executes the actions that correspond to the purchase and to the way in which the user acquires the products.

On the other hand, this class interacts with the VirtualStore class that initializes the scenario, using

the VirtualScenario class and interacts with the CatalogMusic class which is responsible for organizing the stocks of the store. In relation to the virtual scenario, it's important to highlight the functions performed by the class VirtualComponents, as this class initializes the required objects for the simulation of the virtual store. This is done by loading the images on the system and of the caption of the movements performed by the user –class UserOptions- during the travel. The class AgentOptions loads all the information collected by the system to register the user's profile. At the same time, it is responsible for the storage of the information related to the virtual environment to guide the user inside the store. One of the most important things that Lizeth does is searching for information related to the prices of CDs that the user requires and making price comparisons.

The visitor is modeled with the class User, which principal function is to select music according to the preferences of the visitor.

Implementation

The implementation of the agent's model was developed using the Java language, the Agent Builder Tool and the agent's communication language known as KQML. The definition of the behavior is coded using Java functions to make queries on knowledge bases. With the information obtained, Lizeth performs its activities autonomously. Experiments with KQML have been performed and positive conclusions were presented, such as [7] where KQML is conceived as both message-handling protocol to support run-time knowledge sharing among agents [8].

AgentBuilder [18] is a tool for constructing Java agent systems based on two components -the Toolkit and the Run-Time System-. The Toolkit includes tools for managing the agent-based software development process, analyzing the domain of agent operations, designing and developing networks of communicating agents, defining behaviors of individual agents, and debugging and testing agent software. The Run-time System provides an agent engine, that is, an interpreter, used as execution environment of agent software. The agents created with AgentBuilder toolkit are Java programs so they can be executed on any platform with the Java virtual machine

Virtual environment

The virtual store environment was developed using the three dimensional modeling and rendering software Light Wave. 3D modeling begins with surfaces that describe the rooms in volume mode. For this project, the goal is to create a modern building for CD store. Certain planes would require the user to get closer to the walls and floors in order to show greater detail. However, much of this design is made with boxes, helping to reduce the complexity of the architecture.

Our virtual design is actually assigned to a computer-graphics architect designer who is responsible for the construction of the store. This would allow us to focus on issues related to the agent construction and e-commerce software.

Solutions to the main deficiencies of today's real time graphics hardware, identification of problems in the areas of antialiasing and texture and reflection mapping were presented in [6].

To avoid speed and space limitations while navigating through a full 3D virtual environment in the Internet, the virtual store must be exported to a standard Internet format such as Virtual Reality Modeling Language (VRML) that makes possible to dynamically download complex scenes from a server directly to a web browser. By using VRML it is possible to interactively navigate through the virtual environment in real time. However, limited bandwidth between servers and clients presents an obstacle to the availability of very complex scenes, since the geometry and texture maps for such scenes may take many minutes to transfer over a typical telephone modem link [17]. VRML scenes found on the Internet are not very sophisticated, in order to achieve a good balance between bandwith and the realism and interaction in the virtual environment

To avoid a long idle time for the user while downloading the components of the store, Lizeth will maintain the visitor entertained providing him some relevant data about his visit.

How does it work?

At the beginning of the application the following steps must occur:

1. According to its knowledge and perceptions, Lizeth activates data loading and integration procedures stored in knowledge bases.
2. After any user input, Lizeth queries the reaction defined by mapping the corresponding knowledge bases. This implies the definition of the information sources according to the behavior exhibited by the particular user type.
3. When Lizeth receives an information request, each knowledge base creates an instance of a method represented by a query.
4. The system collects the requested data, maps the local results into HTML and VRML representation, and then sends the query results back to the user who initiated the information request.

Conclusions

This paper describes the functionality of a system that incorporates intelligent agents in an e-commerce application and requires VRML software allowing an interactive visit through the store's architecture. The user follows a pre-defined tour, but is capable to perform interactive actions such as zooms, free views of the store, and may advance, go back, or finish the visit at any time.

The proposed application, according to the research, solves space, speed and compatibility problems, suggesting an interaction between the user and a virtual environment through an agent that guides the user during the navigation bringing relevant information to each type of user and offering it at the right moment. Additionally, virtual environments provide more realistic experiences, making them suitable for a broad range of applications. They can work as complements for real life supermarkets, or be useful as a preview to a physical visit. As future work, the front-end could be exported to an embodied environment such as REA [9], where the user has complete interaction through the interface agent.

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