A Networked Intelligent Distributed Virtual Training Environment: A First Approach

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Abstract

Collaborative livelong learning is one of the emerging needs of the information age. Access to education is going to become crucial for the success of our information society. Therefore a lot of potential is seen in distance learning and online collaborative environments. This paper proposes an intelligent distributed virtual training environment for distance education through shared 3D spaces

Introduction

The proposed environment would be used for synchronous and asynchronous telelearning providing users with functionality, which supports social learning process in virtual environments. For example within this environment users can find seminar-rooms, where they can share content, point at content through their realistic avatar representation or carry out multilingual discussions. Our aim is to provide users with all those features, which are needed in a collaborative learning environment.

This environment is designed as an integrated system, which is able to educate its users in carrying out tasks within the environment in an efficient and intelligent way, with the help of Intelligent Agents (IAs).

The technological approach is the integration of Distributed Virtual Environments (DVEs) with intelligent agents in order to achieve a more friendly and efficient way for training. The DVEs accomplish the need of interaction among the users with a friendlier user interface as well as the presentation of the knowledge. The intelligent agents help the users to act within the system and to explore complex and unstructured amount of multimedia data.

The role of intelligent agents in distance learning

A computer based distance learning system should interact with the users in order to facilitate the educational procedure. This interaction can be provided by intelligent agents. There are many types of intelligent agents such as collaborative agents, interface agents, mobile agents, information agents, reactive agents, hybrid agents and smart agents [3]. In addition, recently have been developed new types of intelligent agents for specific functions, such as pedagogical agents. Pedagogical agents can inhabit in Collaborative Virtual Environments (CVEs) and be represented by a character (avatar) or a special object (e.g. a book) [1]. Their role is to interact with the users (students and teachers) within the CVEs. The pedagogical agents can further monitor student's interactions as well as guide and advice the users. The main advantage of the pedagogical agents over conventional intelligent learning is that they enable closer and more natural interactions between students and intelligent courseware [2]. This provides more useful and friendly user interface and helps the users to find easily the desired information.

The role of DVEs and CVEs in distance learning

In DVEs the simulated worlds run on several computers that are connected over a network and the people using those computers are able to interact in real time, sharing the same world [4]. CVEs are networked virtual reality systems that support group work. Their central concept is the one of a shared virtual world, i.e. a computer generated space where participants can meet and interact. Users are embodied in the world by an avatar, providing them with a 3D representation that follows the movement of their viewpoint. Using external devices that range from traditional mice to cyber-gloves, users can control motion and interact with the content of the space. The content may represent data, other users or be an interface to application specific computer programs.

The essence of CVEs is that the shared space defines a consistent and common spatial frame of reference. In other words, there is a well-established co-ordinate system in which the relative positions and orientations of different objects can be measured. Furthermore, users' actions and viewpoints are embodied within the space. Therefore, it is possible, at a glance, to visualize what other participants focus on and what their activities are, or pretend to focus on and to do through the projection of their avatars. Consequently, an essential achievement of CVEs is that

they combine the participants and the information that they access and manipulate in a single common space.

Both DVEs and CVEs in education provide the students with an opportunity to experience sensory interactive learning environments, which enable them to move from passive learning to active learning. In addition, such environments are able to support cooperative learning among students at different locations by allowing them to share experiences about exploring a common environment. Activities such as learning by doing are potential with the use of DVEs and CVEs.

Motivation

Research and applications in DVEs can be grouped into two camps with regards to performance of computing and networking. On one side we find military and government supported research with dedicated super computers and high-speed networks. On the other side we find a large research community that tries to bring DVEs to the regular user. With developments in computing and networking, the working conditions for these two groups approach each other. It is therefore, and increasingly will be, possible to transfer technologies and concepts from the high-end to the low end. Furthermore, DVEs need to be about something; in other words they need a pioneer application. Along with research in development in VR technologies, the importance of useful applications and convincing content should not be forgotten.

A distributed virtual training environment should establish virtual communities with a theme, rules, roles, and moderation where useful services can be employed to facilitate educational procedures. It would be available on the actual global computer network infrastructure in use, currently the Internet, in order to contribute in the realistic deployment and take-up of distributed Virtual Reality. This system is facilitated by security and management mechanisms in order to be used for meaningful purposes such as remote collaborative learning. With the integration of various servers, the proposed system achieves the guaranteed quality of service, which is essential in learning environments.

In addition the proposed system uses Distributed Virtual Reality technologies which are capable of running on the average user's PC. These technologies are compatible with standards like VRML [5] and they use platform-independent implementations like Java, which is a great asset particularly with regards to development, deployment and take-up. The above-referred technologies provide services, which are available to the broad public through regular equipment, found in homes and offices. The proposed virtual environment allows inclusion of many real world features such as insertion and changing of objects and exchange of information with objects and users. The proposed environment is an open system, which can be interfaced with standard instructional management systems and data representation schemes and serves as an innovative tool for telelearning and content access.

The proposed environment aims at the following goals:

- The technological:
  - Integration of components such as intelligent agents into distributed virtual environments
  - User support within the environment through intelligent agents
  - Interfaces to standardized content management and/or instructional management systems
  - Shared content access and browsing
- The educational: A qualitatively new approach to distance learning methods through the use of distributed and shared virtual environments

Model description

In order to achieve the above goals our proposal is based on the following concepts:

- Scalability. The ability to support a maximum number of simultaneous users which could vary according to the specific settings of each virtual world
- Persistence. Persistence is realized by distributing and synchronizing user input as well as user independent behavior in order to achieve the impression of a single shared world
- Various contents' support. Several forms of data should be supported and they should be embedded in the DVEs
- Customization. The total design and outlook of the Virtual Environments should be customizable according to the needs of their specific themes
- Coherence. Despite of the particular outlook and functionality that each Virtual Environment will acquire, the service should preserve a uniform structure, concerning mainly the functional and operational characteristics rather than its visual representation

Actually the proposed DVEs should comprise a set of different virtual worlds with three functionalities:

- Serving as a virtual representation of the relevant theme and a presentation means for the available material
- Providing to the users the ability to navigate in a 3D shared space, access the content provided, examine their knowledge, exercise their skills and receive the information provided.
- Enhancing the development of users as autonomous active learners both in the immediate learning context and in the longer term.

The proposed architecture

The system architecture is defined by the following principles:

- A system based on a variety of communication protocols
- scalable to thousands of users

- platform independent
- based on open standards

Our proposal is based on several components that provide all the needed functionality. These components are the following

- User interface. This component is designed to provide the user with all the needed tools for accessing and utilizing the proposed system. It includes the virtual environments, chat, audio/video interface, viewing areas for the multimedia content and any other purpose-specific interface (e.g. authentication, moderation, etc.). All these are unified into a user-friendly and easy to use interface that is based on standard web browsers in conjunction with the appropriate plug-ins. All the software for this component would be implemented with proven commercial tools, aiming at low cost platforms, such as PCs running Microsoft Windows. The technology used supports all relevant standards: HTML, VRML, Java, ActiveX, OCX, Direct3D and OpenGL.
- WWW Server. This component is responsible for delivering to the users all the appropriate data while they are using the proposed system. These data include the virtual worlds, HTML files and the educational multimedia content in the appropriate format (e.g. images, applets, downloaded objects, etc.). The proposed system should utilize a commercial HTTP server that should meet all the specified needs and should be integrated with all the other components. Certain CGI scripts should interact with the HTTP server and the Community server in order to provide certain functionality like authentication processing, HTML template file handling, configuration files, user database access mechanisms and cookie handling.
- Community Server. The Community Server is a main component of the proposed system as it provides all the needed technology to develop a DVE. The Community Server offers many functionalities like real-time chat, motion update, event handling etc. This server receives a notification in the form of an event any time that a client takes an action (e.g. when the client enters into a scene or sends a text). Then the server distributes this event to all other clients that are affected, for instance clients in the same scene or in the same chat group. This server also interacts with the virtual agent server, the shared object server and the audio/video server for providing advanced functionalities.
- Virtual Agent Server and Expert System. This server should implement the concept of the virtual intelligent agent, which is required to interact with the DVEs and the users either through the virtual environments or through co-operating external applications. These agents should interact with the Expert System, which is based on a three layered architecture in order to extract input features, respond to multimodal commands and recognize contexts. This server should interact with the Expert System Fact database where the knowledge is stored and should respond to user actions, like answering to questions, reacting to gestures or providing navigational aid.
- Shared Object Server. This server enables the usage of shared objects. Objects are simply virtual items that can exist in any location and can be owned by users. With this server the virtual environments allow inclusion of many real world features such as insertion and changing of objects and exchange information with objects and users. Objects can be represented as text, pictures and 3D models. Their attributes can be managed as shared within the environment, meaning that any changes are immediately distributed to all other relevant users.
- Streaming Audio/Video Server. This component provide real-time streaming audio/video capabilities to the whole system in order to support the feeling of presence for the user and to transmit multimedia educational material to a group of users. This server will be implemented using appropriate streaming technology.

Database(s)

The database consists of the following three modules:

- **Expert System Fact Database:** Here is stored all the needed knowledge that the virtual agent server uses.
- **Library Database:** This database contains the metadata information relevant to the educational multimedia material.
- **User Database:** It contains information related to the users such as name, login, privileges, group etc. and will be used for administrative and management purposes.

For the latter two databases interfaces to standard instructional management systems or/and content management systems are planned.

With the above in mind, this paper investigates ways of applying the new technologies in distributed Virtual Reality for new scenarios in teletraining. There are two basic scenarios:

- Synchronous learning. In the scenario of synchronous learning there is a group of users: the teacher and his students. This group of users is registered to the system in order to enter in the shared DVE. Each user is represented with a different avatar that he can choose from an avatar library and he has his own information (name, login, nickname, group, privileges, etc.). The virtual world involves objects in order to simulate the traditional class, such as:
  - A slide projector, in which the teacher can add a shared file (such as image, document, and presentation) that the students can view.
  - A whiteboard, in which the teacher could represent

his thoughts for the lesson as well as to paint some figures.

- A bookcase with books that link to predefined educational material, which has relative subject with the lesson.
- A bulletin board, in which the users of the group could attach some shared files such as the program and the exercises for the lessons.

The teacher has different privileges from the students in the world in order to manage the educational procedure: upload of a shared object in the DVE such as a presentation for the lesson in the slide projector, management of the chat and management of the students. In addition the teacher can add 3D shared objects to the virtual world. These objects are predefined and contribute to the educational procedure.

The virtual class environment supports multimodal interaction between the participants. They can communicate through audio capability and the chat function in order to collaborate as if they were in the same physical place. The students use the chat function in order to raise a question to the teacher. In addition the chat function give us a flexible solution for communication when the available bandwidth is limited. In addition the users have the capability to send predefined chat messages to the other participants as well as the capability of gesture interaction.

- Asynchronous learning. In the scenario of asynchronous learning each student enters in his own virtual room after an authentication procedure. In this private virtual room the lecturers are represented by intelligent agents that can be trained to answer commonly asked questions and problems. These intelligent agents are human-like and represented by avatars. The private virtual room supports multimodal communication between the users and the intelligent agents. If the associated agent mechanism is not sufficient to assist a student, the intelligent agent transfers the question by e-mail to a human moderator who can process the issue further and find a solution.

Except the human-like intelligent agents the private virtual room involves objects that simulate a real office, such as:

- A bookcase with books which links to predefined educational material, which has relative subject with the lesson. These books are intelligent agents that help the user to find easily the desired information. The title and the contents of the book are presented to the user in a content projector and the user can choose the desired chapter. The user can add a bookmarker in order to find fast a page in a specific book.
- A personal computer which helps the user to send e-mails.
- Other objects that the user can add in his private room. The user can choose these objects from an object library. An intelligent agent helps the user describing the functionality of each object.

Conclusion

In conclusion, this intelligent distributed virtual training environment represents an attempt to explore new educational applications of virtual environments. The development of this application gives us the opportunity to deal with many interesting technical issues, concerning the creation and usage of virtual environments and shared spaces. In addition to the technical issues we encounter, the social issues that may come up while using such an application may be even more interesting and help us use in a more efficient way the new ways of communication and interaction that distributed virtual reality technologies offer.

References

[1] M. Fabri, M. Gerhard, D.J. Hobbs, D.J. Moore, "Agents for Networked Virtual Learning Environments", Neties '99, 18-19 March, 1999, Krems, Austria

[2] W.L. Johnson, E. Shaw, “Using Agents to Overcome Deficiences in Web-Based Courseware”

[3] H.S. Nwana, “Software Agents: An Overview in Knowledge”, Engineering Review, 1996, USA.

[4] B. Roehl, "Distributed Virtual Reality-An Overview", URL at http://ece.uwaterloo.ca/~broehl/distrib.html, June 95

[5] The Virtual Reality Modeling Language, International Standard ISO/IEC 14772-1:1997, URL at http://www.vrml.org/technicalinfo/specifications/vrml97/index.htm