A Web-Based Multimedia Virtual Reality Environment for E-Learning

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Abstract

The past decade has seen major advances in the availability of broadband computer access. With this ever-increasing connection speed and improved Internet performance more and more web-based applications are becoming available. More complex graphics and multi-media can now be transmitted over the Internet relatively quickly in real-time and with little delay. One area where web-based applications have proved very successful in the past, is within the e-learning paradigm. Traditionally, online learning applications have used a text-based asynchronous format to deliver learning material to end-users. While this has proved successful, it is recognised that the social and collaborative experience plays an important role in education. This paper describes CLEV-R, a Collaborative Learning Environment with Virtual Reality. CLEV-R is a web-based application, that takes advantage of an increased connection speed to deliver a real-time Virtual Reality (VR) environment where learning material is augmented through the use of multi-media. The environment mimics the real world where users, represented by avatars, take on various roles in the VR world.

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1. Introduction

The prevalence of broadband connections in homes and businesses means faster transmission of data to a wider audience using the Internet. This has encouraged developers to broadcast more media types over the Internet. Media-rich applications can now be shared among users with relative ease. E-learning systems have always been at the forefront of Internet applications with whole institutions now established to provide online courses [CCV04]. Today, e-learning systems exist to serve the needs of distant learners and as a supplement to traditional teaching methods. Many of these systems function mainly as management services for course material and their users. Communication takes the form of asynchronous chat rooms, forums and message boards, with the learning material being presented mainly in text form. These learning systems have failed to take full advantage of the availability of high-speed Internet connections to deliver a more intuitive learning environment with many media types, which offer a stimulating way for students to learn, socialise and collaborate. Traditional e-learning systems fail to address the social needs of users. Empirical research [LK02] has shown that collaborative and group work can assist students in attaining a higher achievement level. The importance of classmates is also recognised as an important factor for succeeding in education [JWC99].

This paper describes CLEV-R, a Collaborative Learning Environment with Virtual Reality which aims to address some of these issues by taking advantage of broadband to deliver a VR learning environment, mimicking a conventional university setting. Here, the students are embodied as avatars, i.e. virtual representations of themselves. Each user can see the other avatars and interact with them in real time via audio or text communication channels. The learning material is presented in the VR world using multiple media types to ensure the environment is stimulating and interesting for the users. As the VR world represents the real world, all interaction is intuitive, even for non-expert users.

Section 2 provides a brief description of similar work in the area of online learning systems using VR. Section 3 describes some of the main features and the architecture of CLEV-R is discussed in section 4. Section 5 sets out some further developments of CLEV-R while concluding remarks are given in Section 6.

2. Related Work

Currently, some systems with similar features to CLEV-R exist. EVE [BGT03] and INVITE [BTT01] are two such systems, primarily used for training purposes. They offer multi-user VR environments for learning and collaboration that deliver multi-media content to students and enable the sharing of applications. Features such as shared whiteboards, presentation tables, video and audio facilities are provided. VES [BFK*99] is another multi-user platform, solely aimed at European Secondary Schools. Here, publishing houses provide themed multi-media educational material as a supplement to traditional teaching techniques. Interactive activities are provided for students to reinforce learned theories in a practical manner. Although these systems are akin to CLEV-R, they offer little to address the social needs of students.

CLEV-R, aimed primarily at undergraduate students, has a firm focus on delivering a collaborative environment for students to both learn and socialise. Multi-media can be used for both of these purposes. For example, users can upload photographs and home movies to share with other users in a relaxed social setting. The remainder of this paper provides a description of the multi-media features employed in the development of CLEV-R and the techniques required to improve system efficiency.

3. System Functionality

The CLEV-R system is a web-based multi-user VR environment that aims to support interactive e-learning through the use of several different multi-media types. In addition to providing a visual interface for the users, features such as video, audio and images enhance the learning experience for the user.

The 3D environment of the system is implemented using the VRML ISO standard [VRM04]. This scripting language provides a means of designing a virtual world which can then be rendered and displayed in any VRML enabled Web browser. The CLEV-R project makes use of the freely available Cortona VRML viewer by Parallelgraphics [PG004]. Using VRML it is possible both to design the virtual buildings where the learning is to take place and to create avatars that will represent the users of the system in the virtual world. Functionality for animation and interactive features are also available so it is possible to define movement for the avatars and multiple different ways for the users to interact with the system.

3.1. Graphical User Interface

A key factor in the development of CLEVR was the provision of an intuitive Graphical User Interface (GUI), which is simple to use and comprehend. The GUI for CLEV-R can be seen in figure 1. The GUI consists of two main panels; the upper panel is used for displaying the VRML multi-user environment while the lower panel provides access for users to interact with the system. Three tabbed panels on the lower portion of the screen provide different functionalities for the users. The first panel allows new users to register with the system and authenticates returned users. Users can also select their avatars and choose a user name.

One of the main purposes of the GUI is to allow communication among connected users. The communication controls are highlighted in figure 1. There are three main ways in which students interact, namely gestures, text and voice. The learner can choose gestures for their avatar to depict in the VR world. For example, users can instruct their avatar to raise their hand and so inform other users they have a question. The learner can enter into real-time text conversations by typing messages into the appropriate text field on the GUI. A record of all messages is also maintained. Text messages can be sent to certain groups or individuals which can be selected using the drop down menu, showing all connected users. Voice conversations can also be controlled via the communication panel; again buttons enable different options to be selected.

Group administration can be managed using the final tab on the GUI. Users can set up their own groups of friends, or classmates. This allows for easy collaboration between users. Individual users can also update their profile, register for new courses and other administrative tasks using this part of the GUI. As can be seen in figure 1, the user can request assistance or exit from the system at any stage during a session.

3.2. Virtual Rooms

In order for CLEV-R to be as intuitive as possible, it mimics a real university environment. This creates a realistic and immersive experience. The VR world consists of a number of different areas or "rooms". The main room in which learning takes places is the *lecture theatre*, here students can gather together to view lecture slides and course material on a presentation board. Students see the tutor's avatar who can communicate with students through voice or text chat. A shared white board is provided for users to actively discuss and illustrate complex theories and problems. Video displays are also available in the lecture theatre for demonstrating topics or, in some cases, providing live video of the lecturer in a similar way to video conferencing. *Group meeting rooms* provide formal areas for students to discuss course material; again these rooms have presentation boards. These rooms serve as ideal spaces for collaboration to take place for group projects, brainstorming sessions and similar tasks. The important issue is that all connected users can see the board simultaneously. As in a real university setting the *hallways* provide notice boards where students can place general no-

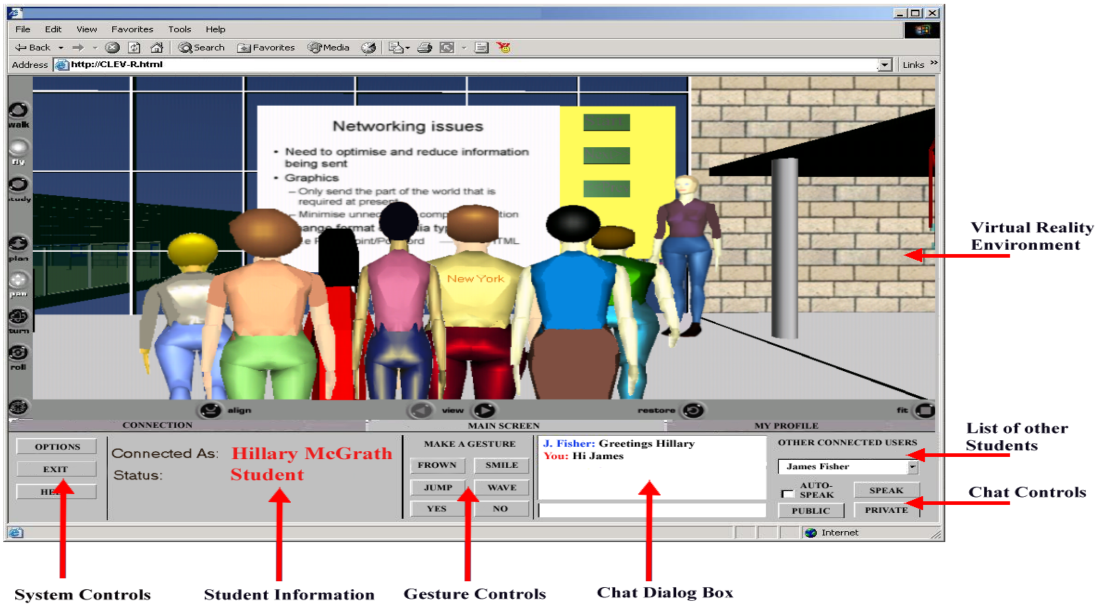

Figure 1: *The Graphical User Interface (GUI) showing a lecture and chat session in progress.*

tices or indeed display project slides. Students are provided with *private spaces* or *personal rooms* where they can store their work and replay lectures.

3.3. Optimising the Graphics

As the system will be accessed by both LAN and dial-up modems, we address many networking issues so that the overall system is efficient and the graphics are displayed in a reasonable amount of time. As we are sending so many different media types across the internet the system is bandwidth intensive. We are currently exploring different techniques for optimising and reducing the amount of information that has to be sent. Different techniques can be used to reduce the time taken for the VRML world to be displayed.

Firstly, Levels Of Detail (LOD)[ANM96] can be defined for different objects in the world so that when the user is far away from the object, it is displayed in its simpler form. As the user moves nearer the object, a more detailed form is loaded. Other optimising techniques can be applied to display certain parts of the world, only when they come into the users line of sight. VRML provides visibility and proximity sensors that can be used to achieve this effect. A more advanced method of this technique is *Visibility Culling* which works under the hypotheses that nothing in a virtual world needs to happen or to exist if it is not observed [Mar03]. One form of *Visibility Culling* is *View Frustum Culling*, where objects that lie entirely out of the field of view are removed. *Backface Culling* which removes any faces in the environment that face away from the user and *Occlusion Culling* where objects in a particular viewpoint that are hidden by other objects are not rendered are further examples of *Visibility Culling*. Using these techniques we limit the amount of the world that is rendered and also the number of animations that occur.

4. Architectural Issues

A client-server architecture is used for the CLEV-R system. The servers are responsible for connecting users to the environment and keeping all users updated about any changes that occur. Other dedicated servers are responsible for the management of media while another will be used to calculate which part of the VRML world should be displayed for each

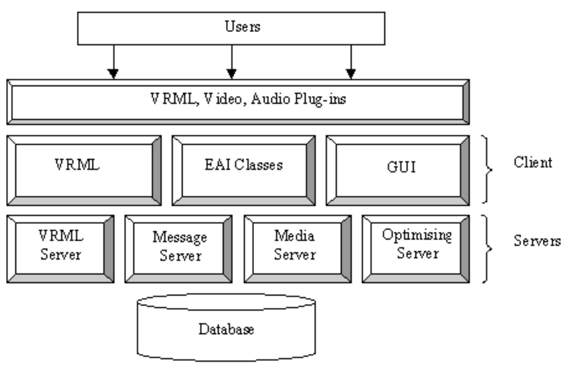

Figure 2: *The system architecture.*

user. The server is linked to a database that stores user information, resources for the different courses, etc. The client consists of a web browser enabled with the appropriate plugins for the different media types used.

5. Further Development

At present an initial implementation of CLEV-R has been developed, incorporating many of the features discussed here. Several users have been asked to test the system and initial feedback has been positive. As the environment represents a real university setting, interaction with the system is seen as intuitive and users believe it will be of benefit in an educational context. The next step in the development of CLEV-R is to further explore the optimising techniques discussed here and to apply them to the system. These methods will make the system more efficient and so it will be possible to explore the extension of CLEV-R to mobile devices. Following on from user feedback, it is also envisaged that a 2D map of the environment will be provided showing the location of other connected users. The provision of agents to control avatars and so aid users is also foreseen. Presently, CLEV-R does not rely on any specific tutoring management system, however, discussions are in progress to determine if collaboration with the ABITS [RM03] research group is possible. ABITS, an Agent Based Intelligent Tutoring System, is built using multi-agent technologies and deals intelligently with the management of tutoring systems. Although independent, it can be used to upgrade other e-learning environments such as Blackboard [BBS04]. It is recognised that once complete, a full scale evaluation of CLEV-R will be required. This will take the form of usability studies and determine the effectiveness of the multi-media types for educational purposes.

6. Conclusions

CLEV-R, a multi-user environment for education offers a new way for university students to learn, collaborate and socialise. The use of VR environment in education is a relatively new idea that is gaining interest, fuelled by the advent of broadband technologies and improved Internet connections. CLEV-R takes advantage of enhanced Internet access to provide stimulating learning environments augmented with multi-media. The VR environment, mimicking a real university setting, delivers all available facilities to the students. This simulation of a real university provides an intuitive means for students and teachers to interact with CLEV-R. A mix of traditional and novel approaches are utilised to ensure network traffic is minimised and the system operates efficiently. Content is filtered depending on individual user's connection speeds and efforts are currently under way to make CLEV-R available on mobile devices.

7. Acknowledgements

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