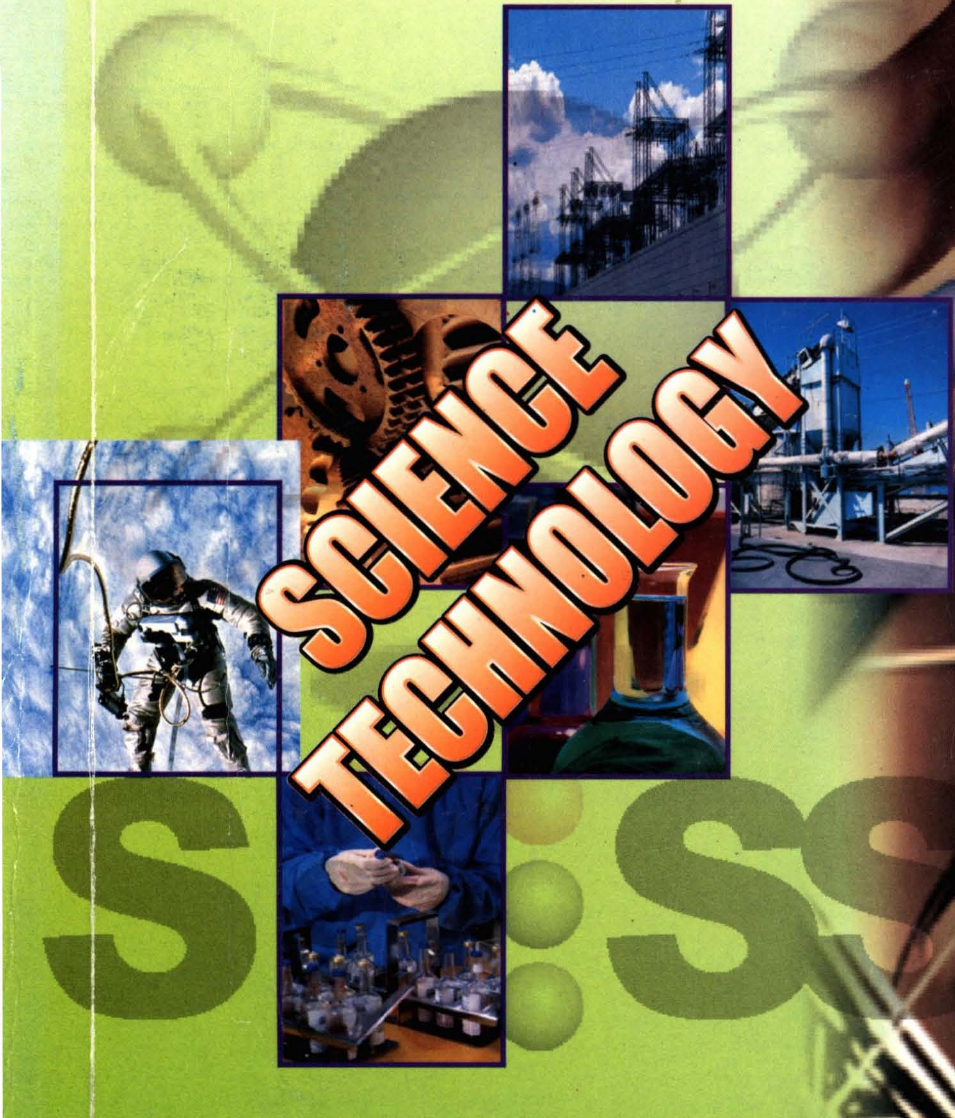
UNIVERSITI TEKNOLOGI MARA

ISO 9001:2000 No Sijil :0500132

Globalising Knowledge and Information

NATIONAL SEMINAR ON SCIENCE TECHNOLOGY & SOCIAL SCIENCES 2006



30-31 May 2006

Swiss Garden Resort & Spa

Kuantan, Pahang

User Interfaces Design
for Collaborative Virtual Environment (CVE) Software

Mohd Kamal Othman

ABSTRACT

The project aims to study and design alternative user interface for Collaborative Virtual Environments (CVE's) software also known as Networked Virtual Environments (NVE's). To reduce cost, most current and operative CVE's use the Internet and standard PC to create a visual Virtual Environment (VE), which can be shared by a large number of users. This project also involves an image processing technique (morphing technique using Thin Plate Spline) for creating a facial expression for the CVE software and OpenGL API for implementation. It discusses communication aspects in the CVE system and proposes the different types of communication that are suitable for the project. It also suggests a suitable user interfaces for the software.

Keywords: *Collaborative Virtual Environments, user interfaces, facial expressions, avatars.*

Introduction

The objectives of this research are to study and evaluate the Collaborative Virtual Environment (CVE) also known as the Networked Virtual Environments (NVE) software, and propose a good user interface for the software. It includes a software analysis and evaluation, updating the software if and when necessary or possible. This research also utilizes an image processing technique (morphing technique using *Thin Plate Spline*) for creating facial expressions for the CVE software. In this project, user interface not only refers to the graphical interface (*Graphical User Interface(GUI)*) between the user and the system, but also includes other interfaces for communication such as aura communication, voice or video interface communication, facial expression, and also standard tools used for communication (i.e. keyboard, mouse, etc). The CVE software in this report refers to the software designs by Oliver Wennel at School of Computing Sciences, University of East Anglia United Kingdom.

Project Design

Project implementation was divided into a few phases, including evaluation of current software, development and implementation (updating the current software), and testing and evaluation. The software evaluation phases were conducted to determine the weakness of the current system and how to improve it. After recommendations on how to upgrade the current CVE's system have been made, the storyboards for the system were built based on the project scenario. Project scenario was designed based on the requirements for the updated version of CVE's software. The development and implementation phase was divided into three main components. The first component is the development of facial expression. The second component is the communication protocol aspects between multiple computers within the same network. The communication protocol is called the "handshake protocol".

Project Scenario

The scenario is a user visiting a CVE system to conduct collaborative work and discussion. The user enters the CVE system and explores the system and the other people in the system. When a user enters the CVE system, the user will be represented by the human embodiment called avatar. The user will need to find other avatars to start a communication with. In the scenario, one way of sensing other people's presence in the CVE environment is to use the user's aura.

Aura is not only used as a means of communication, but could also be used to sense other user's presence. Aura is like radar, which could sense other user's presence within a certain distance. Aura could detect other user's presence faster than voice communication in CVE. Aura for each user in the system is a region that surrounds them. As two or more user's avatars' auras collide/intersect with each other, communication between two users in the environment will be initiated. The system will recognize the intersection/collision of the users' auras and the users will be transformed into a chat mode using text message services. In this mode, the user is still represented as an avatar, but in a 2-dimensional (2D) mode that shows only the user's face. The 2D avatar has a facial expression function where every time the user wants to show a facial expression (i.e. happy, sad, anger, or blur), the user could simply press a predefined key on the keyboard and it would turn into an avatar showing the intended facial expression. This predefined facial expression was created earlier and can be retrieved as needed.

Communication between users in the CVE system will take place using the text message service with the help of facial expressions. Users will engage in a chat once their avatars collide with each other. If a user wants to quit from the chat, then the user could simply walk away until user's aura is no longer intersecting with the other user's aura. This will in turn toggle off the chat mode, and as a result the communication between users will end. After the user exits the communication mode, the user will be shifted back to the CVE environment and the chat mode will be closed.

Project Implementation

How to Improve the Current CVE System

The success of CVEs is determined not only by the number of users using the system or the superiority of the technical aspect of the system, but also by an effective interface for communication between the multiple users in the VE. In order to achieve this goal, new architectures of the CVEs must be developed to provide a new module to be integrated into the CVEs, and a new interface for communication must be introduced to provide functionality and to exploit the main characteristics of CVEs as much as possible.

Multimodal Communication

A system is considered as multimodal if it meets or supports human modalities such as gestures, written or spoken language (Coutaz and Caelen 1991). Designing a good interface for multimodal interaction in CVEs is not an easy task. Many options must be considered, such as the reliability of the system, the accessibility of the design in order to suit the range of users (not only the major user group, but the minor user group as well), the value of designing such a system, or the effectiveness or ineffectiveness of the system if designed in such a way.

Natural ways of human communication are not limited to verbal communication (speech) (Salem and Earle 2000). It also involves non-verbal communication such as eye-gaze, body postures and language (Salem and Earle 2000), haptic and force feedback (Shen, Bogsanyi, Ni and Georganas 2003), and lip movement and facial expressions (Pandzic, Capin, Magnenat-Thalmann and Thalmann 1996). When talking to each other, people tend to convey body gestures and postures to make it more expressive and animated. This improves the communication realism, as it will convey the user's emotional state of mind. This type of natural human communication (verbal and non-verbal) should be mapped into the CVE's to enhance the interaction and communication between users or users with objects within the system. Otto and Roberts (2003) states that non-verbal communication not only involves the communication between users but, also between users and objects, or between user and the environment. To date, there is substantial research that focuses on the important aspect of non-verbal communication; see (Salem and Earle 2000; Guye-Vuillieme et al. 1999; Vinayagamoorthy 2002; Garau, Slater, Bee and Sasse 2001; Kujanpää and Manninen 2000). Most of the research focuses on developing a model of rich interaction for CVE systems.

Research by Coutaz and Caelen (1991) shows that communication between multiple users in a (CVE) must be a multimodal interaction. This would include gestures, facial expressions and lip movements (Pandzic, Capin, Magnenat-Thalmann and Thalmann 1996), audio communication (Magnenat-Thalmann and Joslin 2000), body language, postures, facial expressions, eye-gaze and text messaging (Salem and Earle 2000).

Audio communication (voice-to-voice) could be used within the CVE using an audio link (Magnenat-Thalmann and Joslin 2000). This feature needs a user to have a microphone attached to the system. The microphone is used to capture audio data, which is compressed using a standard compression code before it can be sent to the server and then distributed to other users within the network.

When designing a user interface for communication, the designer should not ignore minority users such as people affected by deafness. The user interface must be user friendly and allow sign language as a mean of communication between users in the CVE's. The sign language could be used with the aid of avatars or using real time video integrated within the environment. Gestures communication could be used as a means of communication for people affected by deafness using rule-based sign language to define some actions (Pandzic, Capin, Magnenat-Thalmann and Thalmann, 1996; Cox et al. 2002).

Avatar Communication

Human representation in the CVE system is represented by an embodiment called an avatar. This embodiment could also be represented by a simple graphical representation (e.g., a textured cube). An avatar is an advanced feature of a human embodiment in a virtual environment and could support facial and gestures communication (Pandzic, Capin, Magnenat-Thalmann and Thalmann 1995; Pandzic, Capin, Magnenat-Thalmann and Thalmann 1996; Capin, Pandzic, Magnenat-Thalmann and Thalmann 1995; Leigh, Johnson and DeFanti 1997).

An avatar is an *incarnation* of the user within a virtual world. As a human representation within a VE, the avatars can meet and interact with each other in an intuitive way and could *sense a presence* of each other in the VE. As discussed by Witmer and Singer (1998); Cuddihy and Walters (2000); Gerhard, Moore and Hobbs (2001), *sense of presence* is an important aspect of a CVE system. *Sense of presence* is more important in a multi-user environment to ensure effective interaction among users (Macedonia, Zyda, Pratt, Barham and Zestwitz 1994; Stansfield 1994).

Communication within a CVE using an avatar requires an efficient and realistic embodiment (Cuddihy and Walters 2000; Capin and Thalmann 1999). In order to further improve realism using avatar communication, human behavior could be integrated into the avatar. This could be achieved through a few methods.

One method is mapping the user's face to the avatar to give the avatar an identity. Using the user's own picture will solve the problem when a few people use the same avatar. This option does not only improve the current CVE system, which only use the avatar's name appeared on the top of the avatar head, but also gives a more presentable avatar's appearance.

Another method is enabling live facial expressions (live video) to be textured mapped onto the avatar (Wang 2004; Pandzic, Capin, Magnenat-Thalmann and Thalmann 1996). This could be done using real time video and textured map onto the avatar face. This technique requires each user to have a video camera attached to the CVE system. Conventional live videoconferencing is not suitable to be used within the CVE's because it requires a separate window, which will again lead to divided attention for users. The importance of live facial expression used in a CVE system is that it will improve the realism of communication and interaction through the avatar because it will show the current emotion of the user.

Apart from using live textured maps of facial expressions, predefined facial expressions could be used to improve the realism of communication and interaction for avatars. This is the easiest way to implement facial expressions. Users simply type the keyboard smiley (i.e.,☺, :o(, ☹, etc) to show their expression to others. This predefined facial expression is stored in the CVE's module engine and could be retrieved when needed. This option is not as good as live expression because users need to remember keys on the keyboards that represent each expression. In some occasions, predefined facial expressions cannot give the exact user facial expression because when the user is talking, they tend to make other kinds of action at the same time such as rubbing the chin.

To date little research has been carried out to show the importance of facial expression as a means of communication within CVE's because it is useful for representing intentions, thoughts, and feelings (Pandzic, Capin, Lee, Magnenat-Thalmann and Thalmann 1997). The research shows that facial expression improves communication in a CVE system (Salem and Earle 2000; Pandzic, Capin, Lee, Magnenat-Thalmann and Thalmann 1997; Fabri, Moore and Hobbs 2004). Methods that could be used to integrate facial expressions in a CVE include video texturing method by continuously texture mapping the user face to an avatar, which needs a user to sit in front of the camera at a particular angle to ensure that the camera could "capture" the face (Wang 2004) and model based coding of facial expressions, lip movement synthesis from speech and predefined expressions or animations (Pandzic, Capin, Magnenat-Thalmann and Thalmann 1996), or lip movement could be used as a means of communication if the user does not have the audio capability system attached. In a real life situation, lip movements are important to the deaf community where they are used as an aid to understand what other people are trying to say.

Facial expressions technique could also be applied using a real-time facial animation system (Goto, Escher, Zanardi and Magnenat-Thalmann 1999). This technique allows real-time user facial expressions to be used in the CVE system. This technique uses MPEG-4 Facial Animation Parameters (FAP) to extract real time facial expression from the video and send it to the virtual environment via the Internet.

A good avatar does not necessarily require details of facial expression or be photo realistic of human anatomy because it is hard to model the avatar to be like a human. Research has been conducted to see how this affects the communication in CVE. It shows that an attempt to reproduce an avatar in detail physically similar to humans is uneconomical and wasteful (Benford, Bowers, Fahlen, Greenhalgh and Snowdon 1995). Another study by Hindmarsh, Fraser, Heath and Benford (2001) shows that direct translations of real human to virtual environment was unsuccessful to some extent. Studies show that a minimalist approach of creating human embodiment in CVE helps to represent humans in a natural way such as using facial expression. It is more understandable that facial expression could provide a good way of non-verbal communication and could be supported by body gestures, eye gaze, etc.

User Interaction/Collision Detection

User interaction in a CVE system includes the interaction between user with user, user with the environment or user with the object. The key of this interaction is collision detection between user with user or users with objects. Collision detection is a program script that determines how close a user is to an object and stops their movement when they collide with the object (Allen et al. 2004), or a more complex response (collision response).

Aura Communication

Collaboration in a CVE system involves communication between multiple users at the same time regardless of their locations. In order to ensure the collaborations are effective, the systems should support various communication types such as aura, visual, textual and social communication as well as spatial awareness.

Aura communication is one kind of interaction and communication that could be used within the CVE's. The aura concept is based on the spatial model (Benford and Fahlen 1993), i.e. in Distributed Interactive Virtual Environment (DIVE) (Carlsson and Hagsand 1993), system or Model, Architecture and System for Spatial Interaction in Virtual Environments (MASSIVE) (Greenhalgh 2004). Aura is an area or a region surrounding the user's avatar (Benford and Fahlen 1993; Koldehofe 2004). If the user's aura intersects or collides with another user's aura, they could sense the presence of other people within the environment. Users not only could sense the presence of other users or be aware of other users around, but they could start a communication between each other.

Multiple Views

When collaboration work takes place in the environment, the user not can only see from his view/angle, but also can see what other users are seeing. This is helpful when collaboration work involves a changing of a particular part of the scene and needs other users to comment on the changes. Research shows that multiple perspectives viewing display are useful for navigational purposes (Capin and Thalmann 1999; Park, Kapoor and Leigh 2000).

Human Factors Issues

The human factor issues which VE researchers are interested in could be divided into three main categories: health and safety, human performance and efficiency, and social implication (Stanney et al.1998). The design of the CVE interface system should maximize the efficiency of human task performance within the environment. The problem with the current system is that there is no standard guideline to design an interactive interface and this defeats the purpose of the CVE system. The goal of designing such interfaces (user friendly) is to minimize learning time for the user and maximize collaboration between users.

Facial Expression Implementation

In this project, avatar facial expression is a main component and was implemented using the warping technique *(Thin Plate Spline)*. The facial expression was created offline using this technique and mapped into the avatar's face when needed. Furthermore, the facial expression implementation created is in 2D mode. In order to make a desired predefined facial expression, two images of the avatar were needed. The first image shows the image before a facial expression had been applied and the second image shows the image after it had been altered with a facial expression.

The warping technique code used in this project enables the creation of facial expressions needed for the project, using landmarks on the avatar's face. The picture in Figure 1. shows how a landmark (the red dot on the face) was applied to an original image (left image) and it changed the original image to a desired image (right image).

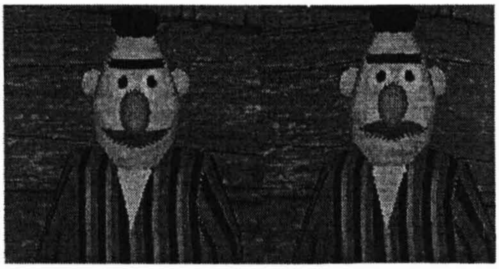


Fig. 1: Facial Expression Construction using *Thin Plate Spline*

Corresponding landmarks on both images are required. If too many landmarks are used, the avatar's face will be squashed and will not look natural, which will destroy the purpose of creating a natural facial expression. Moreover, the locations to place a landmark also needs to be determined correctly; wrong placements could more or less destroy the original image affinity.

In this project, only six basic facial expressions were created and used in the chat system; this includes facial expressions for smiling, being bored, laughing, being surprised, being frustrated and sad. Figure 2 show all the facial expressions that have been used in this project. The reason for using only six basic facial expressions in the project is because it's not easy to create a complex facial expression. A complex facial expression requires more complex changes of facial structure and this is not an easy task using this warping technique, as it would completely change the face features.

The creation of a facial expression needs humanoid facial features, which means that only selected avatars will have facial expressions because not all avatars have complete features to create good facial expressions.

Fig. 2 : Six Basic Facial Expressions Created (From left: Surprised, Laugh, Frustrated, Bored, Sad, and Smile)

Communication in CVE

In the chat mode, the user can start to communicate to other users using the text message. The user not only uses the text message service, but can also use the facial expression integrated within the system. Figure 3 shows the desired facial expression chosen by the user. Facial expressions could also be implemented to the system by simply using a keyboard and specifying a different key for each facial expression. This option seems more realistic compared to using an icon and choosing a desired facial expression because it is easier to implement using OpenGL. Apart from the message that indicates users are currently engaging in chat mode, an icon on the bottom right of the screen is another sign that the user is in that chat mode.

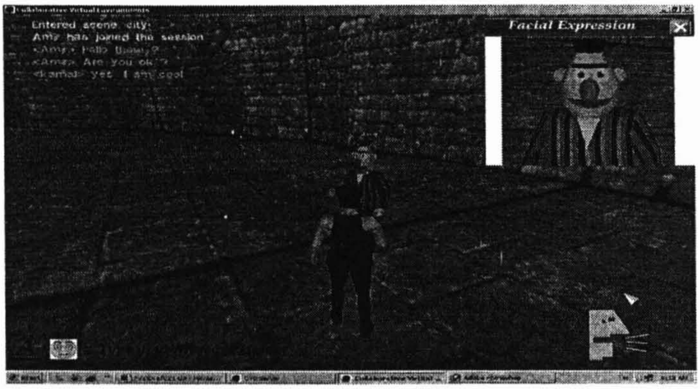


Fig. 3: A Facial Expression Appears when a User uses a Facial Expression

Discussions

There is a lot of room for improvement to the system/software created. These include communication between users using chat mode with the help of predefined facial expressions. The system only enables six basic facial expressions and this could be improved by creating more facial expressions. The use of facial expressions will help the user to communicate better in a VE. Other techniques for creating facial expressions could also be used to create more facial expressions (i.e. cry, shame, blush, etc.) and could probably produce a more realistic facial expression.

A more realistic facial expression could be created by using live facial expressions captured with a camera where a live human face can be mapped to the face of a human avatar. Another option that could be considered when using live facial expressions is using the video where the user's facial expression can be directly displayed on the facial expression window. This option enables users to see real facial expressions of other users not the expressions on the avatar.

Communication using live facial expressions will improve the communication between users in the CVE system. As we know, this option is not always a good option as it also has the weakness when it is implemented to the CVE system. The main problem when using this option is that there could be problems with the network, as it requires a sufficient bandwidth between users.

Text-based communication in a 3D environment, especially in a shared or CVEs, is not realistic because there are other kinds of interaction or communication (i.e. voice, face expressions, gestures communication, avatar, aura, etc) that could be used in 3D as a means of interactive and functional communication. Voice communication could solve the divided attention problem with text-based communication. This is because the user could talk and at the same time could focus on what other users are doing in the environment.

Conclusions and Future Work

This research has been carried out to design a user interface for Collaborative Virtual Environment (CVE) software and some components have been implemented to the existing software. If the desired user interface that has been suggested to improve the existing software were successfully implemented, this will produce a very good piece of work in the CVE field. Future research work could also be extended to improve the facial expression techniques by increasing the number of facial expressions used within the system. The future work must also not limit the communication between avatars in the CVE by the facial expressions, but must also consider other options such as audio, gestures and body postures, etc.

The impact of the social interaction within CVE should be studied in detail in the future to improve the interaction between users in the system. This includes the impact of such interfaces to the users and it is important to know what are the specific tools needed to make a CVE which will be valuable in different research disciplines and applications. Social interaction using aura must be taken into consideration when improving current system or when designing a new CVE system.

References

Allen, K. *et al.* (2002). *Creating and Using Virtual Reality: A Guide for the Arts and Humanities Glossary.* Retrieved on February 5, 2004. [On-line] Available: http://vads.ahds.ac.uk/guides/ vr_guide/glossary.html.

Benford, S. D., & Fahlen, L. E. (1993). Spatial Model of Interaction in Large Virtual Environments. *In Proceedings of the Third European Conference on CSCW (CSCW'93)*: pp. 109-124.

Benford, S. D., Bowers, J., Fahlen, L. E., Greenhalgh, C.,& Snowdon, D. (1995).User Embodiment in Collaborative Virtual Environment. *In Proceedings of 1995 ACM Conference on Human Factors in Computing Systems (CHI'95)*: pp. 242-249.

Capin, T. K., Pandzic, I. S., Magnenat-Thalmann, N., & Thalmann, D. (1995). Virtual Humans for Representing Participants in Immersive Virtual Environments. *Proceeding of FIVE '95:* pp. 135-150.

Capin, T. K., & Thalmann, D. (1999). *A Taxonomy of Networked Virtual Environments.* Retrieved on February 5, 2004. [On-line] Available: http://vrlab.epfl.ch/Publications/pdf/Capin_Thalmann_2_ SNHC_99. pdf

Carlsson, C., & Hagsand, O. (1993). *DIVE: A Platform for Multi-User Virtual Environments.* Computers and Graphics, 17(6): pp. 663-669.

Coutaz, J., & Caelen, J. (1991). Taxonomy for Multimedia and Multimodal User Interface. *Proceedings First ERCIM Workshop on Multimodal Human-Computer Interaction, INESC.*

Cox, S. J., Lincoln, M., Tryggvason, J., Nakisa, M., Wells, M., Tutt, & Abbott, S. (2002). *TESSA, A system to Aid Communication with Deaf People.* In ASSETS 2002, Fifth International ACM SIGCAPH Conference on Assistive Technologies: pp. 205-212.

Cuddihy, E., & Walters, D. (2000). Embodied Interaction in Social Virtual Environments. P*roceedings of the Third International Conference on Collaborative Virtual Environments, CVE'00*: pp. 181-188.

Fabri, M., Moore, D. J., & Hobbs, D. J. (2002). *Expressive Agents: Non-Verbal Communication in Collaborative Virtual Environment.* Autonomous Agents & Multi-Agent Systems Workshop (AAMAS). Retrieved on February 5, 2004. [On-line] Available: http://www.vhml.org/ workshops/AAMAS/ papers/ Hobbs.pdf.

Garau, M., Slater, M., Bee, S., & Sasse, M. A. (2001). The Impact of Eye Gaze On Communication using Humanoid Avatars. *Proceedings of the SIGCHI Conference on Human factors in Computing Systems*: pp. 309- 316.

Gerhard, M., Moore, D. J., & Hobbs, D.J. (2001). An Experimental Study of the Effect of Presence in Collaborative Virtual Environment. In *Proceedings of the British Computer Society Conference on Intelligent Agents, Mobile Media, and Internet Applications*: pp. 113-123.

Goto, T., Escher, M., Zanardi, C., & Magnenat-Thalmann, N. (1999). Multimodal Interaction in Collaborative Virtual Environments. *In Proceedings of the 1999 International Conference on Image Processing (ICIP '99), IEEE Computer Society*: pp. 1- 5.

Greenhalgh, C. (1997). *MASSIVE: Model, Architecture and System for Spatial Interaction in Virtual Environments.* Retrieved February 4, 2004. Nottingham University, Department of Computer Science. [On-line] Available: http://www.crg.cs.nott.ac.uk/research/systems/MASSIVE/

Guye-Vuillieme, A., Capin, T. K., Pandzic, I. S., Magnenat-Thalmann, N., & Thalmann, D. (1999). Non-Verbal Communication Interface for Collaborative Virtual Environments. *The Virtual Reality Journal, Springer*, vol. 4: pp. 49-59.

Hindmarsh, J., Fraser, M., Heath, C., & Benford, S. (2001). *Virtually Missing the Point: Configuring CVEs for Object –Focused Interaction.* In Churchill, Snowdon and Munro (eds.), Collaborative Virtual Environments: Digital Places and Spaces for Interaction, London, UK: Springer Verlag: pp. 115-139.

Koldehofe, B. (2003). Collaborative Environments: Aspects in Communication and Educational Visualisation. PHD Thesis. Retrieved on February 5, 2004. [On-line] Available: http://www.cs.chalmers.se/~khofer/pub/lic.pdf.

Kujanpää, T., & Manninen, T. (2003). Supporting Visual Elements of Non-Verbal Communication in Computer Game Avatars. I*n Proceedings of Level Up – Digital Games Research Conference*, M. Copier and J. Raessens (eds): pp. 220-233.

Leigh, J., Johnson, A.E., & DeFanti, T. A. (1997). Issues in the Design of a Flexible Distributed Architecture for Supporting Persistence and Interoperability in Collaborative Virtual Environments. *Proceedings of the IEEE/ ACM Super Computing '97 Conference*: pp. 1-14.

Macedonia, M. R., Zyda, M. J., Pratt, D. R., Barham, P. T., & Zestwitz. (1994). *NPSNET: A Network Software Architecture for Large-Scale Virtual Environments.* Presence: Teleoperators and Virtual Environments, vol. 3, No. 4.

Magnenat-Thalmann, N. & Joslin, C. (2000). *Virtual Humans in Virtual Environments.* Retrieved on February 5, 2004. [On-line] Available: http://www.miralab.unige.ch/ papers/72.pdf.

Manninen, T. & Kujanpää, T. (2002). Non-Verbal Communication Forms in Multi-Player Game Session. *In Proceedings of HCI 2002 Conference,* X. Faulkner, J. Finlay, and F. Détienne, (eds), Springer-Verlag: pp. 383-401.

Otto, O. & Roberts, R. (2003). *Importance of Communication Influences on a Highly Collaborative Task.* 7th IEEE International Symposium on Distributed Simulation and Real-Time Applications: pp. 195-201.

Pandzic, I. S., Capin, T. K., Magnenat-Thalmann, N. & Thalmann, D. (1995). VLNET: A Networked Multimedia 3D Environment with Virtual Humans. *Proceeding Multi-Media Modeling MMM '95,*: pp. 21-32.

Pandzic, I. S., Capin, T. K., Magnenat-Thalmann, N. & Thalmann, D. (1996). Towards Natural Communication in Networked Collaborative Virtual Environments. *Proceedings of the FIVE '96: Framework for Immersive Working Environments, the 2nd FIVE International Conferences*: pp. 37-47.

Pandzic, I. S., Capin, T. K., Lee, E., Magnenat-Thalmann, N., Thalmann, D. (1997). *A Flexible Architecture for Virtual Humans in Networked Collaborative Virtual Environments.* Computer Graphics Forum, 16(3): pp. 177-188.

Park, K., Kapoor, A. & Leigh, J. (2000). Lessons Learned from Employing Multiple Perspectives in a Collaborative Virtual Environment for Visualizing Scientific Data. *In the Proceedings of ACM CVE 2000*: pp. 73-82.

Salem, B. & Earle, N. (2000). Designing a Non-Verbal Language for Expressive Avatars. *Proceedings of the Third International Conference on Collaborative Virtual Environments, CVE'00*: pp. 93-101.

Shen, X., Bogsanyi, F., Ni, L. & Georganas, N.D. (2003). *A Heterogeneous Scalable Architecture for Collaborative Haptics Environments.* IEEE International Workshop on Haptic Audio Visual Environments and Their Applications: pp. 113-118.

Stansfield, S. A. (1994). *Distributed Virtual Reality Simulation System for Simulational Training.* Presence: Teleoperators and Virtual Environments, vol. 3, No. 4.

Stanney, K. M. et al. (1998). *Human Factors Issues in Virtual Reality: A Review of the Literature.* Presence: Teleoperators and Virtual Environments, 7(4): pp. 327-351.

Vinayagamoorthy, V. (2002). Emotional Personification of Humanoids in Immersive Virtual Environments. *Proceedings of the Equator Doctoral Colloquium.* Retrieved on February 5, 2004.[On-line] Avaiable: http:// www.cs.ucl.ac.uk/research/equator/papers/Documents2002/vino_doctora l_ sub_2002.pdf.

Wang, F. (1998). *Using Live Video to Represent Remote Users in Collaborative Virtual Environment.* Retrieved on February 5, 2004. [On-line] Available: http://www.evl. uic.edu/fwang/video.ps.gz

Witmer, B. G. & Singer, M. J. (1998). *Measuring Presence in Virtual Environments: A presence questionnaire. Presence: Teleoperators and Virtual Environments*, 7(3): pp. 225-240.

Word IQ Dictionary and Encyclopedia, (n.d), Retrieved on February 4, 2004. [On-line] Available: http:// www.wordiq.com/definition/Graphical_User_Interface.

MOHD KAMAL OTHMAN, Faculty of Cognitive Sciences and Human Development, Universiti Malaysia Sarawak.