

Tele-Immersive Collaborative Virtual Environment for Intuitive Interpretation

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Abstract

The purpose of tele-immersive collaboration is to enable people in separate locations to work together effectively by the Virtual Reality (VR) technology facilitating the human intuitive insight and interpretation. Consequently, it is important to cogitate with figures and characters as well as voice communication in Collaborative Virtual Environment (CVE). In this paper, we constructed tele-immersive CVE with annotation capability and free-hand drawing of characters and figures into Immersive Projection Technology (IPT) environment. In addition, participants from remote sites connected over a Wide Area Network (WAN) were enabled to interact with each other by sharing annotations via a PDA application. Moreover, we developed applications for scientific visualization and, for intellectual work based on KJ Method inside a tele-immersive CVE. From these results, we are able to maintain essential information for thinking by making annotation on IPT environment, and have proved the system can support intuitive understanding in remote collaborative work.

1 Introduction

Complexity and multiplicity of large-scale data sets generated from High Performance Computing (HPC) systems have been increasing at a proportional rate to their computational power and network bandwidth.

Collaboration between multi-field researchers using visualization techniques become important in order to inspect these large-scale data sets efficiently, and it can support human insight and interpretation.

In order to work smoothly with participants at remote sites via WAN, Computer Supported Cooperative Work (CSCW) tools, such as E-mail, WWW browser or a TV Conference system, have been used as general tools. However, CSCW tools are limited in 3D expression of data sets possessing depth information because 2D displays or projectors are generally used.

We consider that effective remote collaboration using 3D contents requires a tele-immersive CVE [1, 2] which enables high presence and reality. Collaboration in CVE is important to support problem solving and intellectual discovery by intuitive observation of 3D contents from various view-points in a shared environment.

In this paper, we describe a tele-immersive CVE which supports intuitive interpretation by making annotations within IPT environment. In addition, we describe our applications for scientific visualization and intellectual work in the CVE based on KJ Method.

2 SECI process and Collaboration

Knowledge is differentiated between “tacit” and “explicit” knowledge. Tacit knowledge, unable to be expressed verbally, is an individual’s knowledge or ex-

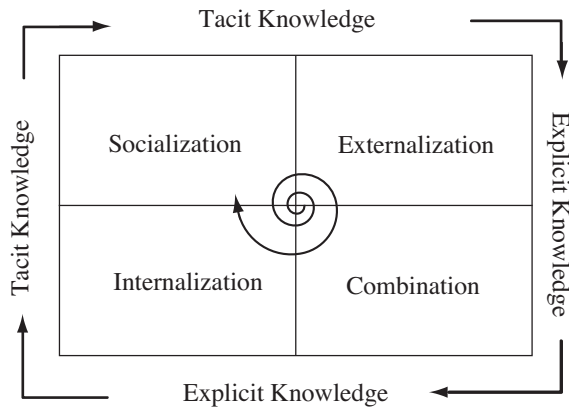


Figure 1: Knowledge Translation.

perience accumulated personally. In order to share tacit knowledge with others, it needs to be converted to a sharable explicit knowledge such as text or figures. On the other hand, the knowledge creation is a continuous process by dynamic interaction between these different kinds of knowledge.

This process is called “SECI process” [3] which has 4 modes (Figure1). **Socialization** is to share a common space through a communication between participants. **Externalization** is to translate from tacit knowledge to explicit knowledge. The explicit knowledge is shared by other participants. **Combination** is the integration of these into new more complex and systematic sets of explicit knowledge. **Internalization** is to absorb this explicit knowledge as tacit knowledge in practical use. These four modes configure the spiral model in the process for knowledge creation.

We consider that collaborative works in CVE have similarity to the SECI process. Socialization process is same as the construction of shared virtual environment. Communication between participants in CVE is similar to externalization and combination. Internalization looks like a simulation of work, and self-schooling in stand-alone mode is equivalent to the work in a VR environment. Externalization process in particular requires various expression methods in order to transmit their ideas and experiences. In addition, combination process requires the externalized explicit knowledge to be converted to own knowledge.

Therefore, it is important to cogitate with figures and characters as well as voice communication, because remote collaborative works in CVE has a tendency to use abbreviation or corresponding expressions. In order to support intuitive knowledge creation, we have constructed a tele-immersive CVE with

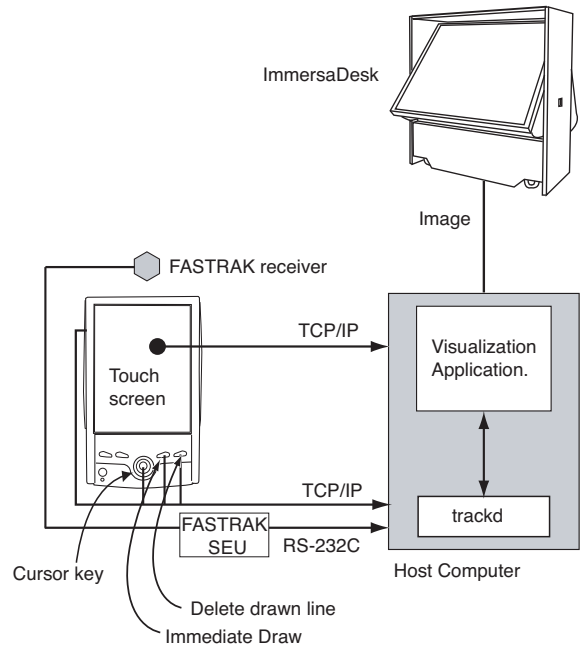


Figure 2: System configuration of our IPT environment.

annotation capability into IPT environment that consist of 3D contents. In this environment, we are able to change the visualization parameter and to make annotations by using PDA. We enabled collaborative to be an understanding of visualization data with annotations which shared with co-researchers of remote places.

3 System Configuration

3.1 Scientific Visualization in IPT Environment

VR technology is one of the useful visualization tools for intellectual discovery. We implemented a PDA-based application for IPT such as CAVE or ImmersaDesk. It can control parameters and make annotations for scientific visualization without moving between the IPT and host computer[4].

Figure 2 shows our system configuration. The host computer generates visualization images and displays them on the ImmersaDesk display. We used the Visualization Tool Kit (VTK) and CAVE Library for visualization. We established a private WAN by connecting several remote sites over the Japan Gigabit Network II (JGN II). Participants in each site can in-

interact by making annotations via a PDA application within IPT. Avatars represents other participants who access from remote places. Coordinate data of each participant's head and PDA in the IPT environment is transmitted between participants and each participant is represented as an avatar with motion.

3.2 Communication in Tele-immersive CVE

Collaborative works between remote places uses a lot of conversation[5] because participants in the IPT environment have difficulty using input interface such as keyboards or mice. Therefore, voice communication is indispensable in achieving smooth communication in CVE. We developed voice communication tools which enable adjustment of volume and PAN level corresponding to speaker's position in IPT environment.

In addition, we implemented two free-hand writing methods to use in CVE since it has a high tendency to use clipped words and anaphoric expressions. One method is the drawing of annotations directly in IPT environment by using a PDA like a virtual pen enabling to move it freely while pressing a PDA's button. This method is suitable for drawing 3D figures or large images. The other method is the use of PDA's touch screen to transfer a drawn annotation into the IPT. This is appropriate for drawing characters or texts. These drawing data are then sent to the IPT environments to be shared by all participants.

4 Application in Tele-immersive CVE

4.1 Scientific Visualization of Fluid Flow

We have implemented an environment for scientific visualization in tele-immersive CVE. Scientific visualization in IPT environment is suitable for intuitive interpretation of complex fluid data. Figure 3 shows an overview of fluid visualization.

Each participant can change visualization parameters and can make annotations in CVE by using a PDA application. Visualization parameter data and vertex position of annotations are sent to each participant's IPT environment in real-time.

4.2 Visualization of Bedrock Destroying Phenomenon

Traditional earthquake researchers have used three orthographic views, however the use of 3D visualization technology has been considered effective for the

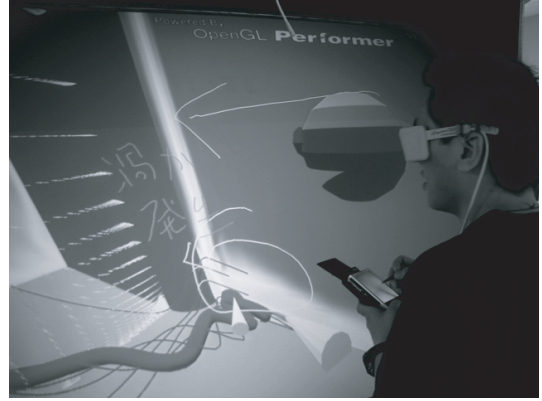


Figure 3: Overview of fluid visualization with participant's avatar.



Figure 4: Immersive bedrock destroying phenomenon visualization and annotations.

analysis of destruction phenomenon. Taking this into consideration, we attempted to use 3D visualization technique to the destruction phenomenon of earthquake in an IPT environment.

Figure 4 shows an example of earthquake data displaying. In this visualization, earthquake sources are represented by spheres and the intensities by colors. The earthquake source location becomes easy to understand by interactively configuring the dense spheres in the IPT environment. In addition, researchers have been facilitated to understand the construction of fault planes via intuitive observation by the virtual walk through to the underground structure.



Figure 5: Overview of KJ Method application in IPT.

4.3 Intellectual Works by KJ Method in IPT Environment

KJ Method is one of the well known techniques for knowledge creation. It makes groups for relationship between each other and the various information are described as cards or "Post-it". In addition, new ideas created by using the KJ Method are described as writing to cards. Since the task of making cards using the KJ Method is generally hard for the users, several software have been released to support this task in a Personal Computer (PC). However, users becomes interfered when the numbers of cards increase, because there is a limitation of working area on traditional PCs.

We implemented an application for using KJ Method within an IPT environment in order to serve as a CVE for knowledge creation. Figure5 shows the overview of this KJ Method application in IPT. In this environment, various image files, such as graph, picture or 3D visualization image, are used as the cards in KJ Method. IPT environments have no limitation regarding working area and are able to add more axis of grouping. Image and additional annotation data in IPT environment are loaded from database system, and are saved in database after the work. Therefore, users are allowed to access the database from a WWW browser and are enabled to carry out the continuation of the work in another environment.

5 Conclusion

In this paper, we presented a tele-immersive CVE which we have developed with free-hand annotation

capability via PDA in IPT environment which consists of 3D visual contents.

Considering the use of annotations such as streamline drawing or marking the noteworthy point, we could conclude that collaboration with annotations inside the CVE supports better communication between participants. From these results, we are able to maintain essential information for thinking by making annotation such as characters or figures on IPT environment and have proved the system can support intuitive understanding in remote collaborative work.

In the future, we believe that the task of making 3D annotations in CVE will be effective for enriching communication tools during the collaborative investigation, and will be a more useful tools for human intellectual works.

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References

- [1] Leigh,J., Johnson,A., Vasilakis,C., DeFanti,T. "Multi-perspective Collaborative Design in Persistent Networked Virtual Environments," In Proc. of IEEE Virtual Reality Annual International Symposium '96, pp.253-260. (1996).
- [2] Ki,B., Klasky,S., "Collaborative scientific data visualization" *Concurrency: Practice and Experience*, Vol.9, No.11, pp1249-1259, (1997).
- [3] Nonaka.I., Takeuchi.H., *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford Univ Pr. (1995).
- [4] Kukimoto,N., Furusho.Y., Nonaka.J., Koyamada.K., Kanazawa.M., "PDA-based Visualization Control and Annotation Interface for Virtual Environment," In Proc. VIIP 2003, The 3rd IASTED International Conference on Visualization, Imaging, and Image Processing, pp.975-980, (2003).
- [5] Ruddle,R.A., Savage,J.C., Jones,D.M. "Verbal Communication During Cooperative Object Manipulation" In Proc. of ACM Collaborative Virtual Environments (CVE'02), pp.120-127, (2002).