e-AG: enhanced Access Grid System for Collaboration among Heterogeneous Systems

Youngho Lee, Sehchan Oh, Seokhee Lee and Woontack Woo
GIST U-VR Lab.
Gwangju 500-712, S.Korea
{ylee,soh,sheelee,wwoo}@gist.ac.kr

Abstract

In this paper, we propose an enhanced Access Grid (e-AG) system which enables distributed collaboration among heterogeneous systems with 3D media. There have been various kinds of studies addressing distributed collaboration systems. Most systems exploit 2D display or provide no communication among heterogeneous systems. Our proposed e-AG system has the following characteristics. Firstly, hardware and software of e-AG are composed in order to open the tele-conference sharing 3D media among heterogeneous systems. Secondly, e-AG can make it possible to display 3D media on any 3D display system without the dependence on a display type and resolution. Finally, context-based protocol is designed to solve interaction problems among heterogeneous systems. Therefore, we can share 3D media with many participants under distributed collaborative environments based on heterogeneous systems. The proposed system has proved a high feasibility for tele-conference and distributed collaboration.

Key words: 3D display, Access Grid, collaboration, context, 3D Media

1. Introduction

The need for share computer resources, applications, and massive data for collaboration has increased in various research fields and between long-distance researchers. Researchers have carried out large-scale collaborations to obtain new results through the scientific interchanges and cooperations. Thus, various collaboration systems supporting such needs have been studied in the part of video/audio conference, text-based chat, and file/data sharing. However, those systems have limitation in sharing their experimental data among heterogeneous environments.

Over the past few years, a considerable number of studies on a distributed collaboration system have been developed, e.g. Access Grid (AG) at ANL, AGAVE and TeraVision at EVL, Tele-Immersion at UNC, ID3DVC at HHI, and etc. AGAVE and TeraVision have intended to deliver stereo 3D media with tracking and interactions [1][2]. Although AGAVE is mainly focused on hardware solutions, its developers do not show CVE and discuss the possibility of programming CAVERNSoft applications [3]. It is difficult to transmit and display 3D media using an ID3DVC system and Tele-Immersion System of UNC, which have a lot of computational complexities [4]. Also, they did not mention connection between heterogeneous systems.

In this paper, we propose the enhanced access grid (e-AG), which supports distributed collaboration by sharing 3D media among heterogeneous systems. e-AG, consisting of Access Grid (AG) and 3D display, allows to share 3D media for collaborative works in a distance. Also, the system can realize distributed collaborations among heterogeneous systems.

Characteristics of the proposed e-AG are as follows. Firstly, Combining the hardware and software in the system, we can operate 3D media during the conference. Secondly, we can share the 3D media through 3D display among the heterogeneous systems, which have a specified display format. Thirdly, using context-based protocol for communicating with each other, we can solve the problem, which can occur during interactions among heterogeneous systems when data type and structure are mismatched.

This paper is organized as follows. We describe how we connect heterogeneous systems to each other in chapter 2. In chapter 2.1, the hardware and software configuration of the proposed e-AG is suggested. Adaptive display of 3D video is depicted in a chapter 2.2. We present a context-based protocol for interaction between heterogeneous systems in chapter 2.3. The implementation and the experiment results are given in chapter 3. Finally, we discuss the conclusion and a future works in chapter 4.

This work is supported in part by KIST and in part by KISTI.

2. Distributed Collaboration among the heterogeneous systems using e-AG

2.1 The Hardware and Software of an e-AG System

The e-AG consists of AG and 3D display. 3D video and 3D CG are considered as 3D media in this situation. They have been used momentously in the area of scientific collaboration. e-AG has used semi-immersive 3D display and user can operate 3D media with an input device. Because collaborative work is performed in a real world, participants are separated from a real world if we use an immersive display like CAVE. Fig. 1 shows an example of the e-AG, which consists of AG and stereo display system.

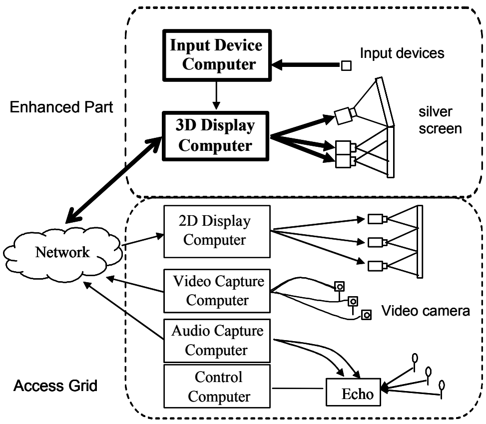

Fig. 1 The picture of e-AG system

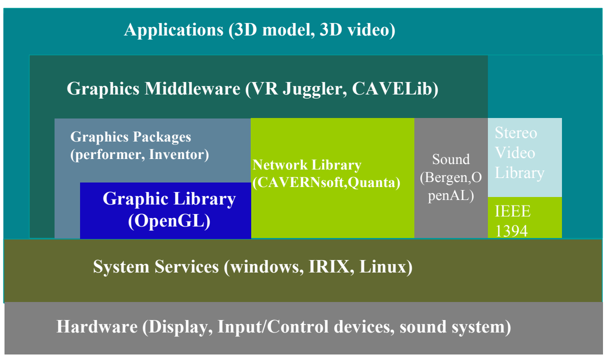

Fig. 2 Software structure of e-AG

Software of e-AG has designed for sharing 3D video and 3D CG model. Because it is practically impossible to equip the identical software and hardware in all distributed collaboration systems, we select softwares to share 3D media in heterogeneous systems. OS can be windows, IRIX, Linux as shown in Fig. 2, and OpenGL performer and Open Inventor can be used as Graphic Package with basic graphic library, OpenGL. VR Juggler, CAVELib, and NAVER are used as graphic middleware to support various display systems and input devices [5][6]. IEEE 1394 driver and stereo video library are installed in order to support video acquisition and a processing of an image. Besides, Bergen, Sonix can be used as a sound library, CAVERNsoft or Quanta as a Network library.

2.2 Adaptive delivery and display of 3D video

Network bandwidth and display type at a receiver should be considered when we deliver and display 3D video. Because two images should be transmitted for stereo display, required bandwidth increased by two times theoretically. There are various kinds of 3D display type and resolution. Therefore, an on-line and an off-line process are designed for delivery of 3D video, and a 3D viewer has designed to support four display types and various resolutions.

When 3D video is delivered, on-line or off-line process can be selected according to the bandwidth. An on-line process makes a complicated encoding process short for real-time acquisition and transmission as shown in Fig. 4. It transmits 3D video after simple processing. An off-line process depicted in Fig. 3 processes a stereo encoding and then transmits or saves the compressed data if real-time transmission is unnecessary.

In off-line process, 3D coding schemes, depending on display types of receiver, can support various resolutions. The proposed 3D coding scheme exploits spatio-temporal scalability that is defined in MPEG2. The layers consist of a base layer and several enhancement layers. The base layer provides the left image having a basic resolution and enhancement layer 1. The enhancement lay 1 provides additional data to improve the resolution of image. In the same way, an enhancement layer 3 supports additional data for high-resolution image. Finally, according to the display types at a receiver, we can select a base image and a high resolution base image added enhancement layer1 or stereo image added enhancement layer2.

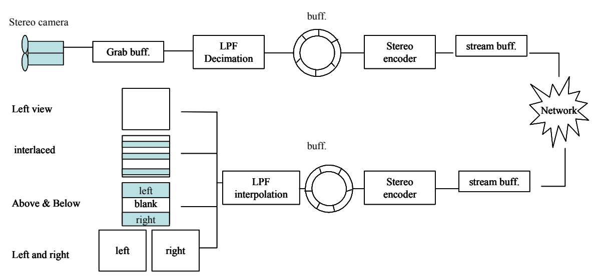

Fig. 3 Off-line process

In on-line process, because a complicated encoding is omitted, 3D video is transmitted and displayed in real time [7]. 3D video acquired from stereo camera is transmitted after passing several steps. Down Sampling is processed individually in a width direction after passing Low Pass Filter. The right and left image in Fig.

4 are arranged as up and down. At a receiver, video signal passes Low Pass Filter, and up sampling is processed. Finally, recovered 3D video is represented according to display type at the receiver.

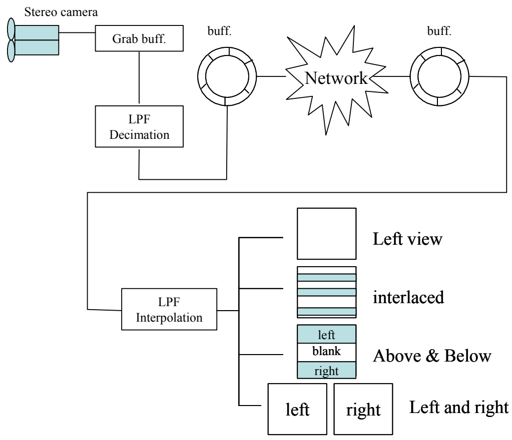

Fig. 4 On-line processing

2.3 Context-based interaction delivery protocol for sharing 3D CG among heterogeneous systems

Data type and structure are different from each system when we connect two remote collaborative systems. For example, in case of 3D model application program, the coordinates and scale of a model can be different from other applications. An interaction delivery protocol (IDP) based on context is defined for this problem and supports communication between heterogeneous systems.

A virtual sensor, context generator and context service manager are designed to share standardized information over a network [9]. The virtual sensor collects all kinds of information about 3D model located in the virtual space and passes information to the context generator. The context generator transforms information to an IDP. After this transformation, IDP is transmitted to other nodes. After receiving IDP, the context manager interprets it as proper forms. For example, if a different coordinate system is used at each node, virtual sensor finds a position of subject and context generator changes the position to the IDP. At the receiver, the IDP is transformed to the proper information in system [5].

Because IDP has a standard way to express input for interaction, heterogeneous systems can process information after analysising IDP. A participant's inputs are expressed in forms of 5W1H [9]. WHO is identity of participant or one's group, or it can be an identity of 3D model. HOW expresses what kind of change falls off, and WHAT designates the virtual object. WHEN is information for the priority order of a command to be determined, and WHERE includes position information of a model. Here is an example of interaction delivery protocol generated by user 1. It can be expressed like <User1 / * /x, y, z / * / move to / *>.

3. Implementation and Experimental Results

We installed a 3D display system and AG in two different places. Also, we implemented the AG with a desktop node and full node in each place, and as for 3D display system, a three-channel active stereo display with curved screen in one place. Passive stereo display system with wall type silver screen in other location was installed as shown in Fig. 5. The left curved screen in Fig. 5(b) that used three projectors utilized three PC as a display cluster. A rear projection is installed so that a user can approach a screen. A user puts on shutter glasses and can inspect 3D scene.

(a) (b)

Fig. 5 Implementation and Execution (a) 3D video with passive stereo (b) 3D CG on 3-channel curved screen

Also, an IS900 tracking system is mounted for interactions with a 3D model. The right screen of Fig. 1 is the AG, which use LCD projector. It is the full node which uses four PC and a Sony D30 camera for acquisition and transmission of a video image. A voice signal is exchanged through the microphone arranged on table. As software for the AG, AG toolkit Ver 2.1 is used.

The frame rate of stereo camera used in this experiment was 15 f/s and its resolution was 640 × 480. However, in actual experiment, the used acquisition rate and the bandwidth were 10 f/s and 147.5 Mbps (640 × 480 × 3 (RGB) × 2 × 10 × 8 (bits)), respectively. Therefore, in on-line process for real time delivery, the acquired two images were processed by down sampling (74 Mbps) and fitted to LAN (100 Mbps). Also, before down sampling, images were processed by a low pass filter to reduce aliasing.

In off-line process, various resolution representations were possible by a combination of image levels [10]. Fig. 6 shows that an adaptive display is possible in receiver. Fig. 6 (a) and (b) show that the left image only has an additional basic layer or enhancement layer1 if equipment for 3D display is not possessed. In Fig.6 (c), (d) and (e), we can see that basic layer and enhancement layer 1, 2 and 3 are combined suitably.

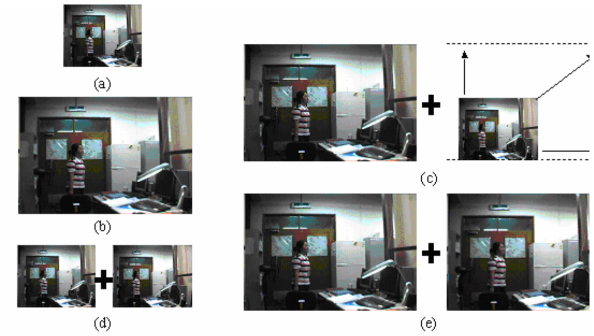

Fig. 6 Base and enhancement layers (a) image with base resolution (b) image with high resolution (c) high resolution image and base resolution image (d) images having base resolution (e) images having high resolution

We have evaluated performance for connections between two e-AG systems installed NAVER and CAVELib over the network. We measured network performance in 100 Mbps LAN and a uniform model was loaded to avoid overload due to rendering. UDP class and performance measure class in Quanta 0.1 were used. As shown in Table 1, IDP was used for delivering coordinates from one node to another. The total number of sent coordinates was 889 and the number of received coordinates was 767. Thus, data loss was about 13.72%. However, as for the last position, it was matched in spite of about 13% data lost because we transmitted IDP included an absolute coordinate of an each position.

Table 1. Comparison of transmission and received information.

	Sending coord.	Receiving coord.
Total # of coordinate	889	767
Delay (sec)	0.18238	
Average Jitter (sec)	0.138133	
Loss	(889-767)/889 × 100 = 13.72%	

Transformation time and error in the context generator were disregarded, and IDP provided robust data exchange against data loss in the network. Also, by communicating changes of user and objects in virtual environment as the form of abstract information, it can provide an extension through heterogeneous systems.

4. Conclusions and Future works

In this paper, we proposed e-AG system enabling distributed collaboration among heterogeneous systems. The proposed e-AG overcomes the heterogeneous problem of collbaoravive system. However, the proposed system did not consider other heterogeneities. We have planned to do that users can join multicast network through AG venue server on a network. Also we will improve interaction over the network. e-AG can be applied to the remote lectures that use the 3D media and a distributed conference.

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