A Networked Telepresence System with an Internet Automobile and its Transmission Issue

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Abstract

Recently, the telepresence which allows us to experience a remote site through a virtualized real world has been investigated. We have implemented a networked telepresence system using omni-directional images which enable multiple users to share a virtualized dynamic real scene in the distance and to see any direction of the scene they want. Adopting multicast transmission, our telepresence system will provide a scene for a lot of users without increasing network loads. In this paper, we introduce our networked telepresence system and discusses its network communication issue when using multicast as a transmission protocol.

Keywords

Multicast, Wireless communication, Mobile communication, Video streaming

1. Introduction

Recently, there are many researches of telepresence that acquires a dynamic real world into a virtual world and enables a user to be immersed in the remote environment [4]. The telepresence can be applied to various fields such as entertainment, medical service, and education. We have already developed a telepresence system which uses an omni-directional camera and enables a user to look around the scene so that he/she increases the presence in telepresence [1, 5]. Our telepresence system acquires and transfers the remote omni-directional scene by an omni-directional camera, and shows a user the view-dependent images in real time. The telepresence system also enables a user to look around the remote scene widely.

On the other hand, the progress of the wiewless network technology, an automobile can have the Internet connection at all times. If our telepresence system applies to the automobile with the Internet connectivity using wireless communication channels, a variety of applications can be realized. For instance, a lot of remote users can experience having a drive and share the scene among them, if the omni-directional video stream is transmitted by multicast. Besides, each user can see any direction of the scene he/she wants. Generally, for the telepresence system, the video stream should be transmitted constantly. Therefore, a robust transmission mechanism is required, since an automobile always moves and the condition of the wireless communication channel might be unstable.

In this paper, we introduce our networked telepresence system, which multiple users on the Internet to look around a remote scene captured by omni-directional cameras, and discuss its network issue.

Section 2 describes the overview of the proposed system. Section 3 discusses the transmission issue and Section 4 describes the related work. Finally, this paper concludes in Section 5.

2. Overview of our telepresence system

Figure 1 briefly shows the architecure of our telepresence system. Our telepresence system consists of an automobile which mounts omni-directional camera "HyperOmni Vision [10]", multicast relay server for video stream on the automobile, and the omni-directional video viewer. The omni-directional video stream is transmitted to the campus LAN from the automobile via a wireless communication channel of IEEE802.11a or IEEE802.11g. A user can receive the omni-directional video contents using a desktop PC, a laptop PC, or even an immersive client with a head mounted display (HMD).

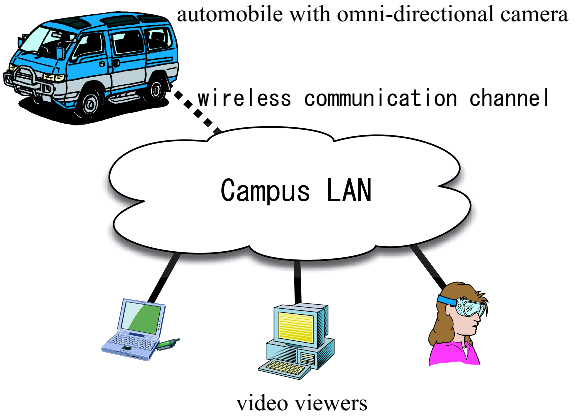

Figure 1. Overview of the proposed telepresence system

2.1. Hardware components on the automobile

Figure 2 shows the hardware configuration on the automobile of our telepresence system. In the automobile, there are three PCs. One PC records GPS data including the positioning data and the time. Another PC is for the omni-directional camera. The omni-directional camera acquires omni-directional progressive video surrounding the automobile (see Figure 3). The acquired omni-directional video is transferred to the PC through the FireWire channel. The PC encodes the omni-directional video (640x480 pixels, 30 fps) to Windows Media Format (1Mbps) by Windows Media Encoder. The other PC is for the wireless communication. This PC has both IEEE802.11a interface and IEEE802.11g interface. The GPS data and the omni-directional progressive video are transferred to the campus LAN through this PC. Table 1 describes the detail specification of the hardware equipped on the automobile.

2.2. Omni-directional video viewer

The omni-directional video viewer converts the omni-directional video (left image of Figure 4) to the common

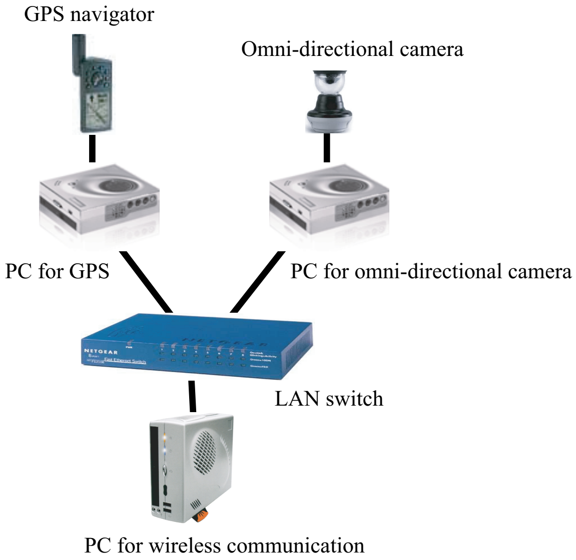

Figure 2. Hardware comfiguration on the automobile of our telepresence system

Figure 3. Omni-directional camera acquiring the scenery surrounding the automotile

perspective video (right image of Figure 4) to show the user the common perspective video. Our telepresence system uses a texture mapping function of GPU (graphic processor unit) for converting video images in real-time by the method of the literature [5].

A user on a desktop PC or a laptop PC can watch the omni-directional video contents through the viewer invoked by a web browser. We have been implementing an omni-directional video viewer using Active-X as a plug-in software of a web browser (see Figure 5).

When the user access the web page which provides an omni-directional video content, the omni-directional video

Omni-directional camera	SONY DCR-TRV900 + Hyperboloidal mirror
GPS navigator	GARMIN GPS V
wireless network interface	IEEE802.11a, IEEE802.11g
PC for omni-directional camera	CPU: Intel Pentium4 2.53GHz OS: Windows XP
PC for GPS	CPU: Intel Celeron 1.0GHz OS: FreeBSD
PC for wireless communication	CPU: Intel Pentium4 1.7GHz OS: FreeBSD
Multicast relay server	CPU: Pentium4 2.5GHz OS: Windows 2003 Server

Table 1. Hardware configuration of our telepresence system

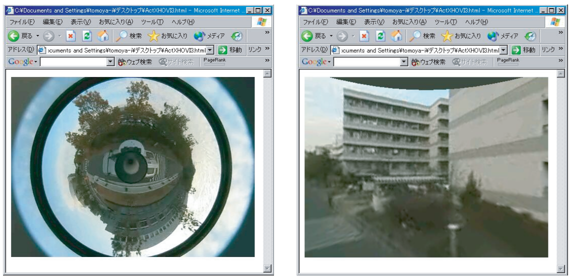

Figure 4. Omni-directional image and common perspective image

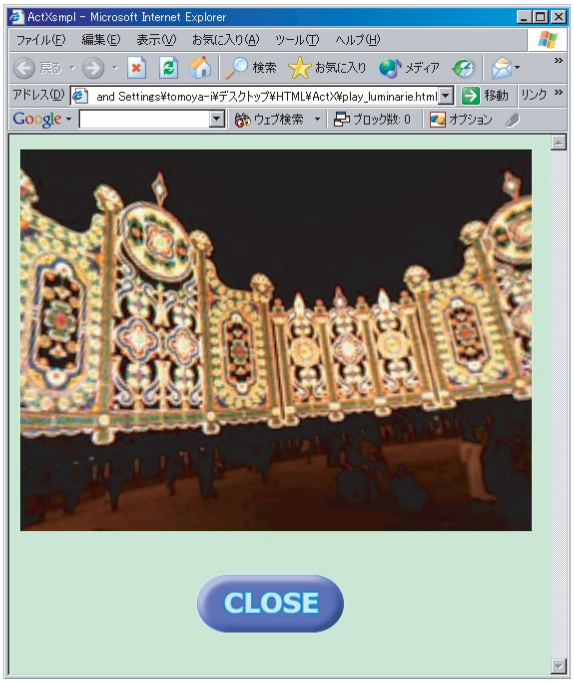

Figure 5. Web based omni-directional video viewer

viewer implemented by Active-X is installed automatically. The user can easily see an omni-directional video content without care of an omni-directional camera type, parameters of camera, file path of the content, and so on, because a content provider embeds them in an HTML file. The user can look around the omni-directional video by using a mouse-drag operation.

2.3. Omni-directional video contents

There are two kinds of omni-directional video contents in the present implementation: stored video contents encoded in advance and live video contents encoded in real-time. Note that stored video contents can be provided as an on-demand-service.

The live video contents are used for simultaneously providing multiple users with the same contents similar to TV broadcasting. The user can see the live video contents acquired by the omni-directional camera and transferred immediately. The live video contents can be transferred to multiple users by multicast without increasing the network load.

3. Transmission issue

In our telepresence system, the communication channel between the automobile and the campus LAN uses wireless communication facility of IEEE802.11a and IEEEE802.11g. Since the automobile runs in our campus, the condition of wireless communication channel is not stable. Therefore, some robust transport mechanism is required.

We have implemented the prototype system of the proposed telepresence system to clarify the problem of the multicast transmission using wireless communication channels. Figure 6 shows the experimental environment.

Now, we discuss the behavior of the network communication of the prototype system. In our experiment, we used “Foundry FirstIron WorkGroup” which has 24 ports of 10/100 Mbps as the LAN switch and “Avaya Access Point III” as the wireless access point. Wireless access point (1) and (2) connected to port 2 and 1 of the LAN switch, respectively. A desktop PC for the omni-directional viewer connected to port 7 of the LAN switch, and we used three laptop PCs which have IEEE802.11a interface and IEEE802.11g interface.

In this experiment, each PC repeatedly did join/leave operation to the multicast group for the omni-directional video stream. Each laptop PC moved between wireless access point (1) and (2). Moreover, in the second experiment,

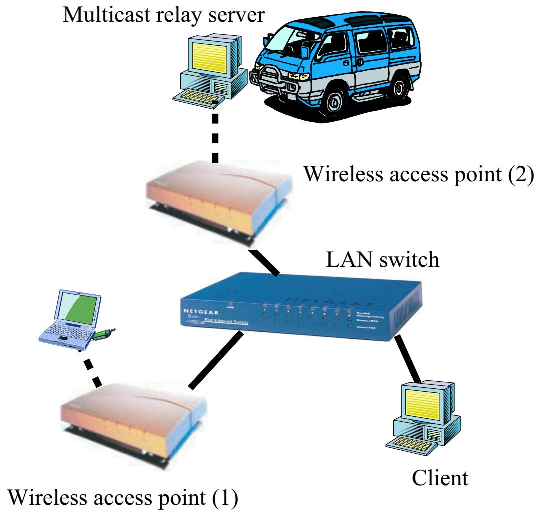

Figure 6. Experimental environment

the automobile moved around the wireless access point (1) and (2), that is, the multicast relay server move between both wireless access points.

Actually four PCs received the distributed omni-directional video. The four users could look around the scene in arbitrary directions. The video stream is displayed on the omni-directional viewer at 30 frames/sec, if the wireless communication channel between the automobile and the campus LAN is stable and the PC uses the same wireless communication protocol. In this time, the both transmitting and receiving network loads of the relay server are 1Mbps. When the number of received omni-directional video viewer increased, the network load did not increase.

Since the multicast sender moves, the sender's IP address of the multicast group changes. In this case, the LAN switch has to change the multicast tree. However, most multicast-enabled LAN switch does not suppose a such situation. Therefore, some addition multicast setting is required for the LAN switch.

When the PC for the wireless communication changed the wireless access point or the wireless communication protocol, the time delay between the acquisition and the presentation omni-directional video took about 10 seconds. Therefore, we need some robust transport mechanism including multicast, which can handle multiple different wireless communication channels simultaneously.

Additionally, if no PCs joined to the multicast group, the multicast traffic sent to the all port of the LAN switch which caused the multicast storm. Therefore, the noble multicast mechanism should be required, especially when multicasting high quality video stream.

4. Related Work

In most telepresence systems [3, 4, 8, 11], active cameras such as panning and tilting cameras are used to present a user view-dependent images of a scene in the distance. This often suffers from the time delay from the change of viewing direction to the change of displayed image. The time delay is mainly caused by both the communication between an observation site and an observed world and the control of cameras so as to follow the user's viewing direction. Especially, the former factor depends on the actual distance between the observation and observed sites.

Moreover, in the existing telepresence systems, if a user want to change the view direction of a scene, he/she have to control a camera. Therefore, it is difficult that multiple users share the same telepresence system.

In the IPv6 technology, some multicast protocols which consider the mobility of the node have been proposed [2, 7]. These multicast protocols can handle the mobility of only the multicast receivers. Source Mobility Support Multicast (SMM) [6] proposed a multicast protocol considering the mobility of the sender. Since this multicast protocol supposes to be used by the Intelligent Transport System (ITS), it uses the Cellular IP [9] as the underlying network protocol between the automobile and the access point. This multicast protocol can not be applied to the other underlying network protocol except the Cellular IP. Therefore, the more general multicast protocol considering the mobility of the sender is required.

5. Conclusions

We have developed a networked telepresence system which easily enables multiple users to look around a remote scene with the omni-directional camera. The system uses a web-browser, and enables users to see omni-directional video such as common video. In the experiment, the omni-directional video was distributed through wireless and wired network by multicast protocol, and multiple users could look around the scene in arbitrary directions in real time. The delay between the acquisition and the presentation of omni-directional video is 10 seconds. In future work, we should reduce the delay in transmitting an omni-directional video stream. Also, we have to provide some robust transport mechanism which can handle multiple different wireless communication channels simultaneously. Moreover, we have designed and developed a new multicast protocol which has redundant multicast path considering the mobility of the sender.

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