§18. Study for Remote Participation System Providing Bidirectional High-presence with a Wide View of Control Room

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The "SNET" is a layer-2 virtual private network (L2VPN) on SINET, which is dedicated for the Japanese fusion research collaboration. Not only the LHD remote participation (RP) but also the QUEST experiment at Kyushu University and the GAMMA10 of University of Tsukuba are participating in this bilateral virtual laboratory framework. The participating sites are mutually connected with high-bandwidth SINET, and therefore they can access the common data platform without being aware of any differences of their geographical distances.

Since the ITER construction practically advances, the importance of the remote participation (RP) technology has been recognized more significantly[1]; however, the current RP methods cannot provide high-quality view of the remote control room. In other words, it never gives a good "tele-presence" to the remote participants. The preceding SNET collaborative studies had coped with the following three RP requirements:

i. Remote data access and share
ii. Remote machine/device control [2]
iii. Mutual human communication.

However, such the popular video conferencing (VC) system can never provide a good presence to the remote sites.

In this study, the idea of "Augmented Reality (AR)" or "Mixed Reality (MR)" has been applied to improve the tele-presence of the remote control room by showing a wide range of landscape view by using the multiple screens. It covers the majority of the effective sight of the participant almost as same as a local participant can see in the control room. It simultaneously provides some working windows in foreground as if a local participant uses a pc console in the control room. By realizing the high presence RP terminal system, we can contribute not only the present SNET collaboration but also the next generation fusion experiments such as ITER.

This study proposes that the scenery of the remote control room would be shown as the desktop background of the multi-screen display in real time. The size of multi-screen display should be optimized almost as same as the effective range of a human sight. It can consequently provide a small "cave-like" AR or MR environment for a single remote participant with a reduced visual stress.

Fig. 1 is the photograph constructed as the prototype multi-screen display. For the flat panels, "frame-less" EIZO FlexScan EV2455 having 24.1 inch size have been used. Its total horizontal and vertical resolutions are 6K×2K. Since the flat screens are reasonable in price nowadays, it is also very significant that it does not cost much.

Through the experience developing a real multi-screen displaying system, we have found that choosing a scenery capturing camera is quite difficult because popular standard cameras do not have enough wide range of sight or horizontal resolution being suitable for this extended multi-screen. Even there are some products, they might be very expensive far beyond the display costs.

To use popular camera products, we have to use multiple cameras simultaneously to capture the wide range of sight, and then the real-time video synthesis would be necessary. Combined optimization for the adopted cameras and the video synthesis method must be further investigated. In addition, it would be also necessary to study how to reduce the occupied network bandwidth because 6K×2K real-time video streaming requires one-digit higher throughput than
1 Gbps Ethernet.[3]

Fig. 1. Prototyping 6-screen display: Total 6K×2K resolution can cover more than 60° of human effective sight in horizontal plane. As nVIDIA NVS series multi-port graphics card and DisplayPort connections are used, it can provide the video and audio simultaneously.

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2) Nakanishi, H. *et al.*; "Remote Device Control and Monitor System for the LHD Deuterium Experiments", 10th IAEA Technical Meeting on Control, Data Acquisition, and Remote Participation for Fusion Research, 20–24 Apr. 2015, Ahmedabad, India (2015) 2O-70.
3) Nakanishi, H., Yamanaka, K., *et al.*; "Test and Verification of Fast Data Transfer methods for ITER-REC", 32nd JSPF Annual Meeting, 24–27 Nov. 2015, Nagoya, Japan (2015) 24pD51P.