Augmented Robot Agent: Enhancing Co-Presence of the Remote Participant

Jane Hwang*
Imaging Media Research Center
Korea Institute of Science and Technology

Sangyup Lee†
Samsung Electronics, Inc.

Sang Chul Ahn‡ Hyoung-gon Kim§
Imaging Media Research Center
Korea Institute of Science and Technology

Abstract

In this paper, we present a tele-meeting system which uses an augmented robot agent as the representation of the remote participant. In this system, we augment a 3D volume video of the remote participant over the on-site robot. The robot agent in this system represents a remote user with camera, microphone, and mobility. Using this robot agent, the remote user and the local user can show their appearances and interact with tangible interfaces. This robot agent system can be applied to various tele-meeting applications such as tele-marketing and tele-tutoring. For example, we implemented a tele-marketing system to show the feasibility of the suggested system.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities;

1 Introduction

Recently, home robots (e.g. vacuum cleaning robots) have become common in many houses and their functionalities are expanding. In the near future, home robots might be more utilized and multi-functioned as an essential home gadget. The basic idea of our research started from those home robots that can be used as the representation of the remote person.

Reproducing the visual appearance and voice of a remote person more naturally and realistically is an important key of the tele-meeting system. Generating and transmitting a 3D video of a remote participant has been considered as a feasible approach to providing a greater co-presence and interactivity to a tele-meeting [1, 4]. Kauff's system [1] is an appropriate tele-meeting with one or two people in the desk environment, but it is not appropriate in the case that the user needs more in-situ tele-operation. Augmenting a 3D video in the in-situ might be more useful for a general purpose tele-meeting [4]. Moreover, producing and transmitting 3D videos of live objects in real-time is becoming possible with a generic desktop computer using GPU acceleration [2]. Therefore, we used a real-time 3D video as the visual appearance representation of the remote participant.

Augmenting virtual sound with real environmental sound is another important issue in the AR research. Wearing headphones makes it difficult to hear real environment sounds and using multiple speakers is expensive and not very accurate. To combine real and virtual sounds, Lindeman [3] used bone conduction to display spatialized audio. If we use home robots as the source of the sound, issues of augmenting sound can be resolved.

*e-mail: hji@imrc.kist.re.kr
†e-mail: sylee@imrc.kist.re.kr
‡e-mail: asc@imrc.kist.re.kr
§e-mail: hgk@imrc.kist.re.kr

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Figure 1 shows the overall configuration of the suggested tele-meeting system which uses an augmented robot. The left part of the figure shows the system for the local participant and the right part shows the system for the remote participant. The local participant can see the appearance and hear the voice of the remote participant as she/he exists instead of the robot. The local user wears video-through stereoscopic HMD (Head Mounted Display) to see the overlaid remote person. The remote participant can see and hear as he is placed in local place instead of the robot because the robot has a camera and microphone. The video taken by the camera is shown to the remote participant on the large display which is in front of her/him.

2 System Setup for the Remote Participant

To immerse the 3D video of a remote participant, the visual hull generation method is used. As shown in Figure 1, the user in the remote location is captured by multiple cameras and the 3D volume of the user is computed by the visual hull server.

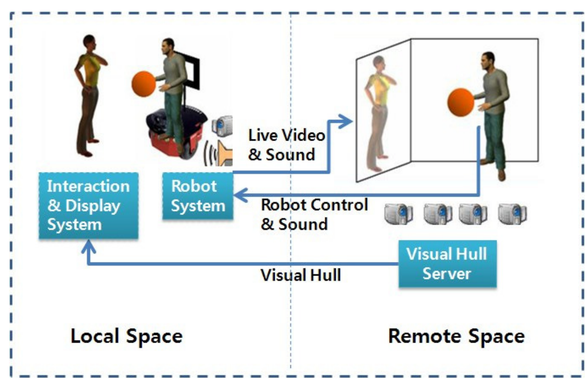

Figure 1: Overall system configuration of the tele-meeting system using augmented robot

Because the visual hull has 3D volume data, it can interact with 3D virtual objects in the environment (Figure 2). This means that the remote user can use his/her body as an interaction tool to interact with the virtual objects and the local user.

To make real-time 3D volume from multi-view images, we used a hardware-accelerated volumetric visual hull representation method. The suggested method achieved the drastic reduction of computation time, making the volumetric visual hull more practical in the various fields. The reconstruction algorithm has three steps: image processing to label object pixels, calculating the volume intersection, and rendering the visual hull. We use the computational power of graphics hardware to compute a view specific pixel-accurate volume intersection in real-time. More details of this process is introduced in the paper [2].

As an interaction tool and controller of the robot, the remote participant uses Wii Remote. By remote user's control, the robot in the local space moves forward/backward and rotates.

Figure 2: Constructed visual hull (interacting with virtual balls)

3 SYSTEM SETUP FOR THE LOCAL PARTICIPANT

The system setup for the local participant is shown in Figure 3. In the figure, multiple fiducial markers are attached to the robot and floor to track the position/orientation of the robot and the head of the user. The robot is composed of a base part and a body part. The base part has a Pioneer robot and a laptop computer. The body part has a body case, a network camera, a speaker, and a microphone. The laptop computer in the body is responsible for movements of the robot, voice recording/playing, and transmitting. Because the voice of the remote participant is heard from the robot, the local participant feels more of a spatial co-presence of her/him. The video taken by the network camera in the head of the robot is transmitted to the remote participant to show what the robot is watching. This makes the remote participant follow the local user and interact with her/him more closely.

The local user wears lab-made video-through HMD which is equipped with two 2M pixels USB cameras. The HMD is a modified i-visor FX-605 stereo HMD which has an 800 by 600 resolution. We generate two 3D videos of the remote participant for right and left eyes to provide stereoscopic depth cue. Generated 3D videos are combined with images from two cameras and shown to both eyes. Provided stereoscopic depth cue might be helpful to perform 3D tasks with remote participants.

The local user has a Wii Remote as an interaction tool. By pressing buttons on the Wii Remote, the user can select/deselect virtual objects and change interaction modes. Also, the user can rotate and translate virtual objects using motion sensors in the Wii Remote.

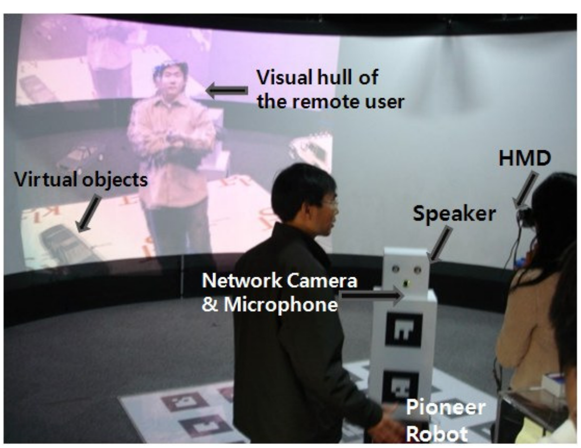

Figure 3: System setup for local participant

4 APPLICATION: REMOTE SALESMAN SYSTEM

The suggested system can be used for various applications which require more co-presence of the remote user. Tele-marketing is one of the promising application areas of the augmented robot agent system. When customers want to get detailed information about products, they need to visit showrooms or meet salesmen. Meeting a salesman virtually in their own homes makes customers feel safer, more comfortable, and it's easier to access. For the salesman or sales company, this system might be beneficial because more targeted marketing is possible and the cost/time per visit is saved.

As an example of the remote marketing system, we implemented a remote car sales system. As shown in Figure 4, the customer can get information from a remote salesman in her/his own home. The remote salesman shows various cars and consults with the customer. The customer also can choose a car to look around and virtually drive that car with changed environment.

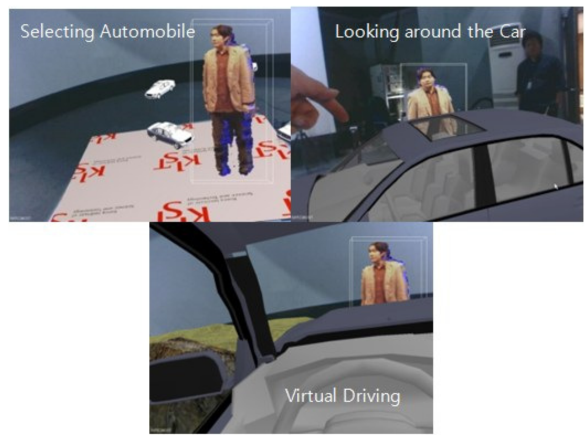

Figure 4: Salesman demonstration: customer can choose, take a look, and virtually drive a car

5 CONCLUSION

In this paper, we introduced a new concept of the tele-meeting system which uses a robot as the representation of the remote participant. We augmented 3D video and sound of the remote person on the robot to improve the co-presence of her/him. We believe that utilizing home robots as this kind is one of the highly effective applications of the future.

As future work, we wish to evaluate the feasibility of the suggested augmented robot agent. Also, we are interested in sharing remote environments as multiple users are co-located.

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