Towards Gapless Tangible Space

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Abstract

In this paper, we propose the concept of "Gap" as the sense of distance and distortion between various tangible worlds. And we represent "Gap" as compositions of effects from various seams and mismatches. Therefore, the gap can be said as the negative representation of presence or realism. Also, we grouped various seams and mismatches into perceptive seams/mismatches and cognitive seams/mismatches.

We applied this "Gap" concept to the tangible tele-meeting application to re-design more natural tangible tele-meeting system.

Index Terms: K.4.3 [Communications Applications]—Computer conferencing, teleconferencing, and videoconferencing

1 Introduction

The ultimate tangible space we can imagine is the space where users cannot sense the gap between various tangible spaces and objects. For instance, when a user is in the middle of various objects, if he cannot differentiate between the actual object and the virtual object, the actual object and the transmitted remote object, the actual object and the object recorded in the past, then we can say that the user cannot sense the "Gap".

Similar concept of the gap is the *inverse of presence*. Generally, a high presence score means that there is a small gap between different spaces. *General presence* in the virtual world indicates the level of user felt gap between real world and virtual world. Also, *tele-presence* could have the inverse relation with the user felt gap between the actual world and the remote world. But it is not always true that high presence score always indicates less gap between spaces. For example, though CAVE-like system can provide the high level of immersion and presence but the user might feel the light hand-held AR system is more seamless with real environment around him/her.

2 Gaps and Seams in Various Tangible Spaces

As we can see in Figure 1, the tangible space can be grouped into the past world, the remote world, the virtual world and the actual world where we are living. There are various types of gaps between these worlds. Space gap exist between the remote space and actual space. Existence gap lies between the actual space and the virtual space. Time gap is in between the past space and the current space.

Gaps between worlds can be also represented as the feeling or the sense of seams/mismatches. This means user can feel the distorted sense when he/she is involved in the virtual/remote/past worlds. These gaps can be modeled as the weighted sum of effects from various seams/mismatches. (1)

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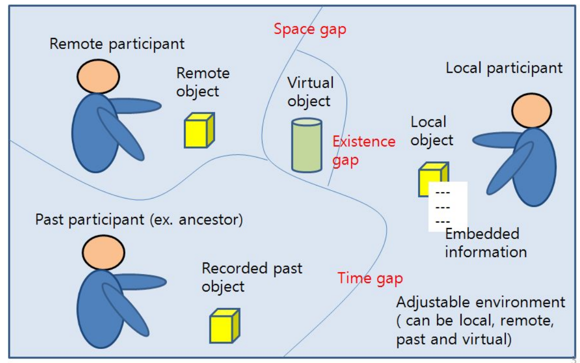

Figure 1: Gaps between participants and objects in various worlds/spaces

$$G = \sum_{j=1}^{z} w_j E_j \qquad (1)$$

where G is the gap between two worlds, z is the number of effective seams plus mismatches, E_j is the effect from the jth seam or mismatch and w_j is the weight value of the jth effect

We can divide these seams/mismatches into perceptive and cognitive ones.

Perceptive seams/mismatches include the lack of visual, auditory and haptic/tactile information in the space. Also the registration problem is another important seam factor which can be felt. As the notion of the "perceptive" implies, perceptive seams/mismatches are perceivable right away. For instance, if a virtual object in the AR has unnatural materials and shadows, the user can perceive the mismatches between the virtual object and other real objects. *Viewpoint mismatch* is also another visual mismatch existing between augmented space and real space [3]. The direction mismatch of the 3D sound is an *auditory mismatch* frequently occurs in the virtual space. The expectation of the passive haptic/tactile when the user touches an virtual object can cause the *haptic/tactile mismatch*. Also the *kinesthetic mismatch* is another mismatch if the system provide unregistered interface such as the opposite navigation direction from the user motion direction. From the view of the interaction, the design like "Tangible Bits" removes such perceivable seams [2].

Cognitive seams/mismatches cannot be perceived at the first place, but can be recognized as the user gives attention to the world [1]. Such as *functions, behaviors, intelligence and contents* of objects and the space could be the cognitive information of the tangible space. When a user wanted to utilize a virtual object, if the object cannot provide the expected function, then the user can recognize that the object have a mismatch with the real object. Or if a recorded 3D video of the user's friend cannot respond as the user expect, then the user might feel that something goes wrong with his/her friend.

3 CASE OF THE TANGIBLE TELE-MEETING

In this chapter, we will re-design the current tangible tele-meeting system to minimize Gap as possible. At first, we will shortly review our current tangible tele-meeting system and analyze seams and mismatches in the system. And then, we will suggest an alternative system configuration which can provide more seamless display and interaction.

3.1 Current Tangible Tele-meeting System

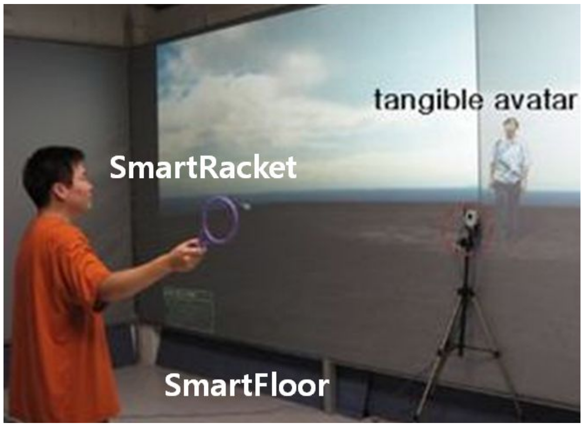

Figure 2: Tele-meeting with remote user through large screen

Figure 2 represents the current version of our tele-meeting system which uses a large screen. In the figure, the user in the local place can see the 3D tangible avatar of the remote site and also can play game using the SmartRacket. When the local user smash the SmartRacket, virtual ball flies to the tangible avatar and the 3D volume of the tangible avatar can touch and interact with the ball. The position of the user is sensed with SmartFloor which presented at Figure 2. There is an array of pressure sensors beneath the SmartFloor which detect the position of the user by the pressure value. The SmartRacket has a 3-axis accelerometer and a button. We interpret the motion of the SmartRacket to generate the hitting command and the releasing ball command.

3.2 Analysis of the Seams and Mismatches of Current Tangible Tele-meeting System

Goal of the tangible tele-meeting system is integrating the local space with the remote/virtual space. To integrate these spaces, we should remove gaps between the remote/virtual space and the actual space. As we can see in Figure 2, there exist the space gap between the remote space and the local space. When users share same virtual objects, there is also the existence gap between the virtual space and the local/remote space. The local user in the system could feel the visual seam because of the visible screen between the local user and the tangible avatar.(Figure 2) Also the generation of the exact 3D sound is another difficult task without the exact information of the user position and the HRTF model. The screen between the remote user and the local user make it difficult to generate direct passive haptic/tactile feedback of the remote user. Also interactions between two users are limited to the indirect form and this causes mismatches of interactions.

3.3 Toward Gapless Tangible Tele-meeting

The Figure 3 shows the design of suggested tangible tele-meeting system. To remove visual seam between remote user, the local user wears HMD and the remote user is visualized on the robot platform. Therefore, the remote user looks like he/she is at the position of the robot. As the robot moves following with the local user, the avatar overlaid on the robot moves with the robot. To remove the auditory mismatch, a speaker is located on the robot to make the local user feels like the remote user speaks.

For the remote user, two microphones and two cameras will be mounted on the robot to capture images and sounds from the local site. These gadgets make the remote user feels the space, where the local user located, without visual and auditory seams.

To provide passive tactile/haptic during interaction, we overlay the virtual object over the real object. For example, if there is a real chair on the floor, we put a virtual chair over the real chair to replace visual image of the real one. While we manipulate the real chair, it looks like we manipulate the virtual chair and the user can feel the mass and material of the real chair.

The above re-designing of the tangible tele-meeting is expected to provide more natural and seamless multimodal display and interaction.

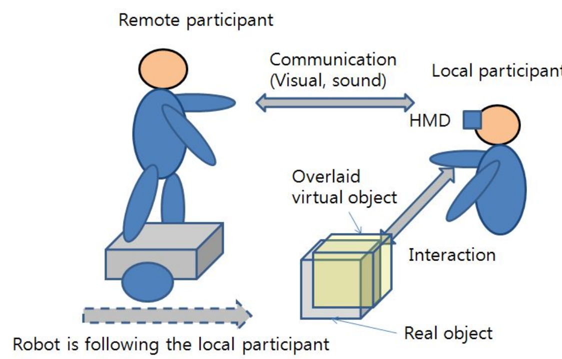

Figure 3: Suggested tangible tele-meeting system

4 CONCLUSION

We suggested the concept of the “Gap” as the sense of distance and distortion between various tangible worlds. Although this concept is quite a new in this area, the modeling of the “Gap” could be effective to design seamless and natural tangible spaces. As the procedure of the re-modeling of the tangible tele-meeting, we analyzed seams and mismatches in the our current tangible tele-meeting system. And based on the analysis we re-designed and suggested alternative tangible tele-meeting system. As the future work, we will implement the suggested tangible tele-meeting system and evaluate seams and mismatches comparing with the previous system. Also, we will develop more sophisticated modeling of the perceptive and cognitive seam based on the temporal function.

ACKNOWLEDGEMENTS

This work was supported in part by a grant from TSI project of KIST and BK21 Software Research Division of Korea University.

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