テレイグジスタンスの研究（第 78 報）
- AR によるレイヤー情報を使用したテレイグジスタンスへの応用-
Study on Telexistence LXXVIII
Layered Information Overlay on Telexistence using Augmented Reality Techniques

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In this paper, we present a method for providing augmented reality information based on a selective layered based hierarchy in ubiquitous telexistence robots. User can receive selective information dynamically depend on the interest and the distance between remote robot and desired object. Layered information is rendered on the remote environment via image based marker boards that also acts as information cards or posters for local users in the remote environment. In this paper, the implementation of the image based AR posters, frame templates in ubiquitous telexistence robots has been discussed and the effectiveness of layered information is evaluated through a set of experiments.

Keyword: Augmented Reality, Telexistence, Robot

1. Introduction

With the advancement of technology, telecommunication infrastructure has become popular in day-to-day interactions among humans. Video conferencing, Skype and similar technologies allow expressing ones visual and auditory expressions. With busy lifestyle people use these technologies to connect with people remotely, yet still many of them prefer to meet their friends/family physically specially if they are around because lack of ability to present oneself in a remote environment. Telepresence and Telexistence robots are two technologies available for presenting yourself in a remote environment with ones own movements. Thus the users feels more engaged with the remote area as if they were physically present there. With telexistence, we have achieved human-like neck movements to visually interact with a remote object in 3 dimensional spaces through previous versions of TELESARV [1] [2]. Even though telexistence allow users to feel that they existed in the remote environment, due to the narrow FoV and the quality of the video, it is sometimes hard to find thing that have not being seen before. Moreover, navigation inside a building is very difficult as the reference frame is not known and it sometimes confuses the user.

To address this issue, we provide layered AR information in the telexistence environment when the operator needs the information. However, too much information will confuse the operator and thus may disturb his/her vision that can make it hard to perform remote manipulations. Therefore, we introduce a technique to selectively display the required content when necessary.

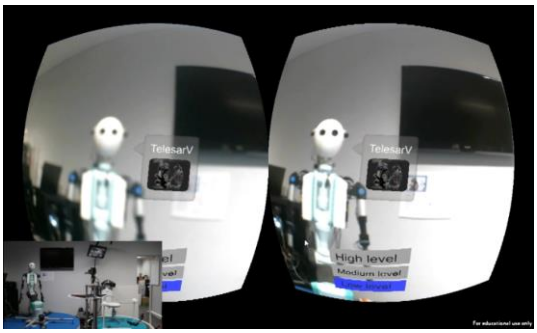


Figure 1: Layered information overlay with 3 levels of information

The information is selected in a way that it provides the necessary information to the operator depending on his preference and what he is looking at the moment. Moreover, by providing augmented reality layered information in telexistence, it can help navigating to where the user is intended to visit, reduce time consumption in finding something that is interested, and reduce the need of asking for help from remote participants.

Proposed layered Information is further categorized such as object properties, personal information and virtual controllers for house hold appliances. With this system, user can feel comfortable to look at the object he/she is interesting and receive the appropriate information at the appropriate distance. User can get closer to the object to learn more. This kind of interaction is very intuitive for human behavior [3]. As a result, user have no need to learn how to select information, just one

sentence of instruction, user will know how to do the interaction which increase the ease of use and satisfaction on user interface.

Above layered information based guidance can be applied for not only robot but also for everyday head mounted display techniques. In recent technology, it can be say that the future head mounted display can become a widely use and augmented reality itself will become one of the important technology. At that time, layered based information also can be applied for any kind of information provider and become standard of interaction for such method.

2. Design Considerations

The design is to provide 3 types of overlay information as below. To detect where to display AR content, image based AR tags are being used. These tags are similar to project information cards or posters in a exhibition venue. This local participants can get enough information by reading the poster information while the same poster can act as an AR marker for online participants so that more dynamic content can be rendered on to the telexistence vision system. Here is the table shows relation between distance and interest in human behavior.

High interest	10 - 120	centimeters
Medium interest	120 - 230	centimeters
Low interest	230 - 500	centimeters

Table 1: Relative between distance and interest in human behavior

These overlay information will provides as Low, Medium and High depend on distance thus, when user feel more interest in project, he/she can move closer to get more information.

2.1 Object properties

In this category, it is mostly focus about different object properties in the remote environment. Depending on the users background such as engineer, designer, or sales person, these overlay information can be customized. Furthermore, when the user goes closer to the object, the insides of the object can be seen in various layers. Here again the inside information can be customized based on the user preferences.

2.2 Personal Information

Name card is traditional way to provide information for local audience. However, small name cards cannot be seen when attending in a remote environment, furthermore these analog data cannot be used to interact with that person. Our design is to use existing information as marker to provide 3 layered of information as same as object properties. Here is the table shows meaningful distance in human [4]

Personal space	0-75	centimeters
Social space	75-120	centimeters
Public space	120-760	centimeters

Table 2: Meaningful distance in human

2.3 Remote Virtual Controller

Similar to analog data in name card information, there may be various home appliances in the remote environment that the user wants to interact. However, the analog interface between the remote side and the users vision does not allow interacting. Therefore we propose grabbing a virtual copy of existing controllers in to your hands and then control the device via it. For example, if the user wants to turn ON the TV on the remote side, he could grab a virtual copy of the real remote from the place that real remote is placed. This virtual copy is fully functional and it can be a gateway between the remote appliance and the telexistence operator. This way operator not only feels that his body is situated in the remote side, but also he can naturally interact with the devices n the other side.

3. Implementation

3.1 Hardware System Overview

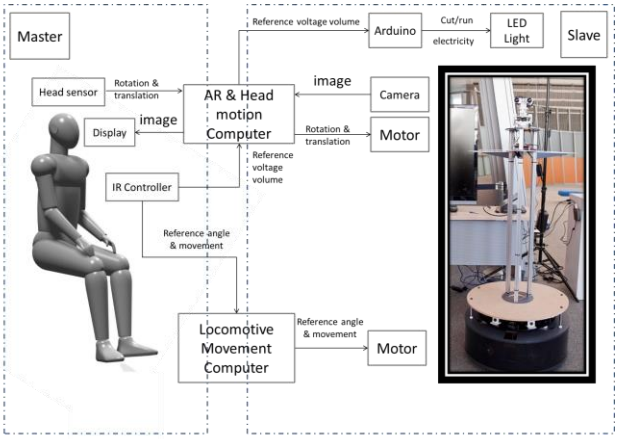


Figure 2: Hardware System Overview

There are 2 parts of the hardware system, Master side and slave side. On the master side, the telexistence user sits in a cockpit where his body motion is tracked and sent to the remote side. On the slave side, Wi-Fi (Wireless 802.11ac) is used to repeat the wireless data that is received over Internet. A custom made robot, TELUBee v.2 is used as the robot base platform. The robot can locomotion in indoors when the user manipulates via a Wii Pad. Robots head motion is synced with the users head motion. Robot has 3 Degree of Freedom that can rotate, pan, and tilt just like human head without torso and neck. The user would be able to control robot head by using intuitive movement of user's head. Oculus motion sensors detect the movement and

send it to computer to generate the data that can control 3 desired motors on the robot.

Robot head uses Full HD camera with 1920×1080 pixels with 90-degree wide-angle field of view (FoV). On the software part, displaying system was integrated with AR cameras that can catch AR code and render 3D virtual object augmented into the real world. User cannot recognize AR camera and user will know when he saw the marker and 3d virtual object was rendered.

By using Arduino connect with network enabled Unity platform [5], it can synchronize overlay information interface in real time interaction. The implementation use Arduino as a processor to control the controllable object such as LED in this implementation. User can use IR controller to turn on and off the light by click it when user saw the AR control panel that will show when user look at specific objects.

3.2 Software System Overview

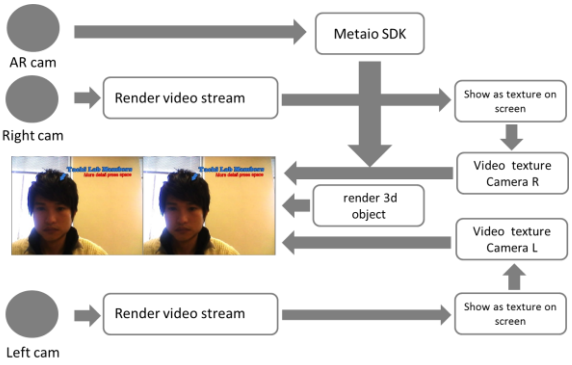


Figure 3: Software System Overview

Above system is implemented using Unity Game engine, so that a community level can do any further development. This will be greatly helpful when the system is being used in common exhibitions and demonstrations where the designers can easily design their own template and integrate into the system.

System uses 3 cameras to provide image data from robot to user display. 2 × Microsoft Lifecam Studio cameras merged with AR camera with 320×240 pixels with Metaio SDK [6] can provide overlay information into front of video texture that render real world image data then use Oculus camera lens correction shader to filter and distort the image data from left and right eyes camera.

3.3 Categorize information based on distance

System categorizes information based on meaning distance between human and object, human and human by using information card as a marker in project information and using name card for provide personal information as following.

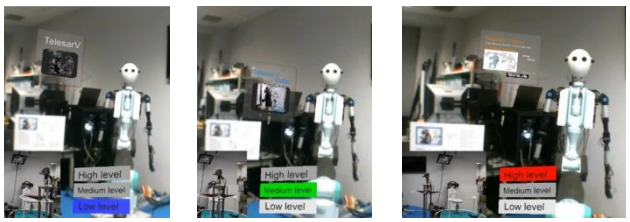


Figure 4: Object Properties Information implementation

Contents/Type	Low	Medium	High
Content	1. Project Name 2. Project Picture	1. Project name 2. Project video	1. Project name 2. System Overview
Distance	500 - 230c.m.	230 – 75c.m.	75 - 0c.m.

Table 3: Object Properties Information Hierarchy

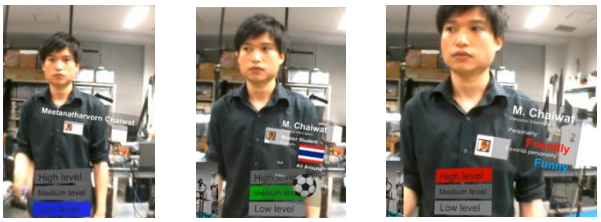


Figure 5: Personal information implementation

Contents/Type	Public	Social	Personal
Content	1. Person name	1. Person name 2. Status 3. Nationality 4. Hobby 5. Skill	1. Personal name 2. Personality 3. Favorite personality
Distance	760 -120c.m.	120 – 75c.m.	Lower than 75c.m.

Table 4: Personal Information Hierarchy

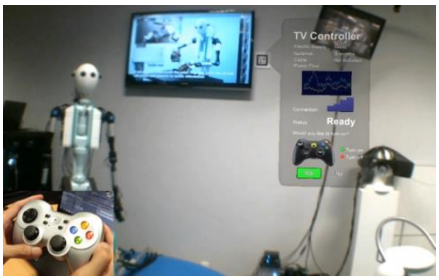


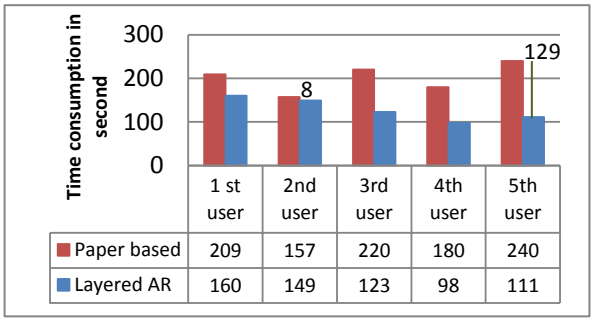
Figure 6: Virtual Controller Implementation

System uses overlay information as an interface to control television by using AR marker [7]. It can provide real-time remote control by using Arduino to send data to AC voltage controller and then control electricity flow to the television.

4. User Study

To find out whether using layered information in Telexistence robot can decrease time consumption on finding object compared to paper based information, a user study was

conducted. The experiment was held in “Living Laboratory Tokyo” at Miraikan. 5 subjects were participated with aged around 20 – 40 years old with random background. Subjects were given enough time to adjust to robot control before the experiment begins. The experiment was started with laying 3 object to let the subject find in the area of 5m× 5m in a normal living environment. The position of each object is randomized on each trial. The evaluation is based on the performance factor or time taken to find each objects. Each trial is repeated 2 times with AR contents and without AR contents as an aid to help the participants.



	1 st user	2nd user	3rd user	4th user	5th user
Paper based	209	157	220	180	240
Layered AR	160	149	123	98	111

Table 5: User Study Result

The result said that using Layered information in Telexistence can reduce time consumption on finding object in average 73 seconds compare to paper based information. Furthermore, acccording to discusion, there were interesting points such as one of the testers is very familiar with the room and knows the object very well so the result becomes faster. The problem they face is how to control the body. One subject said that it is very convenience to use head movement for look around the environment but the resolution of the display is low so sometime, if the subject found the object but he cannot read the detail or even see it clearly. Another subject said that the sign of AR is also very small and hard to read but the color is fine. And tester also commented that it will be more fun if they can control something more than just a light. For example, a fan, light of the room or interact with a tree when tree want more water or the temperature is not appropriate. The zoom function is important because subject doesn’t want to get close to the object by using controller to control the locomotive movement. If there is zoom in and out function, it will be more convenient. Moreover, few subjects also mentioned that if the head go beyond 180 degree and up to 360 degree, subject would be able to look around the room without rotation the body, which may be useful for finding the object. Somehow, the interaction is very new in the user experience and subject are not familiar in the first place but when they learned and aware that if they get closer, they will get more information, they tend to use it with different AR marker to get information also. 2 out of 5 subjects said that the resolution is not so good. And one of the subject feel sick by stereoscopic. One of the subject said that with AR, Telexistence can be applied for using in different propose and the applicable use would be wider. Some response said that having AR can get attention and it is very easy to use.

5. Conclusion

Lack of information in Telexistence makes it difficult when achieving a specific goal such as finding object, getting personal information and controlling home appliances. Moreover, too much information confuses the user. By providing overlay information in Telexistence, even resolution is low, FOV is small, user still can easily achieving a specific goal by reducing time, reduce physical action and knowing information without asking. Moreover the information is categorized into layers and implements it into 3 type of information to display such as object properties, personal information and virtual controllers. As a result from user study, using layered information in Telexistence robot will decrease time consumption compare to paper based information when finding object in living environment.

Acknowledgement

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