LEGO House : Multi Interaction Space Collaboration

Sylvia Irawati [1] Sangchul Ahn [2] Jonggil Ahn [3] Jinwook Kim [4] Heedong Ko [5]

Abstract

Recent advanced interface technologies allow the user to interact with different spaces such as Virtual Reality (VR), Augmented Reality (AR) and Ubiquitous Computing (UC) spaces. Here, we present a LEGO House application, a collaborative application which involves multi interaction spaces -VR, AR and UC spaces. The LEGO House application is built based on the VARU framework which is designed for enabling the prototyping of a tangible space application. The application is about an interior design. One user is located in the combined AR and UC space and interacts with the AR LEGO house and the physical smart devices. The other users interact with the virtual LEGO house but they share the same environment, the LEGO house. Therefore, they can collaborate together as they are co-located.

Keywords: virtual reality, augmented reality, ubiquitous computing, tangible space, collaborative application

This research was supported in part by Korea Institute of Science and Technology under the Immersive Tangible Space Experience Technology project and by the Ubiquitous Autonomic Computing and Network Project, the Ministry of Information and Communication (MIC) 21st Century Frontier R&D Program in Korea.

[1] main-author : Ph.D student at University of Science and Technology, Research Student at Korea Institute of Science and Technology; e-mail: sylvi@imrc.kist.re.kr

[2] co-author : Ph.D student at University of Science and Technology, Research Student at Korea Institute of Science and Technology; e-mail: prime@imrc.kist.re.kr

[3] co-author : Research Student at Korea Institute of Science and Technology; e-mail: hide989@imrc.kist.re.kr

[4] co-author : Senior Researcher of Imaging Media Research Center at Korea Institute of Science and Technology; e-mail: jwkim@imrc.kist.re.kr

[5] corresponding author : Principal Researcher of Imaging Media Research Center at Korea Institute of Science and Technology, Head of Human Computer Interaction and Robotics Department at University of Science and Technology; e-mail: ko@imrc.kist.re.kr

1. Introduction

Nowadays, people are living with the advanced interface technologies which allow them to interrelate with the different interaction spaces. VR technology enables the user to be immersed in a computer-simulated environment and interact with it. On the other side, the UC technology tries to bring the computer into the user's world, rather than force the user to go inside the computer. In the UC space, computers are being embedded in objects of everyday life and people interact with them without being aware of doing so. In between, the AR technology, in which computer generated images are superimposed over the real image and typically viewed through head-mounted or handheld displays, allows the user to interact with both virtual and real objects simultaneously.

Previous HCI issues in VR, AR and UC have been largely carried out in separate research communities. The major advancements and increased maturity within each individual research area has motivated us to combine those three interaction paradigms - VR, AR and UC - into a single interaction paradigm, called a Tangible Space [1]. In this paper, we present a LEGO House application, a collaborative application in the tangible space which involves the users from different interaction spaces. The LEGO House application is built based on the VARU framework -VR, AR and UC framework- which is designed for enabling the prototyping of a tangible space application.

2. Related Works

Our work is motivated by earlier research work in VR, AR and UC technology. There have been various attempts to combine VR and AR environments. Tinmith-Hand [3] allows the collaboration between outdoor AR and indoor VR system to support interactive constructive solid geometry modeling. Kiyokawa et al. [4] introduces the collaborative transitional interfaces for supporting two-user face-to-face collaboration.

There are also few attempts to combine UC with AR technologies. Barakonyi and Schmalstieg [5] proposed an AR framework that dynamically and proactively exploits distributed resources. DWARF [6] is a component based AR framework which focuses on developing a research platform for AR on wearable computers and in the intelligent environments.

Our work differs from the existing works in which we present a collaborative application which involves different interaction spaces -VR, AR and UC. In our application, users from different spaces collaborate together as they are co-located.

3. VARU Framework

In this section, we give an overview of the VARU framework. More details about the VARU framework are explained in [2].

3.1 VARU Framework Design

The VARU components can be classified into two main parts: the VARU Server and the VARU Client.

The main role of the VARU Server is to synchronize the object across different spaces. As shown in Figure 1, the VARU Server consists of three main components - the Simulation Server, the Object Server, and the Object Database. The Simulation Server is responsible for generating a simulation in the virtual environment. The Object Database is a storage which contains all objects used in the specific application. The Object Server is responsible for synchronizing the objects states in different interaction spaces.

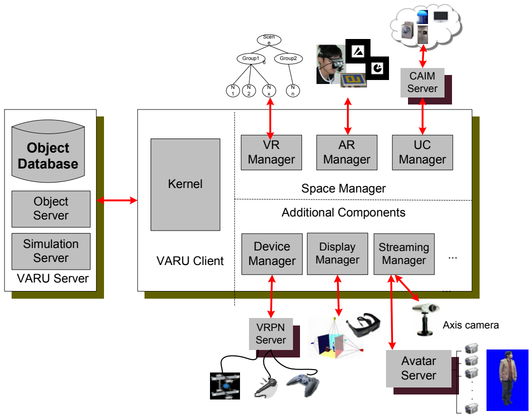

Figure 1 VARU Framework Components

The VARU Client is composed of several components. The Kernel is the mandatory component that the VARU Client must have. It bridges the communication between the VARU Server and the VARU Client.

Besides the Kernel, the VARU Client must also have at least one Space Manager -VR Manager, AR Manager and UC Manager- which is responsible for managing its interaction space. It is possible for the VARU Client to have a combined space manager, such as a combined AR and UC Manager.

The VR Manager is mainly responsible for managing the VR space. It is responsible for loading, rendering, and managing the scenegraph. The AR Manager is responsible for configuring the AR space in order to properly render the virtual objects and the real image. The UC Manager is used for controlling the UC space which consists of smart objects. These smart objects are controlled by the user and may have corresponding virtual representations on the other spaces.

Besides the components mentioned above, additional components, such as Device Manager, Display Manager and Streaming Manager, are also available in the VARU Client. The Device Manager is responsible for managing the input/output devices used for interaction. The Display Manager is a component which is mainly used in the VR and AR spaces for configuring the display system, including the synchronization among multi channel display systems and the generation of a stereoscopic view. The Streaming Manager is a VARU Client component which is used to stream an image through a network. This component could receive a streamed image from an Axis network camera and from the Avatar Server [7].

3.2 VARU Framework Implementation

The VARU API is an extended version of our previous work, NAVER [8], a VR framework which provides a base platform for VR applications. We have extended NAVER not only to support VR, but also to work with the AR and UC environments. VARU API consists of several modules. It is implemented using a C++ library and is based on several libraries, shown in Figure 2.

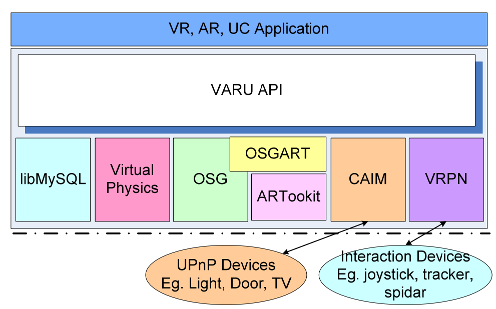

Figure 2 VARU API Library

MySQL database is used to manage the objects in the VARU Server. For managing the peripheral interaction devices, such as joystick, tracker, wand, etc., VRPN [9] is used. The current version of VARU API uses OpenSceneGraph as the main visual graphics rendering tool. For managing an AR application, it uses OSGART, a library which combines an ARToolkit tracking library and OpenSceneGraph to simplify the development of AR applications.

In the VR and AR spaces, different types of simulations could be generated. In our current implementation, VARU API provides an access to the Virtual Physics library [10] which enables the developer to simulate the physics law in the virtual environment.

4. LEGO House Application

We have developed a multi interaction space collaborative application based on the VARU framework described above. Here, we present an interior design application in a LEGO House platform which involved three interaction spaces.

4.1 Collaborative Participants

There are three kinds of interaction spaces which have been tested so far, VR space in a CAVE-like environment (CAVE space), VR space in the Smart studio (SS space) and AR combined with UC space (ARLEGO space), as shown in Figure 3.

A CAVE user, is located inside the CAVE-like environment, interacts with the virtual LEGO house using Spidar [11], a 3DOF haptic device, combined with a speech input command. A SS User is located in a smart studio with 11 cameras to capture the images used for visual hull generation. The SS user can see the virtual environment on the 2D projected screen and navigating inside the house using a joystick.

An AR user stands up in front of the physical LEGO house, wearing e-Magin head mounted display with a camera attached. The graphics overlaid onto this real world view is displayed in the head mounted display.

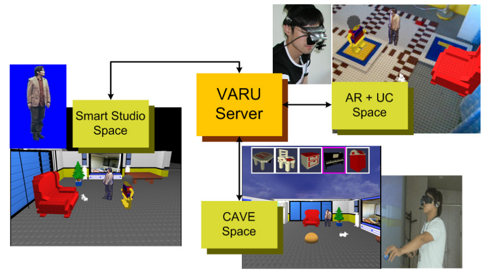

Figure 3 Three interaction spaces involved in the LEGO House

4.2 LEGO House Platform

We have created a real miniature house using LEGO bricks. Instead of building the house complete with furniture and decorations from the LEGO bricks, using AR technology, we augment the real LEGO house with virtual furniture. As shown in Figure 4, some AR markers are attached to the LEGO house. Here, we create AR markers using LEGO bricks. Fixed furniture, which is not moveable, is represented by the real LEGO bricks, such as a lamp, TV, tree, etc. Moveable furniture is represented by a virtual object, such as sofa, chair, table, etc.

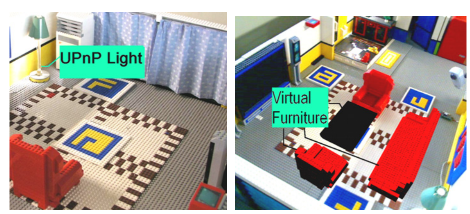

Figure 4 A LEGO house platform

Our LEGO house is also equipped with several smart devices, such as a light, door, TV, etc. These objects are implemented as UPnP [13] devices which can be controlled by the user through CAIM middleware [12].

4.3 Interior Design Application

In the interior design scenario, three users, an interior designer, a presenter and a client, collaborate together to arrange furniture inside the house. The designer is located in the combined AR and UC space and sees the environment with third person view. The presenter is located in the SS space. The client, the CAVE user is immersed in the virtual LEGO house equipped with virtual furniture, decorations and devices.

At the beginning, the designer proposes some furniture arrangements to the client while the client sees the proposed arrangement. Next, the client may choose and discuss some modifications. Both the designer and client can change the current arrangement by modifying the object position, rotating the object, adding more objects into the house, and removing some objects from the house. The presenter is navigating inside the house and explaining the house to the client.

Figure 5 AR LEGO House

LEGO character is shown in the AR LEGO house to represent the CAVE user (Figure 5) and the 3D video avatar representing the SS user. When CAVE user and SS user navigates in the virtual LEGO house, LEGO character and 3D video avatar moves following the movement direction of the CAVE user and SS user respectively. When the AR user updates the furniture position or adds new furniture to the LEGO house, the CAVE space and the SS space will be updated respectively. So the users can share the same interaction space as if they are physically co-located.

The designer has the AR menu showing the different types of furniture or house decoration; he grabs a paddle and uses the paddle to select the virtual object from the AR menu (see Figure 6), to place the object in the LEGO house, and to push the virtual object inside the house. The user can also control the smart physical objects inside the house, such as light and door using a speech command input.

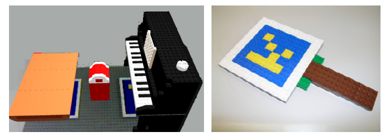

Figure 6 AR Menu and AR Paddle

On the other side, the client sees the furniture/decoration menu in the head up display (see Figure 7). He may choose the furniture from the menu by using combined Spidar and speech input. Using the Spidar, the user can push the objects and feel the force feedback when the interaction point collides with the objects.

Figure 7 CAVE LEGO House

To support this application scenario, application-dependent components have been added and linked to the existing components, as shown in Figure 8.

In our LEGO House scenario, the Navigation Manager is responsible for updating the virtual camera position and orientation. The HUD Menu Manager renders the furniture menu in the head up display, enabling the user to choose furniture and place it inside the house. The AR Paddle Gestures Manager is used for recognizing the paddle gestures and configuring the AR Menu. The Animation Manager is used for rendering a 3D LEGO character which represents the CAVE user.

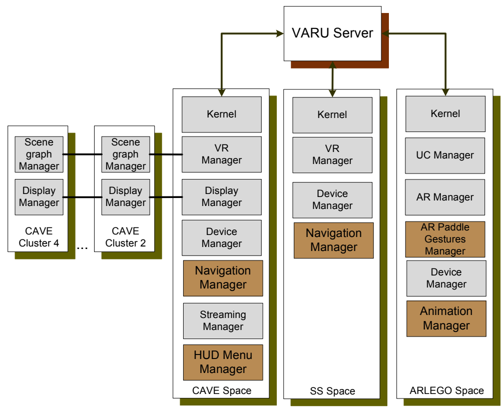

Figure 8 VARU components used in the LEGO House

5. Conclusion

In this paper, we present a LEGO House application, a multi interaction space collaboration which involves different interaction spaces. We briefly describe the VARU framework used for developing LEGO House application.

There are several areas of future research that we intend to explore. We want to explore different combinations of multi interaction space collaboration based on the VARU framework. Furthermore, a more interesting scenario could be implemented in our current LEGO platform.

References

[1] Heedong Ko, Myon-Woong Park, and Hyun-Jhin Lee, "Conceptual Framework of Tangible Space Initiative and its Application Scenario to Heritage Alive!", VSMM, 2002.

[2] Sylvia Irawati, Sangchul Ahn, Jinwook Kim, and Heedong Ko, "VARU Framework: Enabling Rapid Prototyping of VR, AR and Ubiquitous Application", to be appeared in IEEE VR, 2008.

[3] Wayne Piekarski and Bruce H. Thomas, "Tinmith-Hand: Unified User Interface Technology for Mobile Outdoor Augmented Reality and Indoor Virtual Reality", IEEE VR 2002.

[4] Kiyoshi Kiyokawa, Haruo Takemura, and Naokazu Yokoya, "SeamlessDesign: A Face-to-face Collaboration Virtual/Augmented Environment for Rapid Prototyping of Geometrically Constrained 3-D Object", Proc. of IEEE Int. Conf. on Multimedia Computing and. Systems, 1999, vol. 2, pp. 447-453.

[5] Istvan Barakonyi and Dieter Schmalstieg, "Ubiquitous Animated Agents for Augmented Reality", ISMAR, pp. 183-186, 2006.

[6] Martin Bauer, Bemd Bruegge, Gudrun Klinker, Asa MacWilliams, Thomas Reicher, Stefan Rill, Christian Sandor, and Martin Wagner, "Design of a Component-Based Augmented Reality Framework", ISAR, 2001, pp. 45-54.

[7] Sang-Yup Lee, Ig-Jae Kim, Sang Chul Ahn, Heedong Ko, Myo-Taeg Lim, and Hyoung-Gon Kim, "Real Time 3D Avatar for Interactive Mixed Reality", VRCIA, 2004, pp. 75-80.

[8] Park, C.H, Ko, H., and Kim, T., "NAVER: Networked and Augmented Virtual Environment aRchitecture; design and implementation of VR framework for Gyeongju VR Theater", Computers & Graphics, 2003, 27, pp. 223-230,.

[9] Taylor, R. M. II, Hudson, T. C., Seeger, A., Weber, H., Juliano, J., and Helser, A. T., "VRPN: A Device-Independent, Network-Transparent VR Peripheral System", VRST, 2001.

[10] Jinwook Kim, "The Realtime Dynamics Simulation Library", http://virtualphysics.imrc.kist.re.kr.

[11] Sato, M., "Development of string-based force display: SPIDAR", VSMM, 2002.

[12] Sangchul Ahn, Donghoon Kang, and Heedong Ko, "The Interaction Framework of Context Aware System", HCI, 2005.

[13] UPnP, http://www.upnp.org