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Mixed Reality and Human Centered Media for Social and Physical Interactive Computer Entertainment

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Abstract

This paper outlines new facilities within ubiquitous human media spaces supporting embodied interaction between humans and computation both socially and physically. We believe that the current approach to developing electronic based design environments is fundamentally defective with regard to support for multi-person multi-modal design interactions. In this paper, we present an alternative ubiquitous computing environment based on an integrated design of real and virtual worlds. We implement three different research prototype systems: the Virtual Kyoto Garden, Touchy Internet, and the Human Pacman. The functional capabilities implemented in these systems include spatially-aware 3D navigation, tangible interaction, and ubiquitous human media spaces. Some of its details, benefits, and issues regarding design support are discussed.

Keywords: Ubiquitous Human Media, Augmented Reality, Tangible User Interface

1 Introduction

Ubiquitous computing is a new paradigm that outlines the vision of the next generation of computation[1]. A lot of research efforts have been put in the human-computer interactions, as well as the integration of the computation world with the physical world. A major requirement of such integration has been the development of ubiquitous human media, allowing computational services to be pervasive throughout our work environments.

In this paper, we describe how 3-D images and graphical interactions using the principles of mixed reality support the creation of novel ubiquitous human media. This allows a new paradigm in human computer interaction to be explored by researchers, developers, and users.

We show in this research work that 3-D graphics and image analysis as applied to mixed reality allow ubiquitous human media to be implemented and expressed in action. Mixed reality allows intuitive interaction between real objects in the physical world, and 3D virtual content. Interaction with the computer can be designed in such a way that the environment and physical objects become the user interface. Additionally, we show that based on the mixed reality technology, the ubiquitous human media allows social interactive concepts to be introduced, and where the interaction is not in a linear or rule-based manner, but instead can be improvised in real-time by the user both socially and physically. The structure of the remaining part of the paper is as follows: In the following section, we describe some theory of mixed reality and ubiquitous computing research. In Section 3, 4, and 5 we detail examples of mixed reality for social and physical interaction. We discuss how each of these applications is an example of ubiquitous human media. Finally conclusions are drawn in Section 6.

2 Background

Mixed reality refers to the incorporation of virtual computer graphics objects into a real three dimensional scene, or alternatively the inclusion of real world elements into a virtual environment. The former case is generally referred to as aug-

mented reality, and the latter as augmented virtuality. Azuma[2] has defined three characteristics that are integral to an augmented reality interface. First, it combines the real and the virtual. Second, it is interactive in real time. Third, it is registered in three dimensions.

The mixed reality approach is an exemplar of ubiquitous human media[3]. Ubiquitous human media is a next generation computing paradigm that involves the elements of ubiquitous computing, tangible interfaces and interaction and social computing. In this way, it moves the computer interface away from the traditional keyboard and mouse and into the environment, supporting the more interactive behavior.

The three important research paradigms on which ubiquitous human media is founded, are Weiser's ubiquitous computing[1], Ishii's tangible bits or "things that thinks"[4], and Suchman's sociological reasoning to problems of interaction[5].

These three research visions have a central strand that deals with the role of context in interaction. The role of context is seen in the spatial and temporal context found in ubiquitous computing, the physical context found in tangible computing, and the social, cultural, organizational, and interactional context found in social computing. Thus, all are mutually dependant on the concept of embodiment, or a presence and interaction in the world in terms of real-time and real-space. Hence, they define the concept of embodied computing[1].

For example ubiquitous and tangible computing is based upon the idea of the computer being embedded in our environment, in objects, and in the background. Thus the interaction is embodied in the physical environment, rather than on abstract representations on a computer system. Similarly social computing places the real-time and real-space activities of humans as social beings, or embodied actions, at primary importance. ubiquitous human media ties all these ideas together, as a single research vision. Furthermore, ubiquitous human media foresees that the future of human-computer interaction will lie in an interface to computing that appears throughout our physical space and time. Thus, humans as physical beings now actually become situated inside the computational world.

Here we present three example systems developed in our lab. They are the Virtual Kyoto Garden, Touchy Internet, and Human Pacman. In the following sections, we will describe these systems in details.

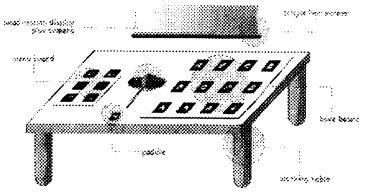

Figure 1: The layout of the Kyoto Garden system.

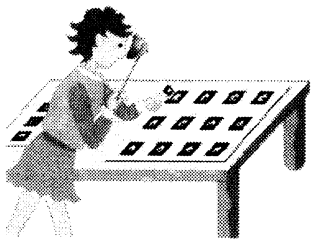

Figure 2: The user holds the Head-mount-display, and point to one of the boards to view the virtual garden and menu.

3 Mixed Reality Kyoto Garden

Kyoto in Japan is famous around the world for its unique garden art and culture. Designing a mini sand garden can be a good aid for human mind therapy. However, designing a physical sand table is time consuming, and the white sand can really get messy. To solve this problem, we come out with an novel idea of applying ubiquitous human media approach and develop an virtual garden designing system.

3.1 The System Design

The system layout is shown in Figure 1. On the table, there will be a base board consists of 12 different markers. The base board gives the position of the garden base. On the left, there is a menu board, where a catalogue of three dimensional garden object models is created and displayed on each page of the menu.

Viewing of the objects As shown in Figure 2, to view the virtual gardens and the objects

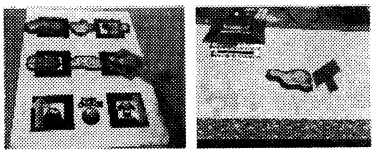

Figure 3: Picking up an virtual object from the menu, and drop it to the sand garden.

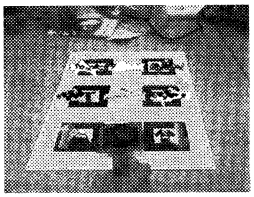

Figure 4: By hitting the virtual button using the paddle, users can change the pages of the menu.

inside, the user needs to hold the Head-mount-display and camera, and point to one of the boards (menu board or base board). If he holds the paddle in front the camera, he will see a virtual wood paddle.

- **Picking up and Dropping.** By pointing the paddle closer to a virtual object on the menu board, the user can pick the object up. After moving the paddle with this virtual object on top to the base board (White Sand Garden), he can then drop the virtual object on the Table by tilting the paddle to a certain angle relative to the Table surface. (Figure 3)

- **Flipping pages of the menu.** At the left hand bottom of the menu page, there is a virtual button with virtual text "page change" on top. Using the paddle to "hit" the button gently will change the pages of the "menu". Then users can browse through different virtual objects on each page. (Figure 4)

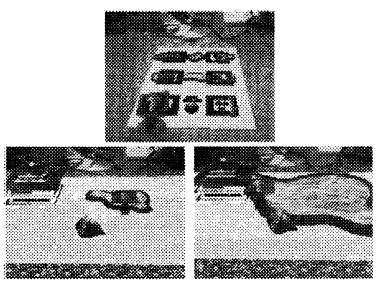

Figure 5: The paddle can also be used to scale the objects up and down in the garden.

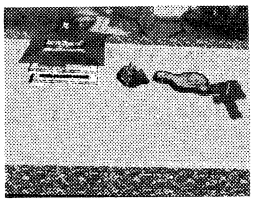

Figure 6: The paddle can be used to push the objects in the garden.

- **Scaling of the virtual ponds in the Sand Table.** Pick up the "scale up" or "scale down" arrow from the menu and move the paddle horizontally closer to the center of the pond in the Sand Table, and then slowly move it away from the center. By doing this, users can easily increase or decrease the pond's size. (Figure 5)

- **Moving of the virtual objects in the Sand Table.** Put the paddle parallel to the table surface and about the height of the virtual object which it's going to push. When the paddle is close to the object, a yellow box will appear around the object to indicate that it is in the"push" mode now. If the user continues to push the paddle, the object will be moved accordingly. (Figure 6)

Following the above steps, users can easily select the virtual objects that they are interested and design their own garden. This kind of human computer interaction is a radical departure from scrolling through a list of three-dimensional models on a computer screen. The interface now is the real-world object: a board and a paddle in this case, and thus it is a good example of ubiquitous human media space.

4 Human Pacman

Human Pacman is a novel interactive entertainment system that ventures to embed the natural physical world seamlessly with a fantasy virtual playground by capitalizing on mobile computing, wireless LAN, ubiquitous computing, and motion tracking technologies. It is a physical role-playing

augmented-reality computer fantasy together with real human-social and mobile-gaming. It emphasizes collaboration and competition between players in a wide outdoor physical area which allows natural wide-area human-physical movements. Pacmen and Ghosts are now real human players in the real world experiencing mixed computer graphics fantasy-reality provided by using the wearable computers on them. Virtual cookies and actual tangible physical objects are incorporated into the game play to provide novel experiences of seamless transitions between real and virtual worlds. We believe Human Pacman is pioneering a new form of gaming that anchors on physicality, mobility, social interaction, and ubiquitous computing.

Human Pacman system features a centralized client-server architecture that is made up of four main entities, namely a central server, and client wearable computers, helper laptops, and Bluetooth embedded objects. Wireless LAN serves as a communication highway between the wearable computers, the helper computers (laptops), and the server desktop computer.

Physical location and players' status updates are sent from the client wearable computers to the server every 10 ms to 21 ms, depending on the processing load on the client. The server maintains up-to-the-minute players' information (location, status etc.), and presides over any communication between the Bluetooth objects and the wearable computers.

The players are assigned to two opposing teams, namely the Pacman team and the Ghost team. The former consists of two Pacmen and two Helpers; correspondingly, the latter consists of two Ghosts and two Helpers. Each Pacman\Ghost is in coalition with one Helper, promoting collaboration and interaction between the users.

Pacman collects a cookie by walking through it. Such physical action is reflected visually in Pac-World through the disappearing of the cookie in both the AR and VR mode. In Figure 7, the top images show the HMD view of the Pacman player as she collects a cookie. When she walks through the cookie, the cookie disappears. This collection is also reflected real time in the virtual Pac-World (seen by Helpers) and Pac-World map (seen by both Pacmen and Ghosts) through the disappearing of the cookie in the corresponding

Figure 7: Pacman collecting cookies.

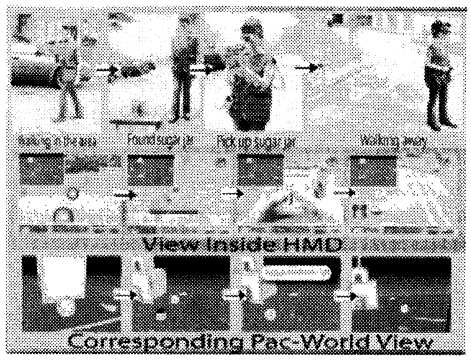

Figure 8: Sequence of pictures showing the collection of a special cookie.

location.

In Figure 8, a sequence of pictures shows a Pacman collecting a special cookie. When the Pacman is within range of the Bluetooth object (about a distance of 10 meters), communication takes place between the wearable computer and the Bluetooth device. The wearable computer sends the unique address of the Bluetooth device to the server. Upon receiving it, the server will then decide if the player is eligible to collect the special cookie that is associated with the physical Bluetooth object.

5 Touchy Internet

This system is a human-computer-pet interaction system that transfers the human physical body petting through the internet to the pet and at the same time transfers the pet motion in real time with a physical doll movement on our low cost

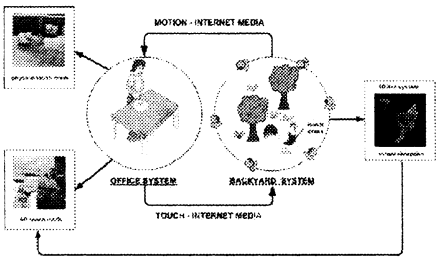

Figure 9: The general schematic of our system

X-Y positioning table or as a real time 3d live view of the pet in a virtual garden augmented on the owner's desk. Figure 9 depicts the general schematic view of the system. As can be seen in this figure, our system consists of two physical entities. We define the *Office System* as the space and setup at the owner's office premise; it is where the owner touches the doll (or virtual 3d live view of the pet) and sees its physical movement that follows the pet motion. This in fact can be anywhere and not just an office. We also define the *Backyard System* as the space and setup where the real pet is reared. The Office System and Backyard System are separated by any distance, as they are both connected to the internet. The pet wears a special dress with some vibrators and whenever the doll (or the virtual 3d Live view) is touched the action goes through the Internet to the pet dress and the vibrators are activated and the pet feels the fondling sense.

5.1 Multi-Modal Office system

To represent the pet for the owner in her office, we have realized a multi-modal interaction system with the pet which has two related parts. The first one is representation as a real time live captured 3d object augmented on the owners desk that we call *3d Live AR touch mode* (Figure 10). The second method is representation by a doll which we can have a real physical interaction with, which we call the *Physical touch mode* (Figure 11).

In the physical touch mode of the office system, the pet is represented by a real object: a doll. The doll consists of a touch-sensing board, a RF transmitter, a microcontroller and the doll itself with a hollow body. The aim of this device is to detect the user's touch on different parts of the body of the doll and to send this data (touch event and touch position) to the pet dress for activating the related vibrators on the dress, and thus cause the real pet to feel the touch in the same place as the human touching the doll.

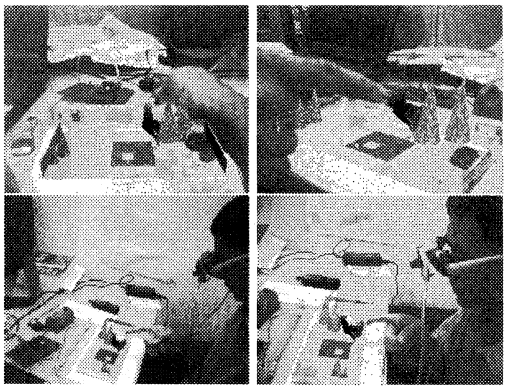

Figure 10: 3d live AR touch mode examples with virtual touching of the pet. Note that the pet is not a pre-animated or created 3d model but a live 3d viewpoint. Occlusion between the live pet and virtual objects such as trees can be achieved.

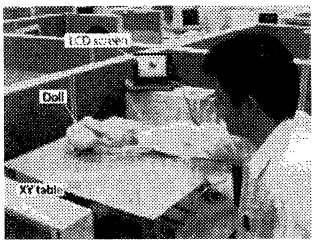

Figure 11: The pet owner fondles with the doll, which has touch sensors, and moves according to the remote located real pet.

The doll and the touch-sensing board are shown in Figure 12. The inside body of the doll is hollow and we concealed the touch-sensing board and the sensor pads inside. The capacitive touch sensor pads are distributed on various parts of the doll.

5.2 Backyard system with Wearable Computer on Poultry

In the backyard we have set up the 3d live system containing six cameras mounted around the subject (the poultry in this application) to provide real time 3d live data of the pet from any arbitrary view point. If we do not want to use 3d live AR mode in the office system, we can have only two cameras: one on the ceiling for tracking of the pet

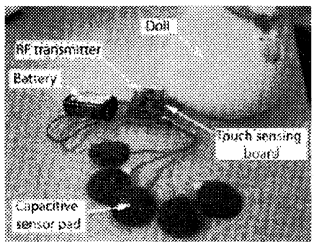

Figure 12: The doll and its electronic devices: touch-sensing board with battery and capacitive sensing-pads

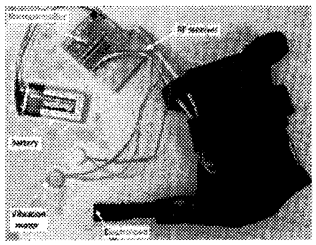

Figure 13: The dress of the pet with micro-controller, electodes and vibrators

based on computer vision algorithms and another one for the front view imaging.

We have also provided a special pet dress for transferring the user's touch to the pet. Therefore the pet can feel whenever its owner touches its avatar on the office. In the rest of this section, we describe the design details of our pet dress, our vision-based tracking algorithm for 2D detection of the pet and its orientation and finally we describe the 3d live system that we used in the backyard to provide a real time realistic view of the pet.

Figure 13 shows the hardware system and the pet dress. Here we put five vibration motors on neck, back, left, right and breast of the pet. The total weight of our dress with hardware and battery is just 127 grams. Figure 14 depicts our pet (a rooster in this application) wearing the dress. Many tests on our pet rooster showed that it did not make any problem or discomfort for the pet to wear it.

6 Conclusion

In this paper, it was proposed that 3-D images and graphical interaction using the principles of mixed reality allows the new methodology of ubiquitous

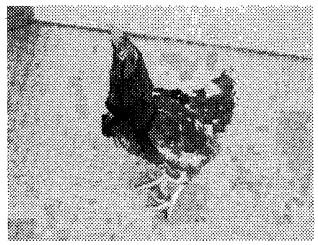

Figure 14: The rooster wearing the pet-dress

human media to be implemented and expressed in action. Ubiquitous human media is a computing paradigm that involves the elements of ubiquitous computing, tangible interfaces and interaction, as well as social computing. Using ubiquitous human media, a new paradigm in human computer interaction can be explored by researchers, developers, and users. Essentially, humans as physical beings now actually become situated inside the computational world.

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