Ubiquitous Interaction

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摘要

本文描述一個數位空間共存的互動形態，稱之為「互動無遠弗界」。此種基於 P2P 對等網路架構所形塑出來的互動形態，可以將不同實體空間與數位空間彼此揉合，利用獨立節點的系統資源，來分散處理不同的空間資訊之相關內容，可以有效快速底透過網路系統，傳遞不同空間的內部與外部資訊，並能夠即時進行回饋與反應，達成數位空間的共存目的: 從數位空間擴展到真實空間之中。

關鍵詞：互動無遠弗界，P2P 網路，互動式使用者介面，數位空間共存

Abstract

In this paper, we describe a networked space with co-existence in a P2P environment that it is based on the concept called “ubiquitous interaction”. This means by a user in a physical space locally can control any spatial components in other physical space remotely through a digital interface. This framework is expected to extend the local side of physical space to the remote side and then be able to interact with in both. We successfully demonstrate an interactive real-time system design in the above idea.

Keywords: Ubiquitous interaction, P2P network, interactive user interface, co-existence of digital space.

1. INTRODUCTION

Based on the flow of information, a networked space such as cyberspace is interesting in some specific issues in spatial interaction with human behavior [1-6]. A digital space is one kind of co-existed space that combines the physical and virtual spaces as an integrated and interactive environment [8-9].

However, this kind of co-existed space still lacks a well exploration for designing an interactive system in the above idea. The main problem of this paper is focused on that how to find a co-existed way to integrate with different physical spaces based on spatial interaction of a user.

Under this vision of interaction, our aim is followed this concept that we call it “ubiquitous interaction” and describe an interactive system to implement this idea by a communication service in a peer-to-peer (P2P) environment. In the following section of this paper, we will describe our idea and demonstration step by step.

2. LITERATURE REVIEW

2.1 Network with Interaction

In General, a networked space is represented as an information space. It is usually constructed on WWW by mass information of daily experience and become a main communication mode in space and society issues [1]. The Environmental Image theory of Kevin Lynch’s book: *The Image of the City* (1960) also provides a foresighted influence for the interaction studies of networked space [2-4].

However, based on the information flow, a networked space forms a newly spatial structure and produces a newly spatial relationship, which is spatiality. Not only redefine a newly body theory of human being but also change the interactive modes of traditional communication, the human get beyond the limitation of physical environment and effect into the transition of their lifestyle by this kind of networked space [5-6].

Figure 1 Two kinds of user interface in WWW. The left side is the *PALACE* (after http://www.thepalace.com**); the right side is the *ACTIVE WORLDS* (after** http://www.activeworlds.com)

Typically, there are two main classifications of digital spaces that are based on metaphorical conveyance of physical space in design phases of Human-computer interaction: one is non-object-oriented system such as the PALACE system (http://www.thepalace.com/), uses 2D chat room as a main spatial interface; another one is object-oriented system such as the ACTIVE WORLDS system (http://www.activeworlds.com/), uses an avatar to walk through the digital space and

interacts with others in 3D simulation environment. Figure 1 show these two kinds of interface in a networked space.

The main representation of a networked space is led into webpages techniques that can be presented some fragmental information of physical spaces such as VRML technology, node and linear video, static picture and panoramic view. Figure 2 is an example of this kind of implementation in a networked space. The related platform can intensify the cognitive behavior of human being in the physical space, moreover, it also can provide a well help that human processes a way of spatial information [7].

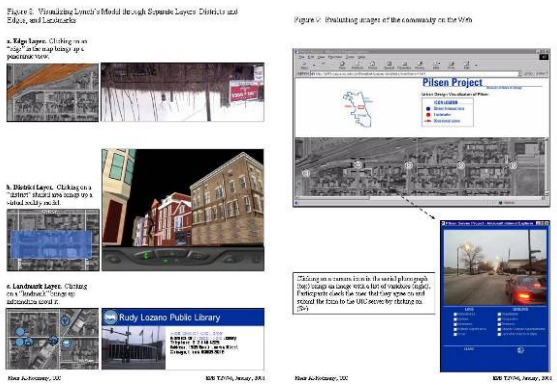

Figure 2 Spatial design of using networked space (after Al-Kodmany 2001)

2.2 Co-existence of Digital Spaces

In a networked space, a digital space becomes a newly co-existence spatial form that as a main result of digital combination in between physical space and virtual space. The digital combination includes all possibilities that are applied by digital tools and techniques. It composes the spatial dimension and spatial interaction together and as a digital environment with entirety and variety. If we want to begin studying the spatial interaction from different phases in designing, it must differentiate and analyzes the definition and relation in between physical space and digital space. Through some phenomena of spatial co-existence among these spaces, they are combined together and are integrated as a digital space [8].

The significance in the existence of digital space is located on that the dimension of spatial design can extend from physical space to digital one. Simultaneously, there are many different combinations among these spaces and dependable devices. Under this situation of spatial interaction, we can stretch the networked space by the interactive dimension in between architecture and media designing.

However, the transformation of spatial dimension can distinguish the digital space into physical networked space, virtual networked space, and co-existed networked space. The generation of new space can influence the change of spatiality, the interactive relationship between human and space is also been follow these variation to change, and then produce the transformation of the sense of places that exist new spatial interaction in digital space. There are three main phenomena in these kinds of spatial interaction: human-to-human, human-to-space, and space-to-space [9].

In fact, for the most part of these above theories are progressed by the development of media technologies, the simultaneity of media and globalization of societal interaction become a new dimension of designing space.

Therefore, we can manipulate three material forms with exchangeable processes and functions to construct a digital space: the first level is electronic pulse that is constructed by electron and electronic communication, computational environment, and high-speed transmitted circulation that is also based on information technology. These conditions can be built the infrastructure of digital space.

The second level of digital space is constructed by networked nodes and hubs, networked nodes can be interpreted as a local active basement of networked environment, then hubs are played the roles of exchange data and information communication.

The third level of digital space is a kernel that users can control the information and strategies through actions, concepts, decision and execution and then connect different spaces in digital environment [10].

3. UBIQUITOUS INTERACTION

3.1 What is Ubiquitous Interaction?

The “interaction”, is a recursive process that it begins from stimuli, then a reaction, and then stimuli again. In spite of we live in a digital era, the “interaction” seem that it only be existed in some specific situations such as a game, or a conversation between human and group.

Otherwise, in architecture domain, there are some researchers begin to think about the concept of interactive space and get some implementations in these tasks, but it often be limited within human and spaces and not yet has a entire consideration.

In fact, we need an interactive space to connect with other spaces outside and expect that we can communicate with someone. For this reason, the physical space can be transformed to a non-enclosure space that it has the digitalities and networked characteristics, then extend as a networked space that contain the visual features, telepresense, synchronous interaction.

Furthermore, we expect to solve some problems that need to exist with some kinds of relationship or situations in an interactive behavior of human. In

other words, through network space interaction, we hope the user who inside an environment can manipulate an intuitive multi-mode interface to attain the "ubiquitous interaction".

For example, the most part of buildings in the future we assume that tens of thousands sensors, processors, digital devices, and computer software are integrated in these buildings, and then we can use these devices to transmit our activities to anyone who will locate at every corners and every environments in the world.

Base on the above vision that consider about "ubiquitous interaction", this paper suggests an interactive framework that it is constructed with a peer-to-peer method of spatial interaction. This framework is described that physical spaces are connected with P2P network; each physical space has a real-time visualized interface within a digital space, or a projected space, or an augmented space. We can manipulate this interface from the opposite side of physical space, then to control any objects in the opposite side, exchange spatial information of a physical space, trigger any events that are occurred in each space.

3.2 Construction of Ubiquitous Interaction

Ubiquitous Interaction is co-existed with different physical spaces and one digital space: physical spaces are real places that some events are occurred; digital space is a virtual interface which is manipulated the physical one. In this composition, it discriminates three related layers from the physical space to digital:

1. **Presentation I/O (PSIO)**: include the sensors (SS) and displays (DS) in main components. The components of this layer are used to show some useful messages to someone who want to get some spatial information. They're usually constructed by hardware devices or equipments.
2. **Information I/O (IMIO)**: include the multi-modes inputs (MI) and ubiquitous outputs (UO) in main components. These of this layer are small controllable devices to transmit and receive spatial data from physical space; they could be hardware or software.
3. **Ubiquitous Kernel (UK)**: the component of this layer is usually called Central Service Server (Css) include the management system (MS) and a spatial database (SDB). This is the core equipment of ubiquitous interaction. It is usually designed with digital media in an integrated way, so it could be called "integrated media (iM)" in the ubiquitous interaction.

The operation procedure of ubiquitous interaction would be composed as following: Thought human and objects are co-existed, spatial events or human behaviors are generated by multi-modes from active inputs or passive sensors. These analogical generations will be respectively collected into UK, the Css for ubiquitous interaction, to process the digital transformation, computing results, and then record these processed data in SDB. The UK will transform the complied method of spatial events or behaviors which is based on the spatial records in SDB, then MS will be represented these processed spatial events or behaviors by an interface of digital space on a real-time thread network. Figure 3 is shown scenario composition of ubiquitous interaction.

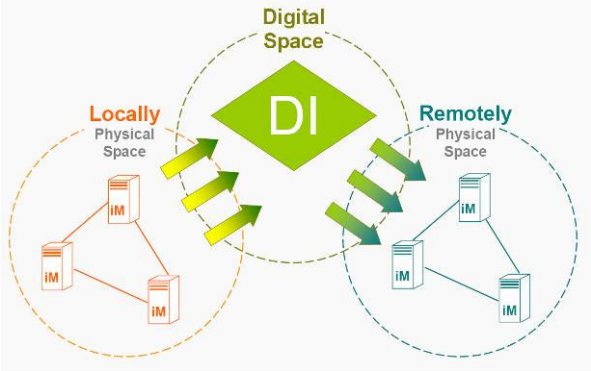

Figure 3 Concept of ubiquitous interaction.

There are eight components in this structure. Figure 4 is shown what the relationships of these components with different layers are. Now we describe details of these components as following terms:

1. **Digital Interface (DI)**: this is a digital representation of a physical space in augmented, projected, or simulated form. A user in remote space can immediately interact and communicate within the connection of digital interface from the remote side to the local side.
2. **Management System (MS)**: this is a server system that it processes any requests of remote information and collects local spatial information. The collections of spatial data are gathered from input devices and sensors, and then are represented in the visualized components of space communication interface.
3. **Spatial Database (SDB)**: this uses to record the spatial information and restore the spatial interaction of personalized modes.
4. **Multi-modes Inputs (MI)**: an active-controlled input device has multi-mode of spatial information such as gesture recognition, pressure surface, and remote controller.

5. **Ubiquitous Outputs (UO)**: output devices of spatial information such as walls, sound, digital smell, or force feedback etc.
6. **Sensors (SS)**: such as body tracking sensors, CCD cameras, Infra-red sensors, and GPS location system.
7. **Displays (DS)**: mean by the display devices of remote physical space in local physical space to show the concurrent state of remote physical space that people in local physical space can sense the situations or events. For example, spatial projection, TV walls, monitors, mobile phones, personal digital assistant (PDA).
8. **Spatial Objects (SO)**: the interactive components such as the human themselves, pets, desktops, refrigerators, walls, columns and beans in a physical space.

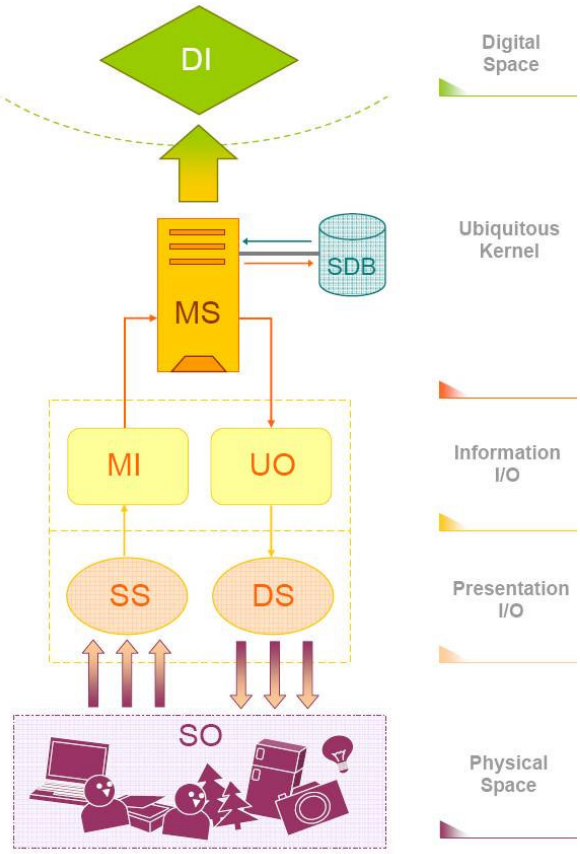

Figure 4 Concept of ubiquitous interaction.

4. Scenario of Ubiquitous Interaction

Basically, the networked node of a physical space is constantly broadcasted an interface of digital space in a single direction if this physical space is not interacted with other physical spaces. An iM of physical space locally must connect to other iM of physical space remotely while these nodes of physical spaces will be interacted with each other and be generated an interactive behavior or an interactive event through using the DI of digital space.

After connecting with the DI of digital space, the iM of locally physical space could present the DI in iM of remotely physical space to the DS of local one, then the spatial behavior or events that occur in locally physical space will be changed the reaction of spatial information into the iM of remotely physical space through the DI of digital space.

4.1 Interactive Frameworks of P2P network

Based on the above scenario, we can define two of main interactive mode in ubiquitous interaction. One kind of these is the iM of remotely physical space reads and records the data of spatial information in SDB. Then it complies these data appropriately when the iM of remotely side through the DI of digital space is received the input data from a spatial event or a spatial behavior in locally physical space. After that, we can reply an analog signal into remotely physical space. There are a pair of interactive behaviors or interactive events be generated by this two-way direction of interactive framework that is called "situated interaction".

Another kind of interaction mode in a networked space is that it has only one DI of digital space in one of several nodes. It just like that selected nodes of physical spaces are connected together into an interactive environment of digital space and interacted with each other on DI. We called this kind of mode is "shared interaction".

4.2 System Architecture

The main implementation of this paper is focus on the immediate connection of ubiquitous interaction and the exchange of spatial information. However, we do not want to describe how the spatial information be sensed and be outputted, and how the spatial data be restored and be reused because of it relates the spatial situation and driven motivation of an interaction issue.

We implement a prototype of task, the "space wall", to test and verify this interactive framework.

The "space wall" is an intermedium that a physical space locally, the local side, through it to connect other of remotely one, the remote side. In this example, a "space wall" in locally physical space is broadcasted the real-time image of other physical space remotely. The user in locally physical space to touch a broadcast object on the real-time image, then can control it as a switch in remotely physical space and try to change the state that get some feedbacks of massages.

Local side: we use a computer and a touchable monitor, the touchable monitor as a prototype of the space wall, and a web camera is used to capture the

real-time image. The display on the touchable monitor is the real-time image from the web camera and some text massage in remote physical space. These massages can make the user understanding what the immediate variation in remotely physical space is.

Remote side: in remotely physical space, there is a web camera which be used to capture the real-time image, and one computer which connects a transform card with several electric appliances that it can convert the signals between analog and digital devices. And then it must have another one as the iM of UK. In this machine, the monitor can show the state in other side of physical space, the state of switches on electric appliances, and the log file of the change on these switches.

In sum, the each part of interactive framework in this example describes the following details:

1. **DI**: we broadcast the spatial image captured by web camera in each physical space and run a real-time streaming service of network in the internet.
2. **MS**: one computer in local side; two computers in remote side.
3. **SDB**: we use XML documentation as the data format and the exchange structure in this example.
4. **MI**: a human operate a pick action on the touchable monitor in local side; the pick action is transmitted to the remote side and change the state of electric appliances that be simulated as a mouse click.
5. **UO**: one display and one set of horn in local side; one transform card that uses to control electric appliances and one set of horn in remote side.
6. **SS**: we use a web camera to capture the image of spatial environment and use a microphone to collect the environmental sound in both local and remote sides.
7. **DS**: a real-time image captured by one web camera in remote physical space is shown on touchable monitor in local side; the monitor is shown the image captured by web camera and a control window of electric appliances in remote side.

4.3 Implementation

After setting the entire system, we process an interactive event to demonstrate as a testing task. In locally physical space, we connect to the iM in the remote side and get the spatial image captured by the web camera and show it on our DS through interactive software. We add a layer as a filter on the spatial image; use a human finger as a mouse cursor to touch the monitor.

Figure 5 A user in local side of physical space interacts with remote side through touching a object on screen, from left to right are: (a) the user selects the desk light in local side, the light is immediately turned on, and replies a massage of interactive action from the remote side; (b) when the user turn off the desk light, it also replies a message; (c) the user also points to an electric fan on the screen, it also immediately turned on, and replies a massage.

When finger pass by on one electric appliance in spatial image, the iM in remotely side sends a signal to the SDB through XML socket, passively control the state of selected electric appliance, and play a music that set up to mapping this select action. Then read the XML data which is restored in SDB of the remote side and show the read result of interactive record as a text string near the select electric appliance in the local side.

5. DISCUSSION

We have implemented a kind of P2P way of digital interaction by using remote control techniques through the internet connection. The implementation has implied, on the hypothesis of no obstacles in inputs and outputs, that every single object in a physical space has opportunities to become a medium for connecting or communicating with another physical space.

Through the Internet connection, instead of interacting within websites or web services, we could interact not only with human beings, but also physical environments, artifacts, furniture, or machines. We have tried the first step to find out how can different physical spaces interact.

However, we think that merely visual and acoustic experience is not enough for conveying space perception, and, referring to what can one control during interaction, it still has many technical problems to be overcome in order to reach the goal of “ubiquitous interaction”. So, a more intuitive, immersive, and multi-modal way of interacting with physical spaces should be explored further.

When virtual space begins to reflect the real space, the virtual space is no longer that virtual one. In this implementation, we use web cameras to capture real-time image of a space and present it in digital form with added information overlaid the image to help the physical spatial communication. This has shown the combination of physical and digital way of conveying spatial information. Spatial information is stored into XML form for computer to access to know

when to update added information or to assist the task of interaction in physical spaces. This could be much useful to help to customize or personalize the way of spatial interaction.

6. CONCLUSION

This paper has presented a framework of real-time interaction of different physical spaces through a digital space interface with P2P environment. By the usage of digital tools, we could change a space into a communicative space, or create a new way of communication in physical space. In this view, spaces are no longer closed, for people could extend physical space virtually to interact with real things. The boundaries among spaces have begun to merge.

This conclusion has also implied that modern development of websites or web services on the Internet could go for more real-time and spatial interaction with clients, other than just offering interactivity within cyberspace, to offer more sense of reality.

We are just in the early stage of exploring the physical space to physical space interaction and preliminarily concluded a P2P model. Our future works will be of three directions:

1. **A more deep and multiple ways of spatial interaction**: According to the discussion, physical space interaction should be more intuitive, multi-modal, and immersive. This is also one of the goals of human-computer interaction, and we would like to study what interaction modes are proper for space interaction.

2. **Establish a spatial interaction model**: The framework proposed in this paper is a peer-to-peer physical space interaction model. However, our living world is constituted by many spaces and places; as a result, peer-to-peer is not the only way for space interaction.

3. **Applications of the P2P model**: We hope that we could apply this P2P model in common life to help to improve the quality of interaction/communication between people in different spaces. For example, patient care, aged people care, long-distant museum, or long-distant learning.

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