IP^{++}: GCOMPUTER-AUGMENTED INFORMATION PORTAL IN PLACE

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Abstract. In this paper, we introduce the concept of *information portal (IP)* that is a smart environment composed of a variety of computer-augmented architectural components. The objective of information portal is to augment information capabilities to places and support interactive media linked to location. A research prototype of information portal called *IP*$^{++}$ is developed. Interactive experiences of *IP*$^{++}$ that take place in a variety of outdoor and indoor settings are demonstrated.

1. Motivation

Using the notion of ubiquitous computing, research efforts in human-computer interaction are quickly moving to integrate the computation world with the physical world. When computers vanish into the background, many kinds of chips and sensors are embedded in everyday things for daily use. Those chips and sensors can save, receive and transport information, and most likely change the way of communication and social interaction in our everyday practices.

To bring ubiquitous computing into our everyday life, we must address several challenges. The major challenge that we confront with the revolution of human-computer interaction is to create natural interfaces integrated with mixed physical-digital reality, to develop a smart environment with sensor networks, and to add information and communication capabilities to physical places.

Some basic questions that quickly arise include: (i) How can the environment sense human activities and respond to human needs? (ii) How can we control the digital world with human activities in the physical world? (iii) How can we link information to location? (iv) How can we increase the communication and information capabilities in urban places? In order to answer these questions, we need to develop a new interactive spatial system that allows users to interact and explore information in both indoor and outdoor settings.

In this paper, we introduce the concept of *information portal* that links interactive media in places. Information portal is a smart environment composed of a variety of computer-augmented architectural components. *Information portal* (IP) is considered as an information entry space in physical world, which is analogous to

Internet Protocol (IP address) in digital world. The objective of *information portal* is to augment information capabilities to places and support interactive media linked to location.

Our work falls into four phases. First, we choose a public spatial corner to install information portal and perform a user experience study by observing user's activities in the location. Secondly, we investigate the sensor technologies and develop varied interaction models. We decompose the designated architectural space into different physical elements, such as floor, ceiling, walls, openings, and furniture. Thirdly, we investigate the design principles of information portal, the outdoor control requirements, and sensor-based interactive behaviour. We analyze adaptability, extensibility and connectivity of the modular components with sensor networks. Finally, we make a practical construction of the designated information portal space by augmenting and composing these components together. We combine the computer-augmented architectural components, and evaluate the usability, and apply the network of information portals in urban scale.

2. Observations

In order to study the functional requirements of information portal, we started a user experience study by observing the user's activities in public places. We chose a corner space next to the entrance of our architectural department building. We put a set of wood cubes at the corner, which can be re-configured to become chairs or tables by users themselves. Users can adjust the layout of the cubes for supporting their activities such as discussion, group meetings, or rest. The user activities at the corner are as shown in Figure 1.

Figure 1. The user activities in the designated information portal space.

The designated information portal space was observed by the following questions: (i) How many people are there in this space? (ii) Where are they? (iii) Are they arbitrarily walking or just standing together? (iv) Where are they moving? We also observe how users participate in shaping the place and what facilities can be added to support it.

We are concerned with the practical experiment about the use of public places for participation. The "participation" means any process by which the users of an environment help to shape it. And we try to find the requirement of activities from the observation of space experiment that is the process when users adjust the cubes for their needs.

By collecting the data, two findings are reported from the above observations:

1. The place provides the environmental context for sharing information and memories. Some information lost meaning when removed from the place.
2. People talked about some valuable information hidden in public places. Information about the environmental ecology, building history, and underground piping flows are common topics to be discussed, yet they are invisible to users.
3. The public corner provides a physical "platform" for social interaction. People sometimes use display equipments to share and exchange information.

The implication of these findings is the need for developing an information portal space that can link media to location, view invisible information from surroundings with sensor technologies, and reshape the environment context in place by using interactive media.

3. Experimental Studies

3.1. INTERACTION WITH SENSOR TECHNOLOGIES

Sensor technology can roughly be divided into three categories: (i) interaction with the environment (ii) implicit interaction with humans (iii) explicit interaction with users (Rogers & Muller, 2003). These three categories are divided by varied interaction modes. By bringing sensor technologies to physical locations, we can classify sensors by sensing criteria, operational requirements, and input–output signal processing. Different kinds of sensors will be embedded in the components in support of varied interaction activities.

3.2. COMPUTER-AUGMENTED ARCHITECTURE COMPONENTS

Traditionally, a building is composed of various architectural elements, such as floor, ceiling, wall, opening (doors and windows), and furniture. We transform

these components into digital chairs, smart floor, information canvas and translucent screen/wall by embedding interactive computers and sensors.

Digital chairs/tables can sense user's position and augmenting user's personal device. A digital chair can sense user's ID if user has ID tag that can be read and user can inquire privacy data. A digital table provides a personal device augmenting platform for large display and can share information with other people.

Smart floor can sense users' accurate position, route and numbers. These data can be used for interaction in context. Information canvas and translucent screen/wall provide large displays for shared information displays and can connect with the smart floor for changing display size or position. Interactive walls embedded sensors inside can sense user's action and respond to it. We built the experimental computer-augmented architecture components as shown in Figure 2.

Figure 2. The experimental computer-augmented architecture components include digital chairs, smart floor and interactive walls.

We follow the above experiments by developing technologies that embed computer chips and sensors in the components. Users can plug a tablet computer into the table set to explore surrounding environment visualizing 3D augmented-reality images demonstrating the underlying function of the ecological garden (Kuo et. al., 2004). The activities of the corner and the technology equipments are embedded in the prototype of information portal, as shown in Figure 3.

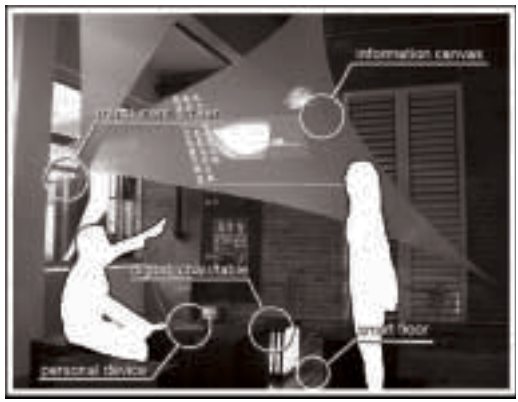

Figure 3. The prototype of Information Portal.

With the IP++ project developed in a digital-physical mixed-reality environment, we can dynamically configure the modular components for various interactive spaces in different scales. We refer to them as Small, Medium, Large, and X-Large IP++ systems:

1. In a Small IP++ system, the single component (a chair or a floor panel) can sense users' activity, so that we can explore and leave information in places with a digital chair or smart floor.

2. In a Medium IP++ system, more components (floors, chairs, and tables) can augment users' personal devices with desktop display on a digital table. We can not only explore information, but also link personal devices to media in places.

3. In a Large IP++ system, we have information canvas and translucent screens/ walls projecting shared information for a group of people. The canvas and other components can be physically integrated into its surrounding landscape in support of the context of sustainable environments. We can explore the feasibility of mixed-reality landscape that will enrich the city space for exploration.

4. In an X-Large IP++ system, we can set up entire IP++ facilities in various corners of city space. The inter-connection of the IP++ systems will link different city spaces to each other, and achieve the integration of digital and physical worlds toward smart networked cities.

4. Applications of The IP++ Project

4.1. INDOOR APPLICATIONS: INTERACTIVE MEDIA EXHIBITION

We implement the computer-augmented architecture components in an interactive media exhibition, as shown in Figure 4. The visitor can get information about the design competition from the computer-augmented components, such as digital chairs, smart floor and interactive wall.

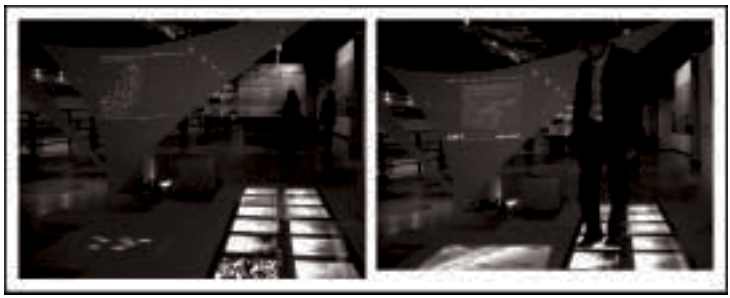

Figure 4. Smart floors and information canvas sense the user's position and provide large displays for sharing information.

We set up a prototype of smart floor and information canvas, the floor sensing

users' position and canvas providing correspond information in large displays. The digital chairs and table can provide the visitor a resting place, and display information on the table when visitors sit down. The system can change the content of the display when visitors sit in different chairs. The visitors can control the virtual model rotate, zoom in, and zoom out displaying on the wall with their gesture. The interaction of the components is shown in Figure 5. The visitors can create situated digital interaction experience in exhibit spaces with these computer-augmented components.

Figure 5. The snapshots of the interactions with the computer-augmented components.

4.1. OUTDOOR APPLICATIONS: GARDEN/BUILDING ENTRANCE

We implement a prototype of the *IP*$^{++}$ project located at the ecological garden in our campus. There is some invisible information under the ecological garden, such as the recycling of water. Information portal provides visualization aid to students learning outdoors for the mechanism of sustainable campus. And it locates the position where is the entrance of department of architecture building, between the ecological garden and the building, providing students and teachers a space for discussion and socialising.

Now we are undertaking a practical construction of the information portal space by augmenting and composing components together, as shown in Figure 6. The components include smart floor, digital chairs/tables, information canvas and translucent screen. The objective is to build a sensor-based physical environment that is able to provide services and can be a social platform and a rest place for supporting outdoor learning.

We put the information portal into the entrance corner, become a interface between indoor and outdoor space, ecological environment and artificial building, and the construction is being undertaken.

Figure 6. The construction of an information portal is being undertaken.

5. Discussions

The *IP*++ project is concerned with the emerging complicated environment context with mixed physical-digital reality. Based on our experience, we suggest a set of design principles of constructing an information portal: (i) technological requirements (ii) functional requirements (iii) cognitive requirements (iv) social requirements (v) experience design, and we now outline these principles.

The technological requirements include the triggering of sensors and the display of information. We study the relation between the operations of sensors and the interaction of users. And we study the different display equipments for viewing information when users are in different situations.

The functional requirements are concerned with the communication between users and interactive systems. What facilities will be used to control the system? The touch screen, keyboard or gesture, voice. Does user need to take special device to interact?

The cognitive requirements are concerned with users' reflection. The user reflects what sensors actuate. The user becomes aware of the connection between actions and perceptions.

The social requirements should consider an information portal as a social platform that provides people information exchange. The information exchange could be synchronous or asynchronous, and may be at the same place or at different locations. People can leave their message in the information portal, and send the message to another information portal. This kind of behaviour turns out to be a complicated information space network.

The experience design has to do with all above requirements through the design of embodied interaction, the display of mixed reality, and the reflection of interactive systems. Users may obtain a new user experience for services of information portal in smart networked city of the future.

These principles were considered before and after we started planning the *IP*++ project. We have attempted to use all these requirements from the observation of spatial experiments and the foregoing principles to undertake the practical construction of an information portal.

6. Conclusion and Future Work

The *IP*$^{++}$ project attempts to provide a network of region-level public information exchange platform that can be applied to any outdoor space such as campus, parks, and cities. People can explore and leave information in places with computer-augmented components in information portals. The development of computer-augmented information portals supports uniqueness, extensibility, and substitutability for various environmental contexts.

In the digital age, distance isn't the key point of obtaining information. Only the person approaching the information portal can engage in the urban activities effectively. The development of information portal has the potential to transform the network of urban environments by adding urban places information and communication capabilities. An information portal that transports and spreads information across the boundaries of the urban places would become a node of networked cities, and be recognized as an inherent feature of smart environments.

Our future work will focus on the practices of everyday life in an information portal, connectivity of information portals in different places, and framing a mixed-reality network toward smart cities.

References

Kuo, G., Hsuancheng. L., Yangting. S., & Taysheng J. 2004, ''Mobile Augmented Reality for Spatial Information Exploration'', *Proceedings of International Conference of the Association for Computer Aided Architectural Design Research In Asia*.

Mitchell, W. 2003, *Me*$^{++}$ *: The Cyborg Self and the Networked City*, MIT Press.

Moran, T. 2002, ''Everyday Adaptive Design''. in *Proceedings of Designing Interactive Systems 2002*, London.

Rogers, Y. & Muller, H. 2003, ''Stop Making Sense: Designing Sensor-Based Interaction to Facilitate Exploration and Reflection'', *Transactions of Computer-Human Interaction*, October 16.