Personal Companion:
Personalized User Interface for U-Service Discovery, Selection and Interaction[*]

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Abstract. In this paper, we propose a mobile user interface named personal companion which enables selection and interaction of u-services based on context of user. Personal companion selects u-services from a list of discovered services, supports camera-based selection with embedded marker and personalizes UI of the selected service in ubiquitous computing environment. In order to verify its usefulness, we implemented personal companion on PDA and UMPC platform and deployed into smart home testbed for selecting and interacting with u-services. The proposed personal companion is expected to play a vital role in ubiquitous computing environment by bridging users and u-services.

Keywords: mobile user interface, camera-based interaction, personalization, embedded marker.

1 Introduction

Recent interest and increased awareness for future computing paradigms such as ubiquitous computing and context-aware computing are getting more attention from both researchers and end-users alike. In these future computing environments, users are served by pervasive and ubiquitous intelligent services for highly personalized and easy-to-use services. Ultimately, the goal is to realize the vision of Mark Wesier who envisioned technologies which disappear into everyday life of users [1].

However, the traditional desktop-based interface and interaction methods have limitations in getting and using the services in the ubiquitous computing environment (u-service, hereafter). This limitation arises, because u-service is characterized by properties such as *ubiquity* and *context-awareness*. Especially *ubiquity* of u-service builds upon the assumption of *mobility* of users, and *context-awareness* requires acquiring and analyzing information of users and the environment. Moreover, all these functionality should be available anywhere and anytime in a form of compact-sized computing resource. A viable approach is introduced with recent advancement

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in mobile device such as PDA, cell-phone and hand-held PC, and many researchers are pursuing to include both intelligence and functionalities into the mobile device [2][3]. Moreover, a mobile user interface plays an important role of a bridge and a *transitional interface* [4] to support different interactive spaces for users in ubiquitous computing environment. To realize this, we need fundamental technologies such as service discovery for getting available service list and functions, selection method for effectively selecting relevant items among a myriad of services, and interaction methods for user and service interaction.

In this paper, we propose a user interface for ubiquitous computing environment named *personal companion* based on the three aforementioned fundamental technologies. The proposed interface enables interaction with u-service by supporting service discovery and filtering, camera-based interaction method, and personalization of user interface. The remainder of the paper is structured as follows. Related works on mobile device as an interface are described in section 2. The design considerations for personal companion are explained in section 3. In section 4, we describe features of personal companion in detail. Prototype implementations are discussed in section 5, and we conclude with a remark for future work in section 6.

2   Related Work

Currently, several projects use mobile device as an intermediary for user and environment. In this section, we review on-going or recent related works in aspect of service discovery, service selection and interaction.

In TRON project [5], they developed Ubiquitous Communicator (UC) for recognizing and acquiring detailed information on RFID-tagged objects. For sensing purpose, small-sized RFID (Radio Frequency IDentification) and barcode are attached to everyday objects and digitized information is embedded. When RFID reader in UC reads digitized information, it is decoded into URL where detailed information can be retrieved. They have developed this idea into applications such as food traceability system and drug traceability system to identify product and trace back product information, i.e., where it is produced and who produced it. ubiController [6] is a mobile user interface for ubiquitous computing implemented on PDA platform. It provides controllability to users for discovering services and controlling it universally. Here middlewares such as UPnP[1] and ubi-UCAM [7] are utilized to detect changes in services and environment. Context of user such as current location, orientation and speed are used to provide situation-awareness in GUI. Moreover, multi-user is supported through mediation in conflict situations by recommendation and sharing personal media contents with other users. In an effort to interact with distributed services in the environment, Voyager framework [8] which is developed as a part of 2Wear project[2], proposed a dynamically distributed interface, *ambient dialogue* to realize disappearing computing and to maximize mobility of users.

There are other recent works using a mobile device with camera and tags such as a camera-based framework [9], EMI[2]lets [10], u-Photo [11] and Vidgets [12]. In the

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camera-based framework, visual codes are used for interaction where a relative distance and angle between camera and visual tags are used for generating input commands like direction, i.e., up, down, right, left and rotation. In EMI^{2}lets framework, a mobile device is used as a universal remote controller for controlling smart objects. The framework includes EMI^{2}Proxy which is a representtative agent for a user, EMI^{2}Object which stands for smart object agent and EMI^{2}BehaviourRepository to support logical operation. For service and smart object discovery, a Jini-like service discovery method[3] which uses Bluetooth and TRIP tag is used. In u-Photo project, they have created a metadata structure for including appliance control and sensor information into digital still image. Through this metadata structure called u-Photo, user can interact using a metaphor of *"take a picture of service/device and control"* to connect physical, virtual and networked devices. Also in Vidgets, camera on mobile device is used to recognize visual markers and to control multiple services universally. Table 1 shows a summary of related work considering service discovery, selection and interaction.

Table 1. Summary of related work

Project	Service Discovery	Service Selection	Service Interaction
UC	RFID/Barcode	RFID Reader	Product traceability
ubiController	UPnP	Image-based	Control and contents sharing
Voyager	Bluetooth	Proximity-based	Interface composition
CamPhoneFrame	Visual Code	Camera-based	Direction and rotation input
EMI^{2}lets	Jini-like	Proximity/Camera	Service control
u-Photo	LED/Eyemark	Camera-based	Service control
Vidgets	Visual Marker	Camera-based	Service control

   As we can observe from Table 1, many researchers are using visual tags or markers with built-in camera. This follows recent trend in market, since most cellular phones sold now have built-in camera. However, distinguishable markers and tags do not assimilate well into the environment, which result in visually awkward and divided attention for user to notice two separate things, an object and a marker. Also in projects where Bluetooth is used suffered from low network performance and limited by ranges. Therefore we avoid using Bluetooth method alone for service discovery. Most researches covered service control and some form of information augmentation. A few works used mobile device as an input device which displayed possibilities of a versatile user interface as performance of mobile device advances. This also opens a door for new interaction methods and extended application areas.

3   Design of Personal Companion

Personal companion focuses on mobility and support for ubiquitous computing environment. Therefore we defined and followed a set of guidelines for personal companion. Moreover, we also introduce a novel *embedded marker* to reduce visual interference of markers in camera-based interaction.

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[3] JINI, http://www.jini.org

3.1   Design Guidelines for User Interface

In order to provide users with more effective user-centered mobile UI, we have considered user's efficiency in performing tasks and flexibility of meeting user's various demands. For an increased efficiency, functions and contents that a user prefers are provided at initial stage. Additional functions and contents are accessible through short cut menus. Moreover, to provide a consistent UI for users, frequently used function keys such as back and exit are placed in the static area of mobile user interface, so no matter what menu page user is on, the static area is associated with consistent functions. Default menu interface is based on icons and we give it a textual description as well to reduce misunderstanding. In case of flexibility in mobile user interface, we allow users to configure own interface by choosing preferred fonts, colors and menu styles.

3.2   Embedded Marker

Personal companion supports interaction with services through camera and embedded marker. Figure 1 shows the concept of embedded marker where an embedded marker is created using an object as a part of a marker or making a marker out of a part of an object.
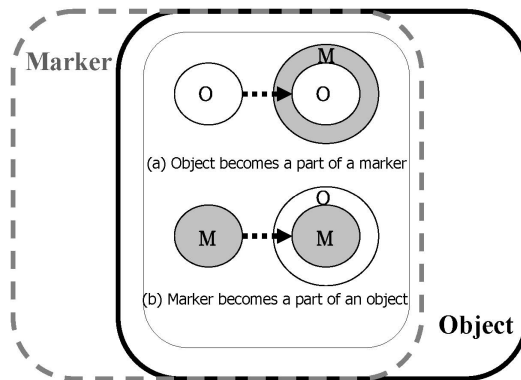

Fig. 1. Concept diagram of embedded marker

We refrain from using the conventional visual markers, because it is visually awkward to eyes of users. Especially, the marker stands out when used in colorful background, grabs attention of users in multiple marker cases, separates user's attention to an actual object and a marker, and does not give semantics in arbitrarily shaped patterns. In our approach, the embedded marker can bring a user's attention into a focused match and does not need to make an arbitrary pattern. Therefore users can get a hint for what information will be delivered from the actual object and marker. Such idea is realized in prototypes in screen saver like marker, a marker based on physical features of an object, and a marker embedded in contents.

4   Functions of Personal Companion

Personal companion is consisted of logical modules for service discovery, service selection and service interaction. For service discovery, UPnP-based method is used. In service selection, there are camera-based selection module (which is comprised of image acquisition and pattern matching module) and direct list-based selection module. For service interaction modules, user interface personalization, reconfiguration and camera-based interaction are included. Figure 2 shows the overall architecture of personal companion.
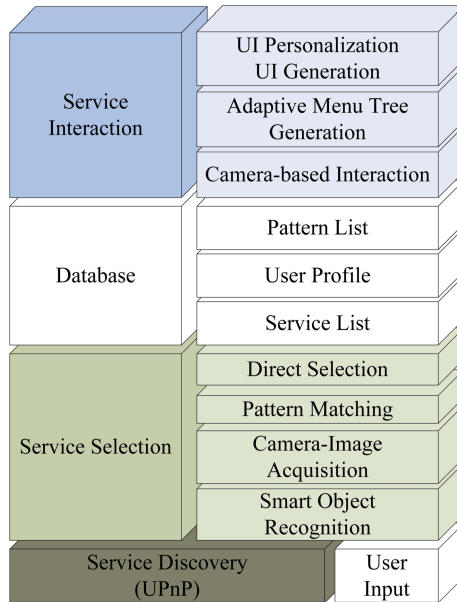

Fig. 2. Overall architecture of personal companion

Table 2. Roles of individual components

Module	Roles
Service Discovery	Discover services in the environment
Smart Object Recognition	Recognize smart objects
Camera-image Acquisition	Acquire image through camera input
Pattern Matching	Compare acquired image with patterns
Direct Selection	Select a service from service list
Service List	A database to save service list
User Profile	A database for user profile
Pattern List	A database for patterns
Camera-based Interaction	Input mode for navigation
Adaptive Menu Tree Generation	Generate personalized menu tree
UI Generation	Generate personalized UI
UI Personalization	Personalize control menu

Table 2 shows a brief summary of each component's roles in personal companion architecture.

4.1 Service Discovery

A distinguished characteristic of ubiquitous computing environment is ubiquity of services. Since users are able to move in and out of environments, there is a need for certain mechanism to tell users what kind of services are available and what can they do with it. In ubiquitous computing environment, service discovery is a process of making ubiquitous and invisible services into visible and personal services. There are several service discovery protocols available [13].   For personal companion, we utilize service discovery protocol known as UPnP where user's mobile device acts as an UPnP control point and services in the environment are implemented as UPnP services. However, UPnP itself does not support use of context; therefore we concurrently used it with our context-aware application framework, ubi-UCAM [7] to utilize context information in both UPnP service and UPnP control point. Once personal companion is run, it searches for new devices and services in the environment. When a new device or service is discovered, its information is saved onto the service database which is accessed for service control.

4.2 Service Selection

There are two possible selection methods, list-based and camera-based. In list-based selection method, service information stored in service database is provided to the user in a list. In this step, icons or tab controls of menu which visually symbolize each service are used as shown in figure 3. Through this association, users can easily select services and intuitively know physical devices, multiple devices as well as logical but invisible services.

Fig. 3. Visualization of services as tab menu in UMPC and PDA

Second method is camera-based selection method. Due to inefficiency of the first method in a scenario with a large number of services, we provide alternative selection method. It is inefficient and difficult to list several items in one screen, therefore we introduce camera-based method which uses user's explicit command or aid. Typically, taking a picture with a camera reflects a user's direct intention of owning and keeping particular moment or information. We extend this notion further to include service

control as well. A similar concept is popularized and used in many other works [9][10][11][12][14]. When the user takes a picture with personal companion, acquired image is compared with patterns in pattern database to identify the object in the picture.

4.3   Service Personalization

After a service is selected through discovery and selection steps, a user interface to control and access functions and contents of the service is generated. Here, *personalization* takes place as a filtering mechanism to tailor services to users. We do not provide all functions and contents to user at one moment, since the screen size of a mobile device is limited. Therefore we utilize preference of users to assign preferred contents and functions higher priority values. As a result, most preferred items are listed first and placed in top menu for easy accessibility. This way, personal companion recommends and guides user's next action. Personalization is classified into two categories. First category is personalization in functions and contents of a service, so different users have different levels of control and access. Second category is personalization in appearance of user interface. In this category, user's preference is used to construct appearance of user interface. Personal companion supports both categories of personalization. For personalizing functions and contents, it filters based on media service genres and for appearance personalization, it customizes colors, fonts, and menu styles according to user's profile [15].

4.4   Service Interaction

When a personalized user interface is generated, the user can interact with services through camera-based interaction. Personal companion provides various interaction possibilities using a camera on the mobile device. First example is controlling smart object after recognition, so it acts as a universal remote controller to discover multiple services and control them. Another example includes an interaction with marker-embedded contents where a user can navigate through virtual reality by tracking relative distance and position between marker and camera. Here, mobile device can be used as an input device for giving directions. Figure 4 shows controlling a light service and navigation in virtual reality world.

Fig. 4. Interaction with services, controlling a light service and VR navigation

5   Implementation and Experiment

The proposed user interface is implemented on PDA and UMPC platform and tested in ubiHome [16] smart home testbed as shown in figure 5.
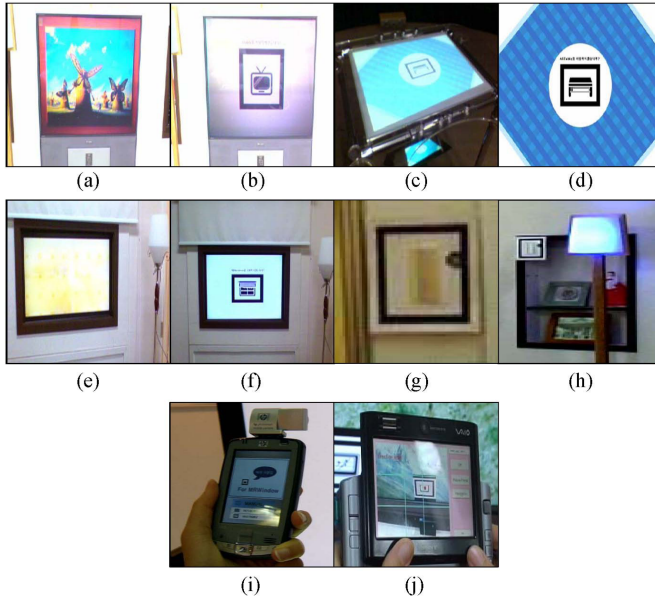

| (a) | (b) | (c) | (d) |

| (e) | (f) | (g) | (h) |

| (i) | (j) |

Fig. 5. Smart Objects and embedded marker prototypes, (a)(b) ubiTV embedded marker, (c)(d) ARTable embedded marker, (e)(f) MRWindow embedded marker, (g)(h) ubiLight switch embedded marker and ubiLight, (i)(j) PDA and UMPC version of personal companion

Earlier prototype is developed for PDA using Pocket PC 2003, and then it is also tested on PDA running Windows Mobile 5.0. In UMPC platform running Windows XP operating system, it was easier to develop applications and performance was much better than PDA platform. Figure 5 (i) and (j) shows the implemented PDA and UMPC version of personal companions. By using these two mobile platforms, we discovered, selected and interacted with u-services. Also prototypes of embedded markers are designed as shown in Figure 5 (a) to (h). Figure 5 (a) to (f) shows each smart object and corresponding embedded marker prototype, in a form of screen saver which turned into a marker when a user comes into the effective service area. Figure 5 (g) and (h) show an embedded marker using physical feature of a light switch.

6   Conclusion

In this paper, we introduced personal companion for discovering, selecting, and interacting with u-services. Personal companion comes with service discovery capability so it can discover u-services and visualize it for easier selection. For

selection methods, we introduced a list-based selection method which is useful for a smaller set of services while camera-based selection method is presented for a larger number of services. When a u-service is selected, the preference of the user is reflected to personalize the interface and its functions. For service interaction, personal companion is used as a universal remote controller and as a directional input device for the VR navigation system. In future work, we will extend the interaction scope to support augmented reality services and support learning in usage of mobile UI to better personalize it. Furthermore, we will conduct usability tests on mobile UI designs and implemented prototypes to update personal companion with the feedback.

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