Physical Browsing Research

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ABSTRACT

Physical browsing is a mobile-device-based interaction method for pervasive computing. In this paper, we describe our research interests and experiences of physical browsing: the user interaction paradigm, scenarios using physical selection and a demonstration application. We also describe a number of research challenges within the field.

Categories and Subject Descriptors

H5.2. [Information Systems]: User Interfaces – Interaction styles.

General Terms

Design, Human Factors.

Keywords

Physical browsing, physical selection, ubiquitous computing, user interface.

1. INTRODUCTION

The prevalent visions of ambient intelligence emphasise a natural interaction between the user and the functions and services embedded in the environment or available through mobile devices. In these scenarios, physical and virtual worlds interlace seamlessly, and crossing the border between the worlds appears natural or even invisible to the user. However, a bottleneck to reaching these scenarios can be found in the natural mapping between physical objects and their virtual counterparts. Physical browsing is a means for mapping digital information and physical objects. If physical objects have tags - small and cheap identifiers - attached to them, information in the tags can be read with a suitably equipped mobile phone or PDA, and the functions provided by the objects can be accessed easily and intuitively. This way the physical environment acts as a 'home page' for the services and information provided by the environment and its objects, and the user can access this

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information by selecting with a mobile device the objects for interaction. Physical browsing is analogous to the World Wide Web: the user can physically select, or "click", links in the nearby environment.

Physical browsing can be divided into steps. First, the user applies *physical selection* for picking the link in the environment with the mobile terminal. The terminal reads the tag and some *action* is launched in the mobile terminal (see Figure 1).



Figure 1. The user selects a link in a movie poster by pointing to it. The mobile terminal reads the tag and the web page of the movie is opened.

Passive RFID tags are a promising and emerging technology for implementing physical selection. These tags are very cheap and get all the power they need from the reader device, which means that it is economically and practically feasible to use them for practically any object we want to access with a mobile terminal. Until recently, the reading range for passive tags has been short. Currently several-meters-range passive tags are being developed concurrently with readers small enough to fit into a mobile phone. Another new technology that is needed for physical selection is interfacing tags with sensors to detect pointing. Ways to integrate optical sensors with passive RFID tags are being researched. The momentum for physical browsing comes from two directions: 1) a need for more intuitive and natural user interaction for mobile applications and 2) the emergence of new technologies - passive sensor-equipped RFID tags and ubiquitous mobile terminals for reading them.

2. RELATED WORK

Want et al. carried out important work regarding the association of physical objects with virtual ones [10]. They built prototypes, some of which were implemented with RFID tags that are read by an RFID reader connected to a PC. Generally their selection method was touching, that is, reading from a short range.

Kindberg et al. built Cooltown [3], an infrastructure over standard WWW technologies, and used it to augment environments like a museum, a shop and conference rooms. They employed short-range RFID tags and infra red communications.

CyberCode by Rekimoto and Ayatsuka [4] is an example of using visual tags. In addition to illustrating the CyberCode as a tagging technology, they described several additional uses for their tags, for example, determining the position and orientation of an object in a 3D space. Additional related work includes GesturePen, a pointing device by Swindells et al. [6], WebStickers by Holmquist, Redström and Ljungstrand [1] and a combination of Bluetooth and passive RFID tags by Siegemund and Flörkemeier [5].

Compared to earlier work, our emphasis in physical browsing is in 1) using passive long-range RFID tags and 2) combining the different selection methods and actions into one unified physical browsing user interface.

3. FROM THEORY TO PROTOTYPE

We have designed and defined user interaction methods for physical browsing and built a prototype that implements those methods. Additionally we have designed several ambient intelligence scenarios that exploit physical browsing as an interaction paradigm.

3.1 User Interaction

One step in physical browsing is *physical selection*, the method by which the user picks with the mobile terminal the tag that he wants the terminal to read – that is, chooses which physical object he wants to access.



Figure 2. The user scans the whole room and all the links are displayed in the GUI of her mobile terminal.

In A user interaction paradigm for physical browsing and nearobject control based on tags [9], we defined an information tag and the *PointMe*, *TouchMe* and *ScanMe* methods for selecting information tags by pointing, touching and scanning, respectively. Pointing (see Figure 1) means selecting an object from a distance, by pointing to it with the mobile device. In touching, a tag is selected by bringing the terminal very close to it. Scanning (Figure 2) means reading all the tags in the environment, a useful method if the user does not know where the tags are located or what services are available nearby. Our focus is in RFID tags, but the concepts can be implemented also with infra red and visual tags.

3.2 Scenarios and User Requirements

In a European-Union-funded integrated project MIMOSA¹, we designed several scenarios [2] for ambient intelligence to aid in the development of new sensor-equipped ultra-high frequency (UHF) tags and other MEMS components. These scenarios utilised physical selection as one of their basic user interaction patterns. The vision of MIMOSA is mobile-phone-centric ambient intelligence in which the user uses her personal mobile terminal to access applications and services in the environment. We designed scenarios for everyday applications and four specific application areas: sports, fitness, housing and health care.

3.3 Proof-of-Concept System

We built a proof-of-concept system for UHF RFID tags [7]. The system emulates the predicted sensor-equipped tags that can be read from a several meters' distance and it supports all three selection methods — pointing, touching and scanning. The behaviour of passive RFID tags is emulated with SoapBoxes [8], active wireless components with several built-in sensors. The mobile terminal in our system is an iPAQ PDA equipped with another SoapBox for communicating with the emulated RFID tags. The system was built to demonstrate the feasibility of physical browsing and to act as a tool for studying various usability issues of physical selection and physical browsing.



Figure 3. The components of the mobile terminal for physical browsing. The box on the right is the central SoapBox acting as the tag reader. In the battery case in the middle there is a laser pointer.

Pointing is implemented by using the light sensors of the remote SoapBoxes and beaming them with either infra red or laser light.

¹ www.mimosa-fp6.com

Touching is recognised by proximity sensors. Scanning reads all tags in the vicinity, regardless of whether they are pointed to or whether the reader is near the tags.

To implement pointing with real passive RFID tags they would have to have sensors to detect the pointing beam. This kind of tags – or more specifically a sensor interface for passive UHF RFID tags – is being developed in the MIMOSA project. Since sensor-equipped passive tags are not available yet, we built our emulator to study interaction with them. Even if the emulator system uses SoapBoxes instead of real RFID tags, the user experience is the same as with real tags.



Figure 4. Physical browsing prototype being used for browsing a poster.

We have used posters as demonstration applications (see Figure 4) with several actions embedded into the poster's tags. This specific poster is a conference poster that describes physical browsing traditionally with text and figures. We added four physical hyperlinks into the poster. One of them is a WWW link that contains a URL pointing to our physical browsing WWW pages where the user can get more information. The second link contains a URL that points to an introductory video clip about the topic. Selecting the link opens the video clip in the media player of the iPAQ. The third link is an email address and selecting it opens the email application with the author's address and a predetermined subject already filled in. The fourth link adds a calendar entry for our physical browsing seminar into the iPAQ's calendar application, using a vCard file.

The resources that the tags point to are easily configured so that other applications for different environments can be quickly built. For example, we could build a similar movie poster that contains links to the movie's home page, ticket reservation service (instead of email), a trailer and a calendar reminder for the premiere.

4. RESEARCH CHALLENGES

Physical browsing presents many research challenges, ranging from the user interaction in physical selection to visualising the links in the physical environment. Our main point of view is on the user interaction, but several interesting questions can be raised from other viewpoints. The contents of the tags have great impact on how and where they can be interpreted. For example, if the tag contains only an ID number, it has to be resolved somewhere into a form that the mobile terminal can use, for example, a URL. If, on the other hand, the tag content is usable "as is", using the tag requires only local connectivity unless it contains a link to the outside world. Optimally, standardisation will provide at least some solutions to these infrastructure questions. The content of the tag also affects the way in which the tag can be displayed in the user's terminal, which directly influences the user experience of physical browsing.

Other important issues that will have impact on the design of physical browsing systems and infrastructures are privacy and security, which will affect the acceptability of applications utilising tags and physical browsing. We will study privacy and ethical issues of physical browsing during our evaluations of MIMOSA scenarios and demonstrations.

In the following subsections we take a closer look at two research challenges we are currently studying.

4.1 User Interface

We are currently continuing work on the user interface for physical browsing. We are evaluating our prototype by conducting user experiments. Some research questions we will look at are the physical properties of pointing and touching (for example, optimal ranges and pointing beam width). Another group of questions is how physical selection should be launched from the mobile terminal. An example of this is whether bringing the mobile terminal close to a tag should be enough for reading it, or should the user also press a button at the same time. Another example issue is the configuration for usable pointing, that is, should the beam be an invisible wide IR beam joined with a laser beam for aiming assistance, or only a narrow laser beam.

We are also studying higher-level user interface issues, such as how to present the results of physical selection to the user. For example, we will look into how results should be displayed if the selection returns zero, one or several read tags, and whether there are differences depending on the selection method and the action provided by the tag. A tag containing a URL could open the URL in the terminal's browser immediately when touched, but what if the user points at a tag and hits another nearby tag as well?

At a later phase we may experiment with different modalities. Speech input, gestures and movements with the terminal could be useful inputs and responses for interacting with the environment via a mobile terminal.

4.2 Visualisation of Physical Hyperlinks

One challenge in physical browsing and especially in the physical selection phase is the visualisation of hyperlinks in the physical environment. Some tagging systems are inherently visual; for example, barcodes and matrix codes must be visible for the reader device to be of any use, and their visual appearance and data content are inseparable. RFID tags, on the other hand, are not necessarily visible because they can even be inserted inside objects. This is sometimes an advantage as the tag will not interfere with the aesthetics of the object it

augments, but from the user's point of view it can present a problem.

The main challenges in visualising physical hyperlinks are:

- 1. How can a user know if there is a link in a physical object or in an environment?
- 2. How can a user know in what part of the object the link is if he or she knows of its existence?
- 3. How can a user know what action or functionality will follow from activating the link?
- 4. How can a user know how a link can be selected if the link does not support all selection methods?

5. PRELIMINARY CONCLUSIONS

In this article we have discussed the concept of physical browsing, a user interaction paradigm for associating physical objects and digital information related to them. As economic and practical tagging systems are emerging, and being integrated with ubiquitous mobile terminals – mobile phones and PDAs – it will be possible to create ambient intelligence settings in greater scale than ever before and truly connect the worlds that have so far been separate, the physical world of our everyday environment and the digital world of the World Wide Web and other information systems.

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