PHYSICAL BROWSING

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Abstract
Physical browsing is a user interaction paradigm for associating physical objects with digital information in an ambient intelligence setting. In this paper, I look at existing work in the area and review the research we have carried out at VTT Technical Research Centre of Finland. Our research evolves from designing ambient intelligence scenarios with physical browsing as one of the basic user interaction patterns. We have defined physical selection methods for pointing, touching and scanning and built a prototype system for studying the user interaction. Last I describe my approach to a further study of physical browsing.

1. Introduction

Physical browsing is a means of mapping digital information onto physical objects in our environment. In physical browsing, the user can access services or information about an object by physically selecting the object itself. The enabling technology for physical browsing are tags that contain information – for example, a web address – related to the object to which it is attached.

One step in physical browsing is *physical selection*, a method by which the user tells his mobile terminal which tag he wants the terminal to read – that is, which physical object he or she wants to access. Three physical selection methods, pointing, touching and scanning, have been defined [9].

After physical selection, some kind of *action* usually follows. Some examples of actions are:

- loading a WWW page related to the object (see
- *Figure* 1)
- making a phone call or composing an email message
- setting a mobile phone in a silent mode
- turning on the lights of the room
- reading a temperature sensor attached to the tag

The examples above only illustrate the numerous possibilities of interacting with tags via physical browsing.

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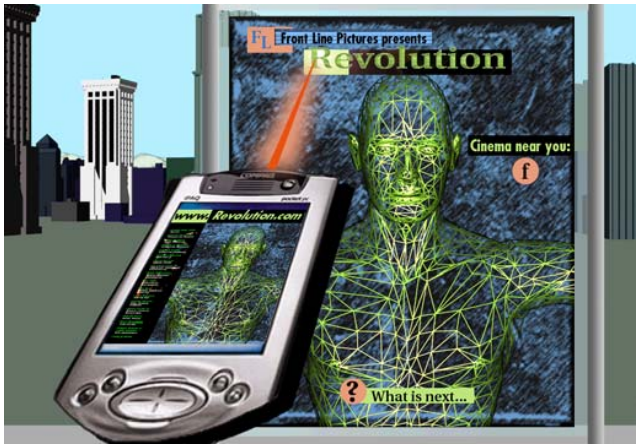

Figure 1. Physical browsing. The user points to a tag in a poster, and the mobile terminal loads a WWW page from the URL, which the tag provides.

2. Related Work

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

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

CyberCode by Rekimoto and Ayatsuka [4] is a good example on using visual tags. In addition to illustrating the CyberCode as a tagging technology, they describe several uses beyond simple identification of 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]

3. Research Carried Out

At VTT Technical Research Centre of Finland, we designed and defined user interaction methods for physical browsing and built a prototype that implements those methods. Additionally we designed several ambient intelligence scenarios that use physical browsing as an interaction paradigm.

3.1. User Interaction

We defined physical browsing and three physical selection methods in an earlier paper, *A user interaction paradigm for physical browsing and near-object control based on tags* [9]. In that paper, we defined an information tag and *PointMe*, *TouchMe* and *ScanMe* methods for selecting informa-

tion tags. We also discussed the concept of a universal remote control based on physical selection, and suggested some implementation options for information tags and how to select them with our physical selection methods. Our research focus is in RFID tags, but the concepts can also be implemented with infra red and visual tags.

3.2. Scenarios and User Requirements

In project MIMOSA, which is funded through the sixth EU framework programme, we designed several ambient intelligence scenarios [2] to aid the development of new sensor-equipped ultra-high frequency (UHF) tags and other components. These scenarios rely on physical selection as a basic user interaction pattern. MIMOSA envisages ambient intelligence as mobile phone centric: the user uses her personal mobile terminal to access applications and services in the environment.

By analysing the scenarios we gathered preliminary user requirements for physical browsing and hardware components, for example, minimum reading ranges for remotely readable tags and acceptable response times. The validity of these preliminary requirements will be evaluated in user interface evaluations (see subsection 4.1).

3.3. Proof-of-Concept System

We built a proof-of-concept system for UHF RFID tags [7]. The system emulates predicted sensor-equipped tags that can be read from several metres' distance and it supports all three selection methods – pointing, touching and scanning. The behaviour of passive RFID tags is emulated with SoapBoxes [8], which are active wireless components with several built-in sensors. The mobile terminal in our system is an iPAQ PDA equipped with another SoapBox to communicate 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 2. A physical browsing system. The iPAQ acts as a terminal device and the attached SoapBox module acts as a tag reader. The button on the SoapBox is used to trigger the pointing beam and the LED in front of the module sends an IR pulse to the remote tag. The battery case contains a laser pointer to aid in aiming.

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

We have used posters as demonstration applications for physical browsing. Several actions can be embedded into the posters using tags, for example, displaying a WWW page, filling in an email address, viewing a video and adding an entry to the calendar application of the iPAQ. The resources, which the tags point to, are easy to reconfigure, so applications for different environments can be built quickly.

4. Methodological Approach

In my subsequent research, I will concentrate on the user interface for physical browsing whereas most of the previous work has been application and infrastructure based. Some questions for my research are:

- What specific parameters define an optimal physical selection system, for example, how wide the pointing beam should be (with a wider beam it is easier to catch a tag but at the same time more probable to catch multiple tags if they are near each other)?
- In what kind of situations people use each selection method?
- How can the links (tags) be visualised to the users, both in the physical environment and in the mobile terminal?
- What are acceptable response times for physical browsing?

I will also attempt to define a framework that combines all the different selection methods, possible actions and various implementation technologies into one physical browsing paradigm. There are several other issues, for example, the contents of the tags, the infrastructure needed to support physical browsing, and privacy and security issues. While these topics are important and to some degree intertwined with user interface, user experience and usability, I will not concentrate on them in this work.

4.1. User Interface Evaluation and Development

My next work on the user interface will be conducting user experiments with the prototype we have built. The research questions of the first experiments are:

- What is the optimal width for the pointing beam?
- What configuration best suits pointing: 1) pointing with an invisible IR beam only, 2) pointing with a visible narrow laser beam or 3) pointing with an invisible IR beam assisted by a visible laser beam?
- What configuration best suits touching: 1) touching by bringing the mobile terminal close to the tag or 2) touching by pressing a button in addition to bringing the terminal close to the tag.

After these experiments I will continue with higher-level user interface issues:

- In which situations do users choose different physical selection methods?
- How should 0, 1 or several "hits" be displayed in the mobile terminal? Is there a difference depending on the selection method used?
- How should the tags be visualised in the mobile terminal?
- How long response times are acceptable for comfortable use?

My approach is quantitative for the first set of experiments and qualitative for the second set.

It would also be very interesting to 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

I will first analyse how hyperlinks are visualised in the current desktop World Wide Web. After that I will take a look at the visualisation used in some existing systems that can be seen as physical browsing. These systems do not support all the actions and selection methods of our physical browsing framework, but valuable information may be found in them if visualisation is documented in the research papers.

Based on these analyses I will study how to visually present the presence and function of a tag to the user, both in the physical environment and in the mobile terminal. In some cases the read links have to be displayed in the terminal before taking the action. For example, in the ScanMe selection method, multiple tags are typically read at a time and they have to be presented to the user in a meaningful way. I will run a small-scale user study on existing visual designs of tags and possibly on my own designs to gain further understanding on the topic.

5. Conclusion

I have described the concept of physical browsing, a tag-based user interaction paradigm for ambient intelligence environments. Physical selection is one phase in physical browsing and it covers the selection of a hyperlink in a physical environment. We have defined three methods for selecting a link: pointing, touching and scanning (PointMe, TouchMe and ScanMe, respectively) and built a proof-of-concept prototype that implements all three methods. In subsequent research I will use the prototype to study the user interaction in physical browsing. My second research theme will be visualising the hyperlinks in the physical environment.

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