Comparing Techniques for Mobile Interaction with Objects from the Real World

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ABSTRACT

Mobile interaction with objects from the real world is gaining in popularity and importance as different mobile technologies increasingly provide the basis for the extraction and usage of information from physical objects. So far, Physical Mobile Interaction is used in rather simple ways. This paper presents a comparison and evaluation of more complex and sophisticated techniques for Physical Mobile Interaction. The results indicate the importance of usability guidelines that pay attention to these new interaction techniques.

Keywords

Physical Mobile Interaction, visual marker recognition, Near Field Communication (NFC), Touching, Pointing, Direct Input

1. INTRODUCTION

Over the last few years, mobile phones, smart phones and PDAs have become a part of everyday life as most people rely on them for personal and mobile communication. So far, mobile interaction mostly takes places between users, mobile devices and the basic functionalities they provide (e.g. phone calls, text messages, organizer functionalities or browsing the internet).

With the establishment of mobile devices as ubiquitous and personal computing platforms, this basic interaction is extended to the interaction with physical objects from the real world. This development benefits from the dissemination of technologies for the augmentation of everyday things with additional information and the increasing technical capabilities of mobile devices – especially mobile phones – to capture, process and use this information. For example, people can use their mobile phones to take pictures of visual markers and have their codes recognized [1]. The usage of RFID [2] and NFC (Near Field Communication) [3] can reduce payment, identification or access control to simply swiping a mobile phone over a reader. Mobile interaction with places – using e.g. GPS or cell positioning– is the foundation of location based services or games, e.g. [4]. Other areas of application that could benefit from Physical Mobile Interaction – ubiquitous interaction with physical objects using mobile devices – are smart objects such as advertisement posters, vending machines, mobile services (see [5]) or information systems, e.g. in museums or at exhibitions.

Physical Mobile Interaction promises to make mobile interaction simpler and more intuitive. Instead of having to navigate nested menus and long lists of items, people can simply point at or touch the things they want to use. However, most existing applications for Physical Mobile Interaction make only little and simple use of different interaction techniques and the technologies behind them. Physical Mobile Interaction often only acts as the first step in the interaction with a web site or a service, as reading NFC-tags or recognizing visual markers only provide e.g. a URL that is opened in a mobile web browser. Further interaction is restricted to the interaction between users and mobile devices – which usually suffers from their small screens, keypads and joysticks.

In this context, the PERCI-project (PERvasive ServiCe Interaction, see [6]) – a collaboration between the University of Munich and NTT DoCoMo Euro-Labs that is funded by the latter - developed a framework, that takes advantage of more complex Physical Mobile Interaction techniques for the invocation of Semantic Web Services (see [5]). This paper presents the results of a user study that was conducted to evaluate different Physical Mobile Interaction techniques that were implemented with a mobile application using the mentioned framework.

The next section gives an introduction to related work concerning mobile interaction with physical objects with a focus on the effectiveness and usability of applied interaction techniques. Section 3 gives a short overview of a physical mobile application that was developed for more complex interaction with physical objects. Section 4 summarizes the results of the user study that was conducted to compare different Physical Mobile Interaction techniques and section 5 concludes this paper.

2. RELATED WORK

The framework that was developed in the PERCI-project generically integrates Semantic Web Services and Physical Mobile Interaction (see [5]). The latter is used to extract information from augmented physical objects and use it for the invocation of services that are associated with them. The framework takes advantage of semantic descriptions of these services for the dynamic and automatic generation of customizable interfaces that again support more complex Physical Mobile Interaction techniques. For this purpose, an intermediate component called Interaction Proxy handles the communication between mobile devices and services. It generates an abstract interface description from Semantic Web Service descriptions for the generation of mobile interfaces. So far, the framework supports XHTML- and Java ME-interfaces.

In [7] Riekki, Salminen and Alakarppa present a framework including a middleware for requesting pervasive services by touching NFC tags with different functions using mobile phones as mediators. A user study revealed that subjects are able to learn and understand the usage of general tags (identifying objects) and special tags (e.g. print, contact maintenance or info). Properties of tag symbols that were considered important for their usability were simplicity, coloring, familiarity, consistency and placement. Users also preferred manual service activation to the automatic execution of interactions as it gives them a better feeling of being in control.

In [8] Rukzio et al. compared and evaluated the physical mobile interaction techniques *Touching* (using NFC) *Pointing* (based on a laser-pointer) and *Scanning* (using Bluetooth) that were used for the selection and usage of smart-home appliances in different context of location and activity (e.g. sitting, lying and standing). Scanning was seen as a very technical and complex interaction technique that was avoided as much as possible. Touching was regarded to be error-resistant, secure, quick and non-ambiguous. Pointing was seen as quick and intuitive although it required some cognitive effort and a line of sight in order to select a device for interaction. In general, the choice for a specific interaction techniques and its usage was dependent on the location of the user, his motivation and his activity.

3. MOBILE TICKETING – A USE CASE FOR PHYSICAL MOBILE INTERACTION

In order to investigate the effectiveness and usability of Physical Mobile Interaction in the context of the PERCI-framework, a prototype for mobile ticketing was implemented and evaluated. This prototype uses the framework for the invocation of Semantic Web Services and comprises a mobile client application that supports Physical Mobile Interaction with 2 posters for mobile ticketing.

The first poster allows users to purchase movie tickets and offers appropriate options (movie title, cinema name, number of tickets and preferred timeslots) together with a selection of values (see Figure 1). The second poster implements a simplified way to buy tickets for a public transportation system (see Figure 2). Instead of having to understand a complicated ticketing system, inexperienced users only have to select options for the stations they want to start their journey from, their destination, the number of passengers as well as the duration of the journey in order to have appropriate tickets suggested.

Figure 1. A poster for buying movie tickets

Each option on the posters is augmented with a NFC tag and a visual marker. They contain or reference the information that is represented by the option, e.g. the name of a movie, the number of tickets or different stations. The mobile client application supports the Physical Mobile Interaction techniques *Touching* (using NFC, see Figure 3a), *Pointing* (using the recognition of visual markers, see Figure 3b) and *Direct Input* of simple identifiers (see Figure 3c) for which a user simply types a number identifier. Users interact with the posters by selecting different options with their mobile devices using the supported interaction techniques. That way, they extract information from the posters and use it for the invocation of associated services,

The posters and the mobile client application distinguish between action- and parameter-tags which are logically mapped to different services and their parameters. Action-tags contain the URLs of different services while parameter-tags provide parameter-values for their invocation. In order to use the posters, an action tag has to be selected first in order to specify the service that is to be used. After that, users can select the different options respectively information they want to use for the invocation of the previously selected service. The layout of the posters does not define an explicit sequence for the interaction with them. Thus all parameter-tags can be clicked in an arbitrary order after the corresponding action-tag has been selected. This allows users to proceed in the way they think is most appropriate.

In order to evaluate the overall concept of the system, a preliminary user-study was conducted with a low-fidelity paper-prototype of the system that only supported interaction through Touching. Both the system and the usage of Physical Mobile Interaction were considered to be helpful, intuitive and easy to use. For details, please see [9].

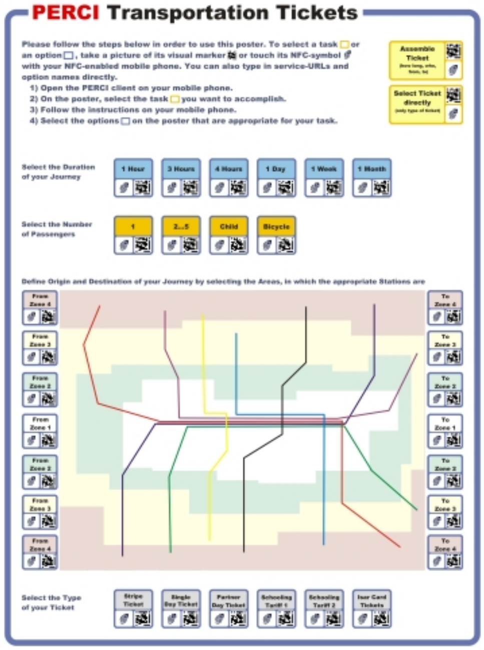


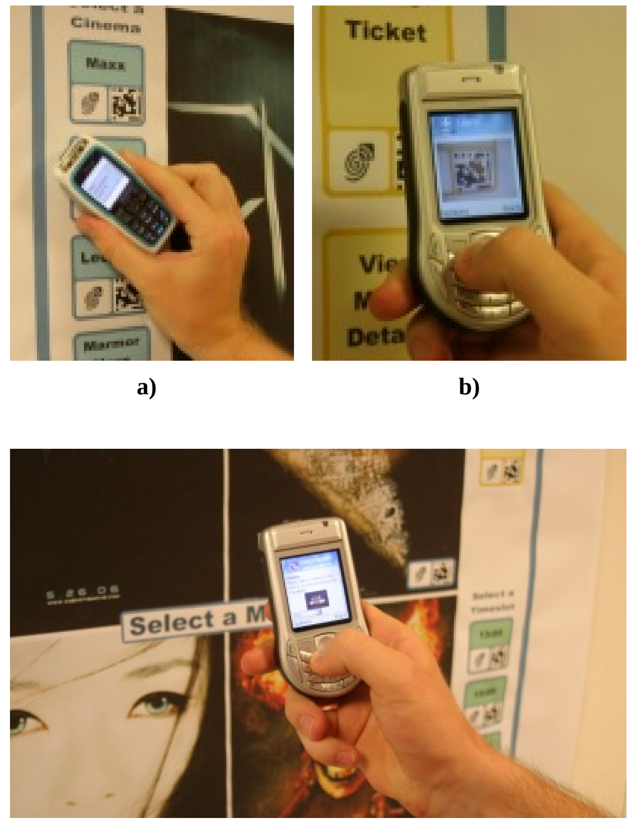
Figure 2. A poster for buying transportation tickets

4. USER STUDY AND EVALUATION

After the low-fidelity paper-prototyping, a user study was conducted in order to evaluate the implemented client application and the posters. The focus of this study way lying on the comparison and overall evaluation of the interaction techniques Touching, Pointing and Direct Input.

17 subjects took part in the user study, aged from 23 to 46 years. The average age was 29 years. 4 subjects were female, 13 were male. After the preliminary interview, they had to carry out a predefined task with each of the supported Physical Mobile Interaction techniques. The task was to buy a cinema ticket using predefined options for movie, cinema, number of persons and timeslot. The sequence of using the different interaction techniques was alternated from user to user to avoid undesired side effects. The techniques Touching and Pointing were tested with a mobile Java ME client application, while Direct Input was tested with a mobile HTML-browser. This usage of different clients results from technological constraints of the underlying mobile platforms as well as the effort to demonstrate the application of the PERCI framework on different target platforms.

At the beginning, many participants could not imagine possible workflows for the interaction with the poster and did not know how to start. Many of them are used to explicit workflows such as starting at the top and continuing to the bottom, e.g. when filling out a form. The subjects in this study were confused by the fact that there was no predefined sequence to select the different options. This problem has already been partly identified in the preliminary study based on paper-prototyping (see [9]). Because of this, the poster as well as the mobile phone application provided different hints of how to use the prototype. Nevertheless, the user study showed that people often ignore and do not appreciate such explanations.



a) **b)**

c)

Figure 3. Physical Mobile Interaction techniques Touching (a), Pointing (b) and Direct Input (c)

As already mentioned, the poster had been augmented with action and parameter tags. The user first had to select the action he wanted to perform (e.g. ordering a movie ticket) and then had to select the corresponding parameter tags like movie title or time slot. Many people did not understand this distinction without a preliminary explanation or reading the instructions.

After using the prototype the subjects were asked how easy it is to handle each of the interaction techniques and how enjoyable, innovative and reliable they are. The possible answers were: completely applies (4), somewhat applies (3), do not know (2), somewhat not applies (1) and not applies at all (0). The average of the given answers is depicted by Figure 4.

Touching and Direct Input were considered as easy to handle. The result for the latter is negatively influenced by the fact that two participants had serious problems using the HTML browser on the mobile phone that was used for the application of this interaction technique. Pointing was not seen as easy to handle because the testers had problems taking pictures of the entire visual code in a sufficient resolution. This result probably improves when using a real time recognition implementation of the visual code system.

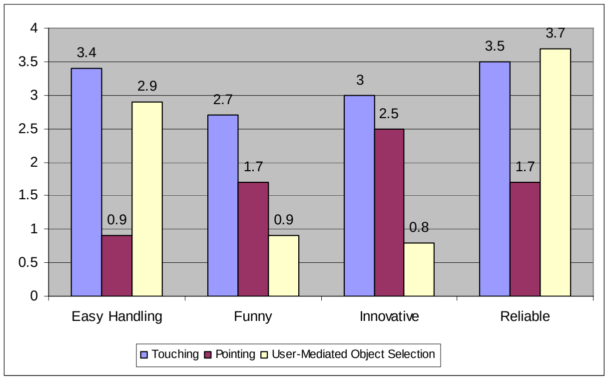


Figure 4. Rating of Touching, Pointing and Direct Input

Many testers said that Touching is an enjoyable interaction technique. They primarily answered *do not know* or *somewhat not applies* when thinking about Pointing and enjoyment. Direct Input was not considered to be enjoyable at all. Most testers regarded Touching as an innovative interaction technique, were often undecided when thinking about Pointing and did not see Direct Input as an innovative interaction technique. Touching and Direct Input were seen as reliable interaction techniques whereby they were undecided when thinking about Pointing.

Most testers said that Direct Input is not an enjoyable or innovative interaction technique. This is probably because people already knew and have already used this technique. The results for Pointing were in general negatively affected by its implementation that needs a few seconds until the user knows whether he has successfully captured the visual code or not.

Before and after the user study the participants were asked which interaction technique they preferred and which of them was the fastest. Before the study, 13 testers preferred the interaction technique Touching while one participant preferred Direct Input and one was undecided. 2 participants did not answer this question. After the user test, 13 participants preferred Touching and 4 Direct Input.

Before the user study, 14 testers said that Touching is the fastest interaction technique while 1 participant voted for Pointing. 2 participants did not answer this question. After the study, 12 subjects mentioned that Touching was the fastest technique whereas 5 subjects preferred Direct Input.

When looking at the overall results, Touching is seen as the best interaction technique when taking the four analyzed attributes and the questions regarding the preferred and fastest interaction technique into account. Touching was highly ranked in all questions regarding the four attributes easy handling, enjoyment, innovation and reliability. Direct input is regarded as a reliable interaction technique that is easy to handle but neither innovative nor enjoyable. Pointing received the worst marks but is seen as more innovative and reliable than Direct Input

5. CONCLUSION

While the presented user-study and evaluation showed the overall acceptance and potential of more complex techniques for Physical Mobile Interaction, it also showed considerable constraints and limitations. New interaction techniques require new usability guidelines as subjects were not yet used to Physical Mobile Interaction and did not always use the system the way it was intended. Future research in this area will have to take usability constraints of Physical Mobile Interaction more seriously into account.

6. REFERENCES

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