Personalized Adaptation to Device Characteristics

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Abstract. Device characteristics, such as screen size and means of interaction, and the context in which a device is used, seriously affect the user's mental representation of an information environment and its intended use. We hypothesize that user characteristics are valuable resources for determining which information is of interest in specific situations. Our project goal is to design mechanisms for adapting navigation support to device characteristics and its context of use, thereby considering that user goals and the resulting expected navigation behavior might be subject to change.

1 Introduction

Mobile access to information is becoming more and more important. A handheld device equipped with a browser and a wireless connection provides an opportunity to connect to the Internet at any time from anywhere [2]. As we know, handheld devices are smaller than desktop devices, in order to 'fit into your pocket' more easily. This has its consequences for screen size and interaction mechanisms. Although screen resolution and input devices can be improved, interaction mechanisms for handheld devices will remain limited because of their size. Advanced adaptive presentation and adaptive navigation support techniques are said to be indispensable for making a small-screen interface more usable [1].

Hypertext systems have the ability to produce complex, richly interconnected and cross-referenced bodies of information. Because of their non-linearity, users frequently experience cognitive overload and disorientation [11]. Various navigation aids have been developed in order to provide the context needed to prevent this problem. Adaptive hypermedia systems build a model of the goals, preferences and knowledge of each individual user, and use this model throughout the interaction in order to adapt to the user's needs [1]. It has been demonstrated that navigation suggestions based on user goals as well as on navigation behavior of previous users have a positive effect on users' spatial and temporal awareness [6]. Sorting, hiding and annotating links as well as map adaptation are some example methods that may help users to find their paths in hyperspace.

It is expected that mobile Internet users primarily want to extract particular bits of information relevant to a current task. Navigation therefore requires strong support

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for this goal-directed activity [2]. Several systems have been developed that summarize 'regular' web pages in order to display them conveniently on a small-screen handheld device. Some of them (e.g. [2]) also provide specialized navigation facilities such as alternative link sorting schemes. Unfortunately, these systems merely make use of content information, although user characteristics are a valuable resource for determining which information may be of interest.

In contrast to handheld interfaces, virtual (three-dimensional) worlds are typically used for exploration and entertainment [3]. Although the environment still needs to offer goal-directed navigation aids, it is likely that users also will want to look around for related information they might be interested in. Ideally, such an interface should posses challenging navigation aids, should invite exploration and should be *fun* to use. Enhanced perceived fun will most likely lead to increased time spent in a virtual world [5], which is interesting from an e-commerce point of view [3].

When providing information through such different interfaces as handheld devices, virtual worlds and regular web pages – which all serve different user goals – adaptation to the environment is an important issue. This environment does not only consist of the device being used, but also of the context of use (e.g. waiting at a bus stop) [1]. Our research is aimed at determining what navigation support is needed in different situations and how user characteristics can be used for selecting the areas of interest. For this purpose, we will consider three different interfaces which all present the same information environment:

– a handheld device interface (which is typically used in a goal-directed way)
– a virtual world (which is typically used in an explorative way)
a 'regular' web page (which is a mix of both ends of the spectrum)

For each of these interfaces, mechanisms will be developed for adapting navigation support to the richness of interaction means provided, its – possibly varying – context of use and the resulting user needs, which might be subject to change as well.

2 Adapting Navigation Aids to Device Characteristics

While navigating a hypermedia document, people use environmental cues and artificial aids such as site maps so that they can achieve their goals without getting lost. Their navigation behavior can be categorized as either goal-directed or explorative. Though mutually exclusive, these activities may become connected: exploration may result in goal-directed search activities, but the opposite direction is likely as well. These two navigation types call for different types of navigation assistance [3].

Handheld interfaces most likely invite a goal-directed kind of use – not only because of the limited interaction mechanisms of such devices, but also because of the situations in which they are used. Interfaces that are rich in interaction means, such as virtual worlds, invite mainly explorative behavior.

Online information can be accessed using such an increasing variety of equipment from almost any place. It is desirable to make use of the same information source for representation on different devices; duplicate effort could seriously tax human and machine resources [2] and, even worse, may lead to inconsistency. As stated before, navigation support should be adapted to the device characteristics and the context in which it is used.

Equally important to selecting the *right* navigation suggestions, is the *number* of suggestions that should be given to the user. An overwhelming amount of information will cause the user to have to spend considerable time scanning through, whereas too little information might not provide sufficient cues. It is obvious that the ideal number of navigation suggestions is highly dependent on the device characteristics and the context of use; users with small screens are reported to follow links less frequently than those provided with larger screens [2].

As suggested in the introduction, there is not one approach for selecting navigation aids that fits all users. When user characteristics are taken into account in the process of adapting navigation support to handheld devices, this might improve the effectiveness of such small screen interfaces [2].

Alternatively, the same user characteristics can be used for creating a virtual world that invites exploration by means of visually attractive navigation aids and embodied agents that support the users' explorative behavior, leading them to those places they are interested in [3]. Such a virtual world might be modeled after the real world (e.g. cities, buildings); it might as well be symbolic, with a topology that is based on non-geographical relations between information nodes.

3 A Pragmatic, User-Centered Approach

Past research has generally been overly technology-oriented, forgetting that the original goal was to deal with usability problems [13]. In our project *PALS Anywhere*[1] we try to overcome this problem by separating research into a cognitive track and a technological track, carried out in parallel by researchers from both disciplines.

Cognitive theory is needed for distinguishing the environmental factors that affect human cognitive task performance. There is no such comprehensive theory, so we will have to develop limited or practical theories on the influence of accepted features of cognition on navigation behavior [10], in order to obtain a foundation for the mechanisms to be incorporated in our models. The applicability of the cognitive theories and the functionality of the resulting system will be validated by usability tests.

Since there is not one single approach that is most suitable for modeling both user and environment [7], it is important to know *what* knowledge such models should express and *how* this knowledge can be obtained, before a proper choice can be made. Observations of user behavior, for example, are commonly represented as statistical data. However, it might be desirable to propagate this primary knowledge to higher-level assumptions that apply to more than one specific device or interface. Such conceptual data is typically represented by explicit, logic-based formalisms, which have strong inferential capacities [12]. Statistical models, on the other hand, are more apt

[1] PALS stands for Personal Assistant for onLine Services; the project is supported by the Dutch Innovative Research Program IOP-MMI. Our research partners are TNO Human Factors and the University of Utrecht, faculty of Mathematics and Computer Science.

to deal with uncertainty and the incremental acquisition of observational data [14]. At present, the only motivation for preferring a particular modeling technique is its observed success [14]. Since we aspire to find generic formalisms based on practical empirical theories, we intend to build our models of both user and environment incrementally and eclectically.

The models will be implemented in an agent-based framework that is able to reason about the interface, the user and environmental characteristics. This framework will provide the core functionality of a collaborating personal assistant [8] that learns about its users and helps them to reach their goals, either solicited or on its own initiative.

Hypermedia documents can be seen as a collection of nodes (separate chunks of information) that are richly interconnected. This structure facilitates capturing its contents and its structure in simple but powerful formalisms, such as adjacency matrices and directed graphs. These representations enable assessment of navigational patterns [9]. With the joint features of these formalisms and user modeling techniques an overlay can be derived that contains only those connections that are relevant to the user. Naturally, in the information model the various relation categories should be categorized. An obvious solution is the use of typed links, such as *analogy*, *abstraction* and *simultaneity* [4].

This overlay is not primarily meant to be shown to the user, but merely as a starting point for the navigation assistance design. Each connection category can be translated into an appropriate structuring element, for instance annotated hyperlinks and contextual menus on web pages or topological layout and landmarks in virtual worlds.

4 Research Goals

Device characteristics – such as screen size, interface design and means of interaction – and the context in which these devices are used, have their impact on the user's mental representation of an information environment. In our project we want to determine how spatial and temporal abilities are affected and what navigation aids can help users to find the information they need. An important consideration is the expected navigation behavior an interface should support, which is either goal-directed, explorative or a mix of both.

We hypothesize that adaptive hypermedia techniques are an important means for adapting an interface to the device and the situation in which it is used. Our research goal is to model user, device and context of use – the 'Trinity of Context' – in order to adapt navigation support to the continuously varying user needs.

A clever selection of navigation aids will offer the user more freedom in navigation. On tiny screens, omitting all items that are not of interest leaves more space for relevant navigation support. Analogously, virtual worlds will become more surveyable; tailored landmarks and personalized assistance in wayfinding prevent the user from getting lost.

We will evaluate our theories on three existing devices, significantly different in intended use, representation and richness of interaction means. Notwithstanding technological improvements, devices will remain different on these factors, because of the contexts of use for which they are designed. Therefore we expect the outcomes of our research will not only be of immediate use, but also be useful in designing navigation aids of novel interfaces.

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