Evolving Search User Interfaces

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ABSTRACT

When designing search user interfaces (SUIs), there is a need to target specific user groups. The cognitive abilities, fine motor skills, emotional maturity and knowledge of a sixty years old man, a fourteen years old teenager and a seven years old child differ strongly. These abilities influence the decisions made in the user interface (UI) design process of SUIs. Therefore, SUIs are usually designed and optimized for a certain user group. However, especially for young and elderly users, the design requirements change rapidly due to fast changes in users' abilities, so that a flexible modification of the SUI is needed. In this positional paper we introduce the concept of an *evolving search user interface* (ESUI). It adapts the UI dynamically based on the derived capabilities of the user interacting with it. We elaborate on user characteristics that change over time and discuss how each of them can influence the SUI design using an example of a girl growing from six to fourteen. We discuss the ways to detect current user characteristics. We also support our idea of an ESUI with a user study and present its first results.

Keywords

Search User Interface, Human Computer Interaction, Adaptivity, Context Support, Information Retrieval.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces.

General Terms

Design, Human Factors.

1. INTRODUCTION

Search user interfaces [8] are an integral part of our lives. Most common known SUIs come in the form of web search engines with an audience of hundreds of millions of people[1] all over the world. This is a very wide and heterogeneous target group with different backgrounds, knowledge, experience, etc. Therefore, researchers suggest providing a customized solution to cover the needs of individual users (e.g., [6]). Nowadays, solutions in personalisation and adaptation of backend algorithms, i.e. query adaptation, adaptive retrieval, adaptive result composition and presentation, have been proposed in order to support the search of an individual user [13, 14]. But the front end, i.e. the SUI, is usually designed and optimized for a certain user group and does not support many mechanisms for personalisation. Common search engines allow the personalisation of a SUI in a limited way: Users can choose a colour scheme or change the settings of the browser to influence some parameters like font size. Some search engines also detect the type of device the user is currently using – e.g. a desktop computer or a mobile phone – and present an adequate UI.

Current research concentrates on designing SUIs for specific user groups, e.g. for children [4, 6, 10] or elderly people [1, 2]. These SUIs are optimized and adapted to general user group characteristics. However, especially young and elderly users undergo fast changes in cognitive, fine motor and other abilities. Thus, design requirements change rapidly as well and a flexible modification of the SUI is needed. Therefore, we suggest to provide users with an *evolving search user interface (ESUI)* that adapts to individual user's characteristics and allows for changes not only in properties (e.g., colour) of UI elements but also influences the UI elements themselves and their positioning. Some UI elements are continuously adaptable (e.g. font size, button size, space required for UI elements), whereas others are only discretely adaptable (e.g. type of results visualization). Not only SUI properties, but also the complexity of search results is continuously adaptable and can be used as a personalisation mechanism for users of all age groups.

2. ESUI VISION

In this section we share our vision of an ESUI. In general, we suggest to use a mapping function and adapt the SUI using it, instead of building a SUI for a specific user group. Using a generic model of an adaptive system, as discussed in [14], we depict the model of an ESUI as following (see Fig. 1). We have a set of user characteristics (or skills) on one side. In the ideal case, the system detects the skills automatically, e.g. based on user's interaction with the information retrieval system (user's queries, selected results, etc.). On the other side, there is a set of options to adapt the SUI, e.g. using different UI elements for querying or visualisation of results. In between, an adaptation component contains a set of logic rules to map the user' skills to the specific UI elements of the ESUI.

[1] Google, for example, has over 170 million unique visitors per month, only in the U.S. `http://www.nielsen.com/us/en/newswire/2013/january-2013--top-u-s\--entertainment-sites-and-we-brands.html`

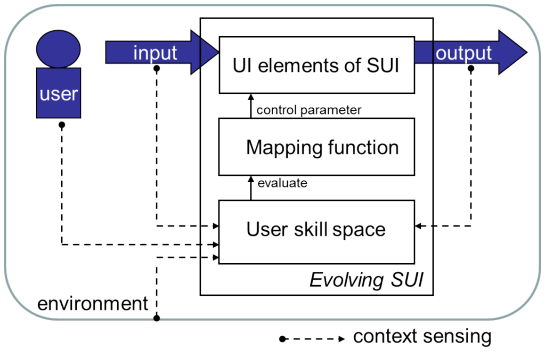


Figure 1: Model of an ESUI.

2.1 Mapping Function

The function between the user skill space and the options to adapt the UI elements of the SUI has to be found. We suggest using the knowledge about human development, e.g. from medical, cognitive, psychosocial science fields to specify the user skill space. The results of user studies about users' search behaviour and SUI design preferences can provide recommendations for UI elements. As far as the research provides information about the studied age group, we can use the age group as a connector between the skill space and the UI elements. Note that we use age groups in the sense of a more abstract category defining a set of specific capabilities while growing up. A lot of research is already done and can be used, e.g. [2, 4, 7]. In addition, if the set of adaptable UI elements is defined, we can evaluate the mapping function by letting users from different age groups put the UI elements of a SUI together (similar to the end user programming).

2.2 Evolving Skills

In order to allow a SUI to evolve together with a user we first have to determine those characteristics that vary from user to user and change during his life (or due to some circumstances like diseases). For example, discussion about the skills of young users is given in [7]. We suggest to consider cognitive skills, information processing rates, fine motor skills, different kinds of perception, knowledge base, emotional state, reading and writing skills.

In the following, brief summary of current research results in human development science is given. Human cognitive development occurs in a sequential order in which later knowledge, abilities and skills build upon the previously acquired ones [12]. *Cognitive abilities* of users in those stages differ, for example, before the last (formal operational) stage they are unable to think logically and to understand abstract concepts. Again, not only age but also some diseases or accelerated cognitive development cause that cognitive abilities, i.e. skills to gain, use and retain knowledge, differ from user to user. *Information processing* capabilities change during life. Children's information processing is slower than that of adults [11]. Therefore, children have a limited cognitive recall. It is widely agreed that elderly people have a decline in intellectual skills which affects the aggregation of new information [15]. *Fine motor skills* are influenced by information processing rates [9]. Therefore, young children's performance in pointing movements, e.g. using a mouse, are lower than that of adults. *Perception* of color can also change while aging. Color discrimination is more difficult for elderly people. Elderly people have also problems with hearing [3]. Children are immature in the *emotional domain* and, especially at the age of six to twelve, require additional emotional support and a resulting feeling of success [5]. Therefore, they require support to increase their confidence. In general, *reading and writing skills* of adults are better than those of children. *Knowledge* is gathered during life. Thus, elderly people posses a larger knowledge base than adults, and adults have usually more knowledge than children. We believe that the discussed characteristics can affect the design of SUIs. However, further research should be done in this direction.

2.3 Detection of User Abilities

An ESUI can provide a specific SUI for a specific user given the knowledge of his specific abilities. A simple case is an adaptable SUI, where a user manually adjusts the search user interface to his personal needs and tasks. An adaptable SUI may also provide several standard settings for a specific user selection to explore the options (e.g. young user, adult user, elderly user). More interesting and challenging is the case of an adaptive SUI, where a system automatically detects the abilities of a user and provides him with an appropriate SUI. Concepts for an automatic detection of user's abilities have been studied in the past. We can use the age of a registered and logged-in user. However, the age provides only an approximation of a user's capabilities. For an individual user an appropriate mapping to the age group has to be found, e.g. using psychological tests covered in form of games. Those games can be used to derive the quality of user's fine-motor skills as well. Furthermore, we can use the user history from log files, in specific, issued queries (their topic and specific spelling errors) and accessed documents. *However, research is required to determine how to adapt a SUI in the way users would accept the changes.*

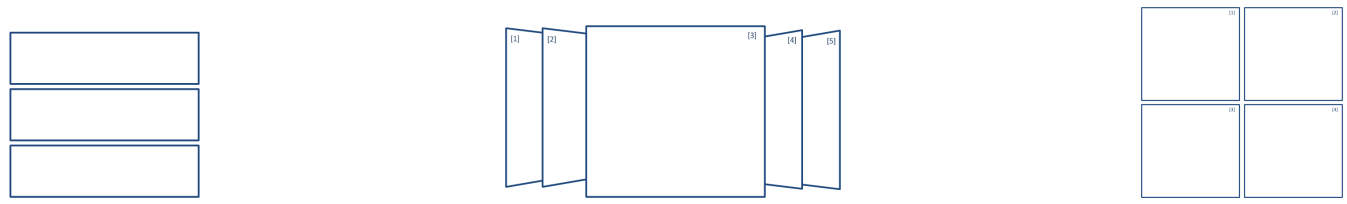
3. DESIGN IDEAS

When designing an ESUI, we first have to define the components of a SUI that should be adapted. We consider three main components. The first component is an *input*, i.e. UI elements which allow a user to transform his information need into a machine understandable format. This component is traditionally represented by an input field and a search button. Other variants are a menu with different categories or voice input. The second component is an *output* of an information retrieval (IR) system. The output consists of UI elements that provide an overview of retrieved search results. There can be different kinds of output, e.g. a vertical list of snippets (Fig. 2a), tiles (Fig. 2c) or coverflow (Fig. 2b). The third is a *management* component. Management covers UI elements that support users in information processing and retaining. Examples of management UI elements are bookmark management components or other history mechanisms like breadcrumbs. Historically, management UI elements are not part of an SUI. But recent research [6] shows that users are highly motivated to use elements of management. Besides these main components, there also exist general properties of UI elements that might affect all the three categories, e.g. font size or color. *We propose to adapt these three main components of a SUI and its general UI properties to the user's skills.*

3.1 Use Cases

In order to demonstrate the proposed ESUI, we consider a young girl called Jenny who is growing older. We show how input and output of a SUI can be adapted to changes of Jenny's abilities.

Use Case 1: Jenny is six years old. She started to learn reading, but she has difficulties with writing. Jenny's active vocabulary is limited to 5,000 words. She cannot yet think in abstract categories and is not able to process much information. Due to her limited writing abilities, Jenny is not able to use an input field and write a query. She is learning to read, therefore, she can use a menu



(a) (b) (c)

Figure 2: Different kinds of output of an information retrieval system: a) *vertical list of snippets* offers a fast overview of several results at once b) *coverflow view of results* offers an attractive animation by browsing, uses a familiar book metaphor, central element is clear separated from the rest c) *tiles of search results* offer a fast overview of several results at once, a user has small jumps by reading within results, however the ordering of results is not so clear as by a list.

(a) (b) (c)

Figure 3: Different kinds of input of an information retrieval system: a) an ESUI enables a six-year-old Jenny to draw her query b) an ESUI supports nine-year-old Jenny by voice input and through several pre-defined categories c) an ESUI enables fourteen-year-old Jenny to use keyword-based input supported by an adaptive query cloud.

with different categories which are supported by images. In order to search for any information Jenny can *draw* her query (Fig. 3a). Jenny's fine motor skills are not fully developed yet. She has difficulties using interactions like scrolling. She also cannot process much information at once. Therefore, the coverflow (Fig. 2b) result visualisation fits her abilities (best). Coverflow allows her to concentrate on one item at a time, thus, her cognitive load is reduced. Jenny can interact with it using simple point-and-click interactions. An integrated text-to-speech reader supports Jenny by reading the results to her.

Use Case 2: Jenny is nine years old. Jenny can read and write short stories with just a few spelling errors. Jenny has some difficulties with typing using a keyboard. She "hunts and pecks" on the keyboard for correct keys. This increases the amount of spelling errors and also slows down the process. Jenny is frustrated because the system does not understand her well. Thus, a standard keyword input field does not fit Jenny's abilities well. Jenny still cannot think in abstract categories and process a lot of information. But her language skills improved and her vocabulary size is increased. Therefore, she can use *voice input* to search for information. A menu with different categories in addition to voice input can inspire Jenny to search for some new information. However, these categories should match her cognitive abilities (Fig. 3b). Jenny can already manage different interaction techniques and is able to process more information than the six-year-old Jenny. Therefore, a list of snippets (Fig. 2a) is an adequate output visualization. It requires not that much cognitive recall as tiles, but allows to process more results items at a time than coverflow does.

Use Case 3: Jenny is 14 years old. Jenny's writing skills are further developed with use of correct grammar, punctuation and spelling. She learns to think logically about abstract concepts. Her vocabulary size is about 20,000 words. She chats a lot with her friends which results in fast typing skills using a keyboard. Therefore, Jenny is able to use a keyword-oriented input search supported by spelling correction and suggestion mechanisms. A SUI can still support Jenny by finding the "right" keywords, for example using a *query cloud*[2] (Fig. 3b). Jenny can already manage different interaction techniques and is able to process more information than the nine-year-old Jenny. Therefore, coverflow and a vertical list visualisation would probably restrain her performance, whereas tiles (Fig. 2c) allow Jenny a better overview of results.

4. USER STUDY

In order to demonstrate the idea of an ESUI, we conducted a user study to compare users' preferences in the visualization of different UI elements of a SUI. In specific, our hypothesis was that *users from different age groups would prefer to use different UI elements and different general UI properties*. We built a SUI that can be personalized, i.e. users can choose input, output and tune general UI properties. In this paper we present our first results, i.e. users' preferences in results visualization. Our SUI allows users to choose between a vertical list of snippets, tiles (Fig. 4b) and coverflow (Fig. 4a). In our experiment we demonstrated these three output types. The subjects interacted with the search system to get a better feeling and were encouraged to solve a simple search task using the prefered SUI setup. 44 subjects participated in the study, 27 children and 17 adults. The children were between eight and ten years old (8.9 on average), 19 girls and 8 boys from third (18 subjects) and fourth (9 subjects) grade. The adults were between 22 and 53 years old (29.2 on avarage), five women and 12 men. Nine of them were students in computer science and four worked in the IT sector. The results for the output are presented in Fig. 5. The majority of the children prefered the coverflow results visualization, whereas the adults had a week tendency towards tiles. These results can be explained by the fact that on average children cannot

[2]Similar to the *quinturakids.com* search engine, accessed on 02.05.2013

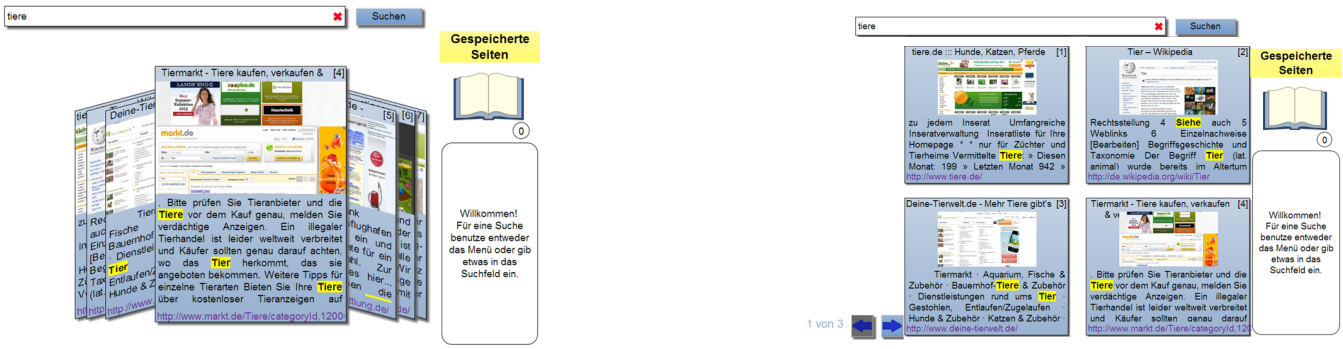


Figure 4: Different kinds of result visualization: a) ESUI with coverflow result visualization b) ESUI with tiles result visualization.

process much information, but adults do. Thus, it is easier for children to use coverflow. Coverflow offers an animation by browsing that is attractive for children. Many adults told us that they prefer tiles as, since many results can be compared at once, tiles offer a good overview of results.

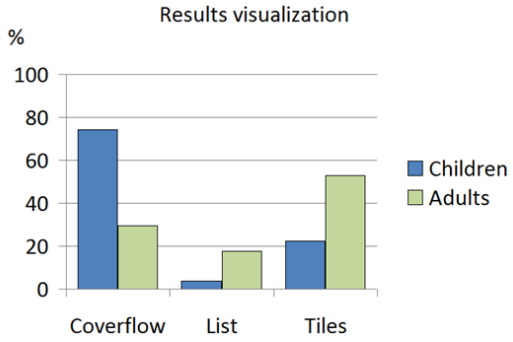


Figure 5: Study results: what type of visualization do children and adults prefer.

5. CONCLUSION

In this positional paper we introduced the concept of an evolving search user interface that adapts itself to abilities of a particular user. Instead of building a SUI for a specific user group, we use a mapping function between user skills and UI elements of a search system in order to adapt it dynamically, allowing the user to perform his search process in a more efficient way. We considered different abilities of a user, e.g. his cognitive skills, knowledge, reading and writing skills, that change during life. Furthermore, we proposed to adapt three main components of a SUI, i.e. input, output and management, and its general UI properties to the user skills. A key component of an ESUI is a mapping function between user skill space and UI elements of a SUI, that has to be found. We elaborate on ways to learn this function. In order for an ESUI to be adaptive, ways to detect user abilities are required. We pointed in several directions how the detection can be done.

6. ACKNOWLEDGEMENTS

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