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Preface to Special Issue on User Modeling for Web Information Retrieval

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1. Introduction

Information access is one of the hottest topics of information society and it has become even more important since the advent of the Web. On one side, our society relies more and more on information, both for professional and personal goals. Information is nowadays considered as one of the most valuable and strategic goods: knowing the right information, at the right moment, as soon as it is available is a 'must' for all of us. On the other side, the amount of available information, especially on the Web, is increasing tremendously over time and we are witnessing an 'information oversupply', a phenomenon called in other different, though significant, ways: 'information overload', 'information glut', 'infobog', 'information smog', 'e-overload' (Alesandrini, 1992; Shenk, 1997).

As a result, the process of accessing what is 'relevant' is very difficult, time-consuming, and in many cases practically unfeasible, since it requires huge cognitive processing, which is out of range for our limited mental resources, energy, and time. For these reasons, since the very beginning of the Web, several automatic tools, which are aimed at supporting the user in finding information relevant to his/her information needs, have been proposed and are still currently exploited. Search engines, meta-search engines, and directories are the most popular tools, however they show very limited performance. We all know that search engines are characterized by low accuracy of the retrieval process (an estimated average precision of 30% (Leighton and Srivastava, 1999), incompleteness and low coverage, low timeliness, and bad ranking of results. Such results hinder effectiveness and efficiency of the process characterizing the transfer of information from authors (producers of information) to readers (consumers of information). It can be observed both when we are searching for information because of a specific information need (the so called 'pull perspective') or when information is sent to us with or without our permission (the so called 'push perspective').

This state of the art requires new innovative tools for information retrieval on the Web. We need more tools, covering in a better way the various aspects of the information access scenario, and we need innovative tools capable of coping with the severe limitations of current tools.

Coming back to search engines' pitfalls, we can highlight two specific problems that characterize their behavior, but limit their performance:

- Linguistic processing. Search engines are typically 'keyword based': retrieval is based only on the presence or the absence of one or more strings (the keywords) in the text, and not on any analysis of its contents, on the identification of the concepts referred in the text, and so on. This is the major cause of the very low accuracy in the retrieval, due to known linguistic phenomena such as sinonimity and polisemy.
- Limited mechanisms for expressing the information need of the user. Usual queries are formed by a few words (an average between two and three): this allows very fast response (one of the most appreciated feature of search engines), but fails in capturing precisely what the user wants and what she does not want. Moreover, it is not possible for the user to communicate to the search engine how she judges the obtained results, what she likes or not. As a result, users are pushed to express their needs in a very synthetic way, different needs are often mapped into similar sequences of search terms, and specific personal exigencies are lost.

The two problems illustrated above call for two important directions of innovation: adding better semantic capabilities to the search tools, and overcoming the typical 'one-size-fits-all' approach by providing better mechanisms for gathering more information from the user. The future scenario, should include tools capable of 'understanding' what the user wants, of evaluating more precisely whether a document is relevant or not to a user information need, and of 'listening' and 'learning' from the user when she provides useful feedback during the interaction. This last point, concerning in more general terms, the approach to the design of HCI aspects of Web information retrieval systems, points out a further direction of innovation: new ways and techniques for interacting with information, for presenting and visualizing results to the user, for browsing in rich and crowded information spaces, for seamlessly providing to the system knowledge, comments, and feedback information. A further basic feature of the innovation concerns the capability to adapt to the evolution of user interests. In other words, the information retrieval (IR) system needs to follow over time the way the user understands and formulates her information needs. This capability is essential, both within a short- and a long-term perspective: when the user 'teaches' the machine what her need is about (since she is often learning herself, changing perspective and improving understanding), or, later, when a natural and common evolution of her interests takes place.

Importance and role of user modeling and adaptive personalization are straightforward in the above scenario. Equipped with user modeling tools capable of comprehending specific user information needs, the new retrieval tools will be able to effectively filter out irrelevant information, to rank information in the most suitable way, to compare the contents of different documents, to personalize information presentation, and to adequately tailor man–machine interaction. Reaching this ambitious goal is not easy. A lot of research is still to be done: new algorithms are needed for adaptive personalization based on techniques such as machine learning, natural language processing, and new paradigms for interaction and navigation.

Several signs are feeding our trust in achieving such goals. The attention of the user modeling community towards the problem of information access has a very long history. Since the early days of user modeling (beginning of the 80s), research has been performed on the problem of adapting information retrieval to the user (Belkin, 1984; Brajnik, Guida and Tasso, 1987; Brajnik, Guida and Tasso, 1990; Brooks, Daniels and Belkin, 1985; Daniels, 1986; Gershman, 1981). Associating the problem of accessing information by means of an interactive computer system with the idea that the user has to be taken into account individually has been understood more than 20 years ago. Since then, a long series of results and milestones have been reached, and with the Web revolution we have further improved, detecting and analyzing new problems, identifying and experimenting new solutions, and applying innovation. The focus on the systematic evaluation of research ideas has grown tremendously, and even if the problem cannot be considered as solved yet, many accomplishments have been reached. A new culture of evaluation has been put forward, as new user oriented factors have been added to traditional IR performance indicators.

In the past, the User Modeling and User-Adaptive Interaction journal has published a number of papers devoted to different aspects of adaptive information access (Billsus and Pazzani, 2000; Brusilovsky, 2001; Hanani, Shapira and Shoval, 2001; Hirashima et al., 1997; Jennings and Higuchi, 1993; Newell, 1997). These papers contributed a lot to the development of the field. This special issue is an attempt to recognize the adaptive information access as a research field within the area of user modeling and to provide a state of the art report of the field. This special issue is devoted to the memory of James Chen, a researcher who contributed to several pioneer research projects that helped to shape the vision of adaptive information access as a field (Kaplan, Fenwick and Chen, 1993; Keller et al., 1997; Mathé and Chen, 1994, 1996).

2. Adaptive Information Access: An Integrated Prospect

The four papers presented in this special issue provide very good examples of applying the ideas of user modeling in four major *information access* paradigms: ad-hoc information retrieval (Micarelli and Sciarrone, 2004), information filtering (Waern, 2004), hypertext browsing (Magnini and Strapparava, 2004) and information visualization (Leuski and Allan, 2004). In ad-hoc retrieval, users get access to relevant information by issuing a query to an IR system or search engine and analyzing a ranked list of documents (for example, book records) returned as a result. In information filtering, (IF) a user specifies a long-term search profile that a filtering system matches against a flow of incoming documents (for example, news articles) to select the most relevant items for the user. In hypertext browsing, a user attempts to find relevant documents by browsing links that connect documents in a collection. In information visualization, a set of documents is presented to the user using some visualization metaphor in 2 or 3 dimensions; the user observes or, in case of interactive visualization, interacts with the visualized set to find the most relevant documents.

During the 'pre-Web' age, these major information access paradigms were developing relatively independently. While information retrieval and filtering were long considered as 'two sides of the same coin' (Belkin and Croft, 1992), attempts to blend information retrieval, visualization, and browsing were relatively rare (Fox et al., 1993; Marshall and Shipman III, 1995; Olsen et al., 1993; Tudhope, Taylor and Benyon–Davies, 1995). The need to support adaptively individual users in their attempts to find relevant information has been independently recognized in IR, IF, and hypertext browsing. A stream of interesting early research on adaptive information retrieval (Belew, 1989; Brajnik, Guida and Tasso, 1987), adaptive hypertext and hypermedia (Brusilovsky, 1996), and adaptive information filtering (Foltz and Dumais, 1992; Jennings and Higuchi, 1993) demonstrated that 'being adaptive' is possible and even beneficial. However, in the pre-Web context, the stream of work on adaptive information access was very thin. In their research communities, adaptive systems were often considered more like curiosities, far from answering practical needs. In this context HYPERFLEX (Kaplan, Fenwick and Chen, 1993) and Adaptive HyperMan (Mathé and Chen, 1994, 1996) projects co-authored by James Chen were really unique and inspiring. Not only did these projects blend together the ideas of information retrieval, hypertext browsing, and user modeling thus pioneering the integrated paradigm of adaptive information access. They have also demonstrated that adaptive information access systems can significantly improve user performance (Kaplan, Fenwick and Chen, 1993) and be successfully applied to solving challenging practical needs – such as providing adaptive access to hypertext documentation for NASA Space Shuttle flight controllers (Mathé and Chen, 1996).

The Web has changed this situation in just a few years. Being the largest ever, yet naturally hyperlinked repository of information, the Web has provided a challenging universal platform to researchers working on all kinds of information access allowing them to apply and enhance the ideas developed over years. Research on Web information retrieval and filtering, Web visualization and browsing flourished. Results of this research were often presented at the same conferences and published in the same sources. It did not take long for the involved research communities to recognize that the coin of information access has at least four sides and, consequently, the number of projects blending retrieval, filtering, visualization, and browsing has increased dramatically.

Similar changes occurred in all branches of adaptive information access research. Bringing together the largest volume of information and the largest variety of users, the Web called for personalization and adaptation. This call has been recognized by many research groups worldwide. A number of techniques for adaptive information retrieval, filtering, navigation support, and even adaptive visualization in Web context have been developed and evaluated. Some of these techniques moved from research labs to industrial world directly affecting millions of users.

The current challenge is to integrate the two processes introduced by the Web – to bring together researchers working on different kinds of adaptive information access and to develop systems that blend several kinds of information access with user modeling and personalization. The pioneer work on HYPERFLEX (Kaplan, Fenwick and Chen,

1993) and Adaptive HyperMan (Mathé and Chen, 1994, 1996) and a few other projects such as Syskill and Webert (Pazzani, Muramatsu and Billsus, 1996) and FAB (Balabanovic and Shoham, 1997) provide good inspiration, yet the number of integrative works on adaptive information access is relatively small. The goal of this special issue was to provide a follow-up to this pioneer work and to contribute to the progress in this direction. The editors, who came from two different fields themselves (Carlo Tasso has more than 15 years of experience in the field of adaptive IR and Peter Brusilovsky has been working with adaptive hypermedia for more than 10 years), think that the issue has achieved that goal. It brings together papers from different research communities, provides good examples of all four major kinds of adaptive information access, and presents a number of interesting user modeling and adaptation techniques. Altogether, it could serve as a single-volume introduction to the field of adaptive information access on the Web. To complement these four papers and to show their place in the current landscape of adaptive information access, we have decided to provide a very brief overview of the field. The main goal of this review is to put the papers presented in the special issue in the context of work on adaptive information access and to explain how the approach to adaptation explored by these papers is similar to (or different from) other known approaches.

3. The Papers of this Special Issue in the Context of Adaptive Information Access Research

3.1. INFORMATION FILTERING

Classic information filtering (IF) is the least interactive paradigm of information access. Users provide long-term profiles of their interests. The IF system regularly matches the profiles against the flow of incoming documents, selects subsets of documents relevant to each profile, and presents it to the user. Presented documents are usually ordered by their relevance to the profile. Naturally, if the current interest profile does not work well it can be improved. In classic information filtering systems, it was the job of the users to edit their profiles tuning them to their interests. The challenge for adaptive IF systems was to assist the users in tuning the performance of the system. The ConCall system presented in one of the papers of this special issue (Waern, 2004) provides a typical example of adaptive information filtering. ConCall operates with a flow of incoming conference announcements. Each incoming announcement is matched against the profile of each user. Periodically, the users receive a set of 'filtered' announcement. Each of the announcements selected by the system is judged by the user as relevant or not relevant to her interests. This relevance feedback is used by the system to improve the profile. The new group of announcement is selected with the improved profile and so on. This approach to adaptive filtering is known as content-based filtering, since it is based on the analysis of the content of the incoming documents. It has been explored in a number of systems that applied different user modeling approaches to different application domains. Typically, adaptive content-based filtering systems exploit machine learning techniques to handle positive and negative relevance feedback provided by the user (Asnicar, Di Fant and Tasso, 1997). For example the Adaptive Information Server (Billsus and Pazzani, 2000) was able to achieve notable results applying a sophisticated user modeling mechanism in the field of news filtering. The paper (Waern, 2004) presented in this issue brings an interesting contribution to the research on adaptive information filtering by examining an interaction between traditional manual profile editing and feedback-based profile improvement introduced by adaptive IF systems.

3.2. INFORMATION RETRIEVAL

The goal of a Web IR system is to deliver a list of links to Web pages that answer the user *information need* expressed as a formal query. Typically, an adaptive Web IR system uses a Web search engine such as Google (Brin and Page, 1998) to retrieve relevant links and adaptively presents the results of this search. Users issue queries. Queries are passed to the search engine that returns an ordered list of links. The adaptive IR system processes these links and adaptively presents them to the user. In that sense adaptive Web IR and IF systems are very similar – both process a relatively small number of documents in order to present them adaptively. There are, however, some clear differences.

The first difference that can be noticed is that an IF system presents either a list of ordered documents or a list of links, while a Web IR system always presents links. Recognizing the fact that the goal of an adaptive Web IR system is to present adaptively a set of links is important. It allows exploring known techniques of link adaptation in adaptive hypermedia – sorting, hiding irrelevant links, and annotation (Brusilovsky, 1996). Among early projects Siskill and Webert (Pazzani, Muramatsu and Billsus, 1996) adaptively annotated the results of Lycos search and (Ambrosini, Cirillo and Micarelli, 1997) used hiding (filtering) with AltaVista results.

A more important difference between IF and IR is that an IF profile represents long-term user needs, while an IR query represents short-term needs. As a result, instead of refining the profile over time as it is done in adaptive IF, adaptive Web IR systems focus on building a model of user long-term interests and preferences. The search results presented by an adaptive Web IR system to the user take into account both the short-term need expressed by the query and long-term interests accumulated in the user model. The *WIFS system* (Micarelli and Sciarrone, 2004) presented in this special issue provides a very good example of an adaptive Web IR system. It uses a sophisticated user model to adaptively filter and reorder search results returned by the AltaVista search engine. WIFS uses explicit user ranking of search results to update the long-term user model. The approach to combine a query and a user model implemented in WIFS is most typical for adaptive Web IR, however, there are at least two other known approaches. One is *adaptive query expansion* (or *reformulation*) where an adaptive system adds specific keywords to the user query before submitting it to the engine (Parent, Mobasher and Lutinen, 2001). Another is *meta-search* where an adaptive system uses the long-term model to select most relevant search engines for the current query of the user (Mori and Yamada, 2000).

3.3. HYPERTEXT BROWSING

As any hypertext or hypermedia system the Web supports browsing, a way to access information that is complementary to searching and filtering. In the context of browsing, the user navigates from page to page in the hyperspace of information using links. An adaptive system in this context observes user browsing behavior, builds a model of user interests, and assists the user by providing *adaptive navigation support* (Brusilovsky, 2001). Generally, adaptive navigation support can be provided in the form of direct guidance, hiding, sorting, annotation, and generation. HYPERFLEX system (Kaplan, Fenwick and Chen, 1993) – that is probably the oldest example of adaptive navigation support in an information access context – applied adaptive sorting. In Web context, the two most popular forms of adaptive navigation support are annotation and generation. Among early Web-based navigation support systems, Personal Web Watcher (Mladenic, 1996) and Siskill and Webert (Pazzani, Muramatsu and Billsus, 1996) provided adaptive annotation while WebMate (Chen and Sycara, 1998) and SiteIF (Stefani and Strapparava, 1998) provided adaptive link generation that, in the context of information access, is also known as link recommendation.

The paper (Magnini and Strapparava, 2004) in this special issue presents an elaborated version of the SiteIF that supports a user navigating a news Web site. The innovation introduced in the paper concerns an original linguistic technique exploited in order to disambiguate natural language text (more specifically polisemic terms) and to identify in a more precise way the topic(s) dealt with in the text of the news. Observing the user navigation (clickstream), SiteIF builds a very sophisticated model of user interests. The model is then used to adaptively generate (recommend) links to most relevant news pages available on the Web site. Site-based link generation used in SiteIF provides a very reliable context for link generation. This context also helps us understand that adaptive link generation is very similar to adaptive information filtering.

3.4. INFORMATION VISUALIZATION

Information visualization is similar to hypertext in the sense that it allows the user to 'browse' through information rather than formulate search profiles and queries. However, unlike in classic hypertext where the user navigates through information page by page, information visualization allows the user to observe many documents at the same time. These documents are usually presented in two or three dimensions where relative positioning of documents can be used to present different relationships between them and various visual cues can be used to present information about documents. This higher expressive power of information visualization is usually complemented by a higher level of interactivity: most information visualization systems allow the user to manipulate the presented documents observing the changes in visualization. In the context of information access, information visualization has been originally explored in conjunction with ad-hoc retrieval. Such pioneer systems as VIBE (Olsen et al., 1993) and Envision (Fox et al., 1993) have demonstrated the benefits of both using more than one dimension to present search results and interacting with these results. The Lighthouse system (Leuski and Allan, 2004) presented in this special issue provides an inspiring example of using *adaptive information visualization* to explore results returned by a search engine. In adaptive information visualization, the user model can influence the visualization presented to the user, while user interaction with information is used to update this model. Adaptive visualization is certainly a very attractive approach to adaptive information access since it has both a higher expressive power for presenting adaptation results and a higher level of interactivity than can be used for better user modeling. Both of these aspects are clearly demonstrated by the Lighthouse system.

4. Adaptive Information Access: The Prospects

We are moving towards a new way of being informed in the knowledge society: new personalized tools for information access are coming. The future generation of information access tools will offer a better way to deal with the information overload by blending multiple ways of information access with adaptation to individual needs and interests. These tools will handle 'oversupply' of both text-based data and multimedia information. The 'information factories' of the future (Tasso and Omero, 2002) will exploit the flow of data coming from the digital information space as raw materials and transform them into 'information goods' by providing personalized information services to communities and citizens.

The papers included in this Special Issue show four different relevant paths to this future; four ways to build innovative personalized tools capable of identifying and selecting the right and relevant information, in the right moment, without waste of time and cognitive activities. Altogether the Special Issue provides a good introduction to the state of the art in adaptive information access. We hope that it will encourage further research on adaptive information access bringing us closer to the achievement of the ambitious goal of improving dramatically the current state of the art of information access and retrieval technologies.

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