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User-centric adaptation of Web information for small screens ☆

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ABSTRACT

A global increase in PDA and cell phone ownership and a rise in the use of wireless services lead mobile browsing to become an important means of Internet access. However, mobile devices have a small screen, which limits the usability of mobile browsing. This paper presents a novel method that automatically adapts a desktop presentation to a mobile presentation, proceeding in two steps: detecting boundaries among different information blocks (i.e., page segmentation) and then generating a user preferred adaptive layout. Distinct from other approaches, our approach analyzes both the DOM structure and the visual layout to detect closely related contents. In the process of page segmentation, our approach first divides a Web page into several common areas (such as top, bottom, and main content), and then further identifies different topics in the main content based on the visual and structural analysis. The page segmentation produces a block tree, which represents the information organization underlying a Web page. Based on the block tree, an adaptive layout, which places closely related information in proximity and minimizes scrolling, is automatically generated. All current approaches support only one fixed style (e.g., a narrow-page style) to render an adaptive layout for a diverse range of users, Websites, and devices. This "one size fits all" strategy could not offer universal usability. Our approach supports a user to flexibly specify the style of an adaptive layout according to his/her personal preferences. The theoretical foundation of such a user-centric adaptive layout is a feature space, which specifies an adaptive layout from different aspects, such as the location and presentation of navigation options. A user can visually manipulate those features to create a personalized style in a graphical user interface, and then an adaptive layout consistent with the personalized style is automatically generated. The user study based on a prototype shows the usability and efficiency of mobile browsing are significantly improved.

1. Introduction

Using handheld devices like mobile phones and personal digital assistant (PDAs) is very common today. A PDA equipped with a wireless network connection and a Web browser can access Internet from anywhere at any time. The ubiquitous access to Web information, however, raises a new challenge to efficient mobile browsing. Currently, most Web pages are designed for personal computers. Without an adaptation, it is frustrating to browse those pages on mobile devices since users have to frequently scroll the display window to find the content of interest.

Markup languages, such as WML and XHTML Mobile Profile (XHTML-MP), have been proposed to support the rendering of information on mobile devices. Though the number of Web pages in the form of WML or XHTML is growing fast, Web pages tailored to personal computers

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still dominate the Internet. Furthermore, keeping two versions of presentations, one for desktops and the other for mobile devices, raises the maintenance cost and causes inconsistencies. Therefore, it is desirable to automatically adapt a Web page from a desktop presentation to a mobile one.

In order to effectively browse desktop presentations on mobile devices, we must first address the challenging issue of detecting closely related information within an HTML Web page (usually called *page segmentation*). In general, existing approaches for page segmentation can be classified into two categories: (a) structure-based approaches [2,9,13,20] that analyze the HTML elements and Web page structure and (b) layout-based approaches [5,11,12,29,30]that analyze the Web page layout. The structure-based approaches, however, cannot effectively handle the irregularity of HTML usages by different Web designers. For example, the main usage of tables in HTML is to organize and display tabular data, implying that information enclosed in a table is closely related. By not displaying the table border, many designers use a table as an organization grid to layout pictures and texts. In this case, the information enclosed in a table may not necessarily be semantically relevant. On the other hand, inconsistent layout templates can cause a false detection in layout-based approaches. For instance, one layout template may place navigation menus at the top of a Web page while another one prefers navigation menus on the left side.

Distinct from other methods, our approach analyzes both the structural and the visual information of a Web page to detect related content. Briefly, the page segmentation in our approach first recognizes common areas in a Web page, such as navigation bars and the main content, by analyzing the overall layout of a Web page. The recognized navigation links and menu bars are used to construct a global navigation in an adaptive layout, providing quick access to different topics within a Website. Then, the main content in a Web page is further divided into different topics based on a set of heuristic rules that summarize common patterns used to organize and present information from the perspectives of DOM structure and visual layout.

The process of page segmentation generates a block tree, which models a hierarchical information organization within a Web page. Based on the block tree, we can produce an adaptive layout, which places closely related information in proximity and minimizes scrolling. However, all current approaches support only one fixed style (e.g., a narrow-page style in Opera Mini or a multi-page style [28]) to render an adaptive layout for a diverse range of users, Websites, and devices. This "one size fits all" strategy could not offer universal usability. Even regardless of user preferences, one fixed style could not cater for the proliferation of diverse types of mobile devices with different display and computing capacities. For example, a thumbnail-based adaptive style cannot fit on an old cellular phone which does not support graphics. Therefore, it is desirable to provide a user-centric adaptive layout, which can intelligently produce an adaptive presentation upon user preferences, browsing environment (e.g., the resolution of a mobile device) and the information being accessed (e.g., reading news stories or browsing products online).

One straightforward solution is to predefine a set of adaptive styles, from which a user can select one that fits his/her personal interest best. However, this solution lacks the flexibility of allowing users to customize a predefined style or even create a new style. We have analyzed existing adaptive styles and summarized a set of fundamental features (i.e., a feature space) underlying those styles. Those features specify the adaptive-layout styles from two perspectives: (1) content presentation and (2) navigation facility. Based on the feature space, each combination of values of those features uniquely identifies an adaptive style. Instead of selecting a predefined style, a user visually manipulates those features to define a customized style. Then, our approach generates an adaptive layout, consistent with the user-defined style. In order to allow users to switch between different topics, the adaptive layout includes an efficient navigation facility, which gives an overview of information being accessed and provides a quick access to a specific topic for a detailed reading. Furthermore, our approach allows end users to remove clutters (such as advertisements) in adaptive layouts.

A prototype, called small screen device browser—*SSD browser*, has been developed to implement our approach. The evaluation result shows that the browsing efficiency and user satisfaction have been increased.

The work reported in this paper is extended from a short conference paper [1]. This paper, however, gives a more complete description of our approach, and presents a theoretical foundation to support multi-styles adaptation. In summary, our contributions can be summarized as the following:

- We summarize a set of heuristic rules, used to detect closely related information from the perspectives of both DOM structure and visual layout. Such a hybrid analysis can overcome the limitations of a pure structural or visual layout analysis.
- Our approach provides an efficient navigation facility. We organize navigation links in two levels: the global level and the local level. The global navigations take advantage of existing navigation links (such as a navigation bar) in the original Web pages while the local navigations are made up of a table of content, providing a quick switch between different topics within a Web page.
- Our approach is featured by a user-centric layout, allowing end users to customize/create an adaptive style based on their personal preferences, rather than just selecting a predefined style. The foundation of our approach is a feature space, which defines adaptive styles from different aspects. Based on the feature space, an end user interacts with a graphical user interface to visually manipulate those features to create a personalized adaptive style.

The rest of this paper is organized as follows: Section 2 gives an overview of our approach; Section 3 describes a set of heuristic rules and discusses page segmentation;