

AWRT: A Recommender System for Improving Revisiting Web Pages

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Abstract— Web revisit has become one of the dominant phenomena in the web. Nevertheless, standard revisit features in typical web browsers currently do not significantly support this phenomenon. Various efforts, therefore, have been carried out to provide web users with approaches for facilitating web revisit. However, these approaches burden users with management tasks such as flagging and marking. This paper presents a novel approach, called the Adaptive Web Revisit Tool (AWRT), which helps facilitate revisiting web pages without involving users with any actions. In a similar way to the recommendation systems of well-known e-commerce websites, pages that are most likely to be revisited are adaptively recommended to users based on three attributes: frequency of visits, relation to current web page, and time per visit. AWRT consists of three main features: most visited pages (MVP), related pages (RP) and browsing behavior pages (BBP). AWRT was evaluated in terms of efficiency and usability using logging files and a satisfaction questionnaire. The results demonstrated an overall high rate of revisiting using AWRT when compared to a typical web browser i.e. Internet Explorer (IE) and a high users' satisfaction was demonstrated as well. Therefore, incorporating recommendation systems and adaptive techniques such AWRT can significantly improve web revisit.

Index Terms— adaptive, HCI, system, revisit, recommender, usability, web

I. INTRODUCTION

Web revisit, the process of visiting a web page which has been already visited before, has become one of the most important topics in the web literature. Nowadays, using the web has dramatically changed due to the vast expansion of the World Wide Web and the abundance of information in it. Currently, web revisiting is one of the predominant activities carried out in the web. Previous studies [1, 2] demonstrated a low rate of visiting new web pages and indicated users continually visit pages they have visited before. In spite of this great expansion and change in web usage, the design of web browsers is almost the same since they were first invented. For example, standard revisit tools (i.e. bookmarks, history, and back button) in current web browsers have not significantly changed and still work the same way they did when first presented in web browsers. Furthermore, bookmarks were not found to be used effectively. For instance, various studies showed that bookmarks contain

large numbers of pages where high rate of duplication or unavailable pages are existed.

Several efforts were carried out to enhance and facilitate web revisit. These efforts can broadly be categorized into the following two categories: improving typical revisit features and developing new approaches for web revisit. Studies in the first category tried to augment standard revisit features with additional features, for example, adding reminders in bookmarks or changing the behavior of the back button.

The studies in the latter category focused on developing new approaches that work together with the web browser to better support web revisiting. Most of these approaches based on marking and highlighting pages content. Also, several studies utilized graphical metaphors for enhancing web revisit such as “dog ear” folding and thumbnails. However, the majority of these approaches burden the user with organizational and management tasks such as linking, flagging, or highlighting although it has been demonstrated that users usually do not manage their bookmarks regularly. In addition, users' objectives and preferences change from time to time, so most flagged or marked pages in such approaches would not be used effectively. Therefore, developing an approach that would help improving web revisit without overwhelming users with management tasks is highly desirable.

The potentials of users' modeling techniques, particularly adaptive and recommendation systems have been clearly shown in different domains such as e-learning, social networks, and e-commerce. This paper tries to fill this gap in the literature by proposing an approach that helps improving web revisit by adopting users' modeling techniques. This proposed approach, called the Adaptive Web Revisit Tool (AWRT), automatically recommends to users web pages that are most likely to be revisited. Pages are recommended here from users' personal history and bookmarks using three parameters: frequency of visits, relation, and time per visit.

The main aim of this paper to investigate whether users' modeling techniques, particularly those implemented in AWRT, can help facilitate web revisiting. Before describing AWRT, the paper starts by highlighting some of the relevant studies in recommendation systems and web revisit. Then the

design and implementation of AWRT are presented, followed by describing the methodology adopted for evaluation. The paper next illustrates the quantitative and qualitative results. Afterward, the paper discusses the obtained results and tries to interpret them into design guidelines that should be taken into account when developing approaches employing users' modeling techniques for enhancing web revisit. Finally, the paper concludes with final remarks and directions for future work.

II. RELATED WORK

A. Recommendation Systems

People behave in different ways; this makes the development of software that satisfies all users' objectives and needs challenging. Therefore, systems that understand users' behavior and differences are in high demand [3]. Typically, these types of systems employ user modelling techniques which can be defined as the process of obtaining knowledge about users to provide them with services adopted to their needs and requirements [4]. It also can be defined as an internal representation of user characteristics such as mood, gender, and interests [5]. User modelling can also be adopted in an application by collecting information about users. This information can be obtained by different ways, such as asking users questions and observing their actions [6]. User modelling can be incorporated into user interface using three major techniques: personalization, customization, and mixed-initiative approaches. Furthermore, the use of adaptive techniques is a well-known approach of personalization and its potential is documented [7].

One of the widely used types of adaptive techniques is recommendation systems. The main role of such systems is to provide users with the most appropriate functions or products among large catalogues [8]. These types of systems typically depend on two types of techniques for recommendations: content-based recommendation and collaborative filtering [9]. Recommendations in the systems adopting content-based technique employ the users' past activities such as web objects, history, and profile [10]. On the other hand, the latter technique is usually adopted in multi-user environments and recommendations are based on their history and ratings of objects. Currently, recommendation systems are used in a daily basis in several domains such as hotel and flight booking, learning, and purchasing or renting a property. Fab, for instance, is one of the earliest recommendation systems in the literature [11]. The main idea of the system is to recommend to users web pages relevant to specific topics in a digital library. The recommendations here go through two main phases: collection of items (i.e. dataset creation) and selection of items from the created dataset. Fab consists of three main components, namely selection agent, central router, and collection agent [11].

Recently, numerous studies were carried out to investigate the utilization of recommendation systems in several research fields. For instance, recommendation

systems were largely utilized by researchers to improve the efficacy and usability of e-learning systems. In such studies, learners and instructors are generally recommended with the most relevant and appropriate learning materials.

For example, Ghauth and Abdullah proposed a novel framework for recommending learning materials to learners [12-14]. Recommendations in this framework were based on content analysis for determining similar documents and good ratings by learners to ensure the quality of recommended documents. One of the limitations of their work is that no usability evaluation was carried out to test the usefulness of the proposed framework.

Leyla et al., on the other hand, developed different e-learning recommendation framework which recommends to users lectures and multimedia sources when searching learning repositories [9]. They used rule-based filtering together with ontology content-based filtering in this framework. They carried out an experimental evaluation to measure the recall and precision and the results demonstrated high potential elements for improving e-learning retrieval systems.

Furthermore, Shelton et al. proposed an open-source platform called Folksemantic which integrates the functionalities of OpenCourseWare, open education resources recommendations, and social networks [15]. This was implemented by adding a small frame of HTML containing the recommend related resources. The main features of Folksemantic are the translation of OCW interface into additional languages as well as providing personal recommendations, as users are allowed to register their feeds such as blogs and bookmarks [15].

Recommendation systems were also widely utilized for improving social network systems such as Twitter and Facebook. Various studies [16-18] employed recommendation techniques to link between users' personal messages and interests with public trends such as blogs and news. On the other hand, some studies [19-21] focused on recommending people based on their relationships and profiles.

Recommendation systems were also found to contribute significantly to the current enhancement of multimedia browsing portals. For instance, various music recommendation systems [22, 23] were proposed in the literature. Such systems usually recommend users with the most relevant music based on several characteristics such as users' browsing history as well as metadata like track, album, and artist. Furthermore, James et al. discussed the mechanism and challenges of the recommendations used in the well-known video website YouTube.com [24]. For example, a lack of video clip metadata and the short length of videos were highlighted as the most important challenges during the implementation of the YouTube recommender system. Moreover, they pointed out that recommendations were based on two types of information: video content like streams and metadata, and users' activities such as ratings and interaction.

The benefits and advantages of recommendation systems are not limited to these research fields, however. They have extended into various recent domains such as e-commerce [25, 26] and mobile applications [27-30].

B. Web Revisit

Web revisiting has become one of the essential activities in web browsing, especially with the vast expansion of the World Wide Web. Tauscher and Greenberg, for example, pointed out that 58% of the visited web pages have been visited before [2]. Three years later, Cockburn and McKenzie found that the rate of web revisiting had notably increased: 81% of visited pages had been visited previously [1]. Therefore, an enormous number of studies was devoted to investigating how to facilitate the process of revisiting web pages.

For instance, several efforts started in approximately 1999 to improve the “back” button. It is one of the most frequently used methods for revisiting web pages in almost all typical web browsers. Web pages can be revisited using this button with a simple method called stack-based behaviour [31-33].

Greenberg and Cockburn [32] investigated how the button is used and discovered this behaviour is error prone. Users became confused when asked about pages that would be displayed after clicking the back button. Therefore, the researchers proposed several techniques for improving revisit web pages using the back button. These techniques rely solely on recent web pages [32], which can be revisited in reverse order.

On the other hand, Shaun and Saul [33] proposed an alternative way for revisiting pages by integrating the back button, history, and bookmarks. In this study, a novel tool that presents previously seen pages in reverse order was developed. Web pages can also be folded using the “dog ear” technique [34]. However, the proposed solution was not evaluated in terms of usability, functionality, and users' acceptance. Moreover, the lack of functionalities and features in the back button inspired researchers to develop and investigate new revisit approaches.

Bookmarks, for instance, are among the dominant features used for revisiting web pages because of their integration in most of the typical web browsers. Abrams, of the vast growth of the bookmark archive (i.e. number of bookmarked pages), a majority of users do not manage their bookmarks. Furthermore, Cockburn and McKenzie noticed that a high rate of adding web pages into bookmarks which face relatively very low deletion will most likely lead to managing difficulties and usability problems [1]. For example, some users in this study had duplicate pages in their bookmarks as well as a high percentage of invalid pages (approximately 25%). Therefore, several efforts were made to augment bookmarks with advanced web revisit features or find alternative approaches.

Baecker, and Chignell [35] conducted a study to analyze and investigate how bookmarks are being used. The results highlighted that the bookmark is one of the main methodologies used for revisiting web pages because of several reasons, such as ease of use,

usefulness, quality, and future use. The results also demonstrated that in spite For example, Denoue and Vignollet in [36] developed an annotation tool, called YAWAS, wherein users can highlight text or a specific part of a web page and add comments on it. When web pages containing annotated text are revisited, all annotations are automatically displayed with a yellow highlight. One of the limitations of YAWAS is that highlighted text is most likely get forgotten as the tool does not provide a list for exploring all annotated text and depends mainly on revisiting the web page (i.e. “out of sight, out of mind”).

In a similar work, MacKay, Kellar and Watters developed an Internet Explorer (a common web browser) add-on called LANDMARKS for marking information within web pages [37]. They called marked areas of web pages “landmarks” and listed them with bookmarks preceded by a flag symbol. They carried out an experiment to investigate the effectiveness of their system and the results demonstrated that “landmarks” outperform traditional bookmarks in terms of time to re-find information and users' satisfaction.

Graphical representations and visualization techniques were also extensively employed by researchers to enhance web revisiting. The presentation of web pages in bookmarks and browser history has been augmented by graphical features such as “dog ear” folding techniques and thumbnails. Kaasten, Greenberg, and Edwards [38], for example, carried out an experiment to investigate the most effective way of

Presenting web pages in bookmarks. The main aim of the study was to compare the recognition levels of thumbnails among different images size and textual titles and URLs among different string length. To achieve this goal, they introduced a tool that presents pages thumbnailed in different sizes. The results indicated a strong relationship between image size, text length, and recognition rate.

Furthermore, Hightower and others [39, 40] implemented an add-on tool called PadPrints, which presented previously seen pages in a dynamic tree. A multi-scale feature was also implemented in PadPrints to display pages with images and text to fit in the screen. The authors conducted several usability experiments to test the effectiveness of PadPrints. The results showed that it helped users revisit web pages with significantly reduced time and number of pages accessed when compared to typical browsing approaches.

Moreover, Tabard et al. [41] also developed an extension tool, called PageLinker, that works together with web browser facilitate the process of web revisiting by linking related web pages together. PageLinker allows users to link currently opened web pages with the most recently opened web pages regardless of their content, based on manual linking and browser copy and actions. Their method presents relevant web pages contextually in the bookmark menu and sidebar. Although the results of the usability evaluation demonstrated a significantly reduced time with less access pages and errors as well, various issues arose that may affect the utilization of the

proposed tool. For instance, overwhelming users with the manual linking among web pages could make PageLinker obsolete after a while. The limitations and issues reported in the literature of bookmarks will most likely persist

with this method because of its use of integrating related pages with bookmarks.

However, Sorensen, Macklin, and Beaumont pointed out that proposed and developed tools for enhancing the

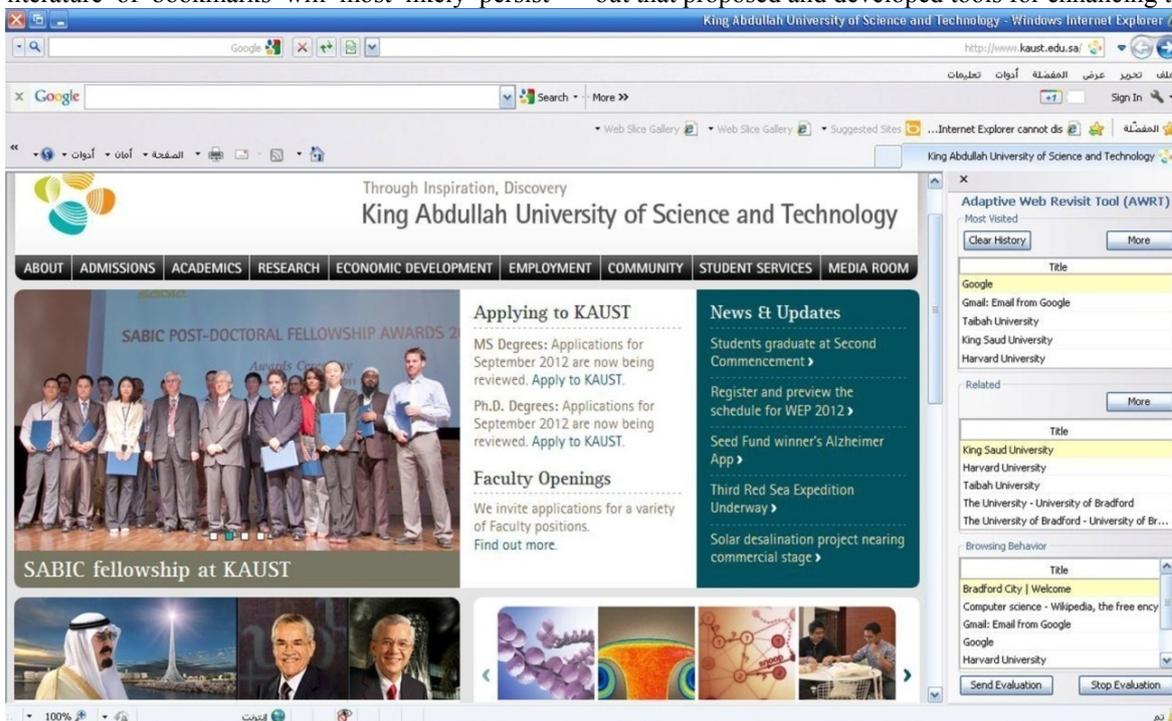


Figure 1. A screenshot of AWRT with an opened web page

web navigation including web revisit have not reached the mass market [42]. Furthermore, Obendorf et al. found in their study that web revisit is influenced by personal habits and the nature of visited web sites [43].

III. AWRT

An experimental tool called Adaptive Web Revisit Tool (AWRT) was developed to investigate whether users' modelling techniques, specifically adaptive and recommendation techniques, help facilitate web page revisit. It works with Internet Explorer ("IE") and has the ability to record all users' browsing activities. In a similar approach to that of most of the well-known commercial websites such as Amazon.com, AWRT recommends to users the most likely web pages that will be revisited. Recommendation in AWRT is based on three main attributes: frequency of use, relationship, and time per visit. These attributes were used together or alone for

Previously visited web page recommendations. AWRT runs automatically as slide bar when a new Internet Explorer instance starts and new tab or window is opened (see Figure 1).

Users' privacy was taken into account when developing AWRT: it can be disabled at any time in a similar way to closing other IE tabs. This disables the browsing behaviour recording. All recorded browsing behaviour can also be deleted by clicking on the button labelled "Clear History."

Figure 2 also shows that AWRT is divided into three main blocks. Each block represents a feature. The first

block, which presents Most Visited Pages (MVP), based solely on the frequency of visiting web pages for recommendation. In this section, the five most visited web pages are presented to the user in a grid table and ordered by number of visit. Recommended web pages can be opened in the same IE tab by clicking on its name from the grid table. The grid table can be extended with up to fifteen pages by clicking on the button labelled "More" located at the top of the most visited grid table (see Figure 2).

The second block presents Related Pages (RP), located at the middle of the slide bar, where users are recommended pages related to the currently opened web page. One of the advantages of this feature of AWRT is that web pages in the bookmarks are compared to the pages recorded in the history as such pages are most likely become obsolete. Relation, here, is predicted based on two attributes: keywords in the title of web pages and domain (e.g. gov, edu). Frequency of page visits is also taken into account for related web pages recommendations. More specifically, when a web page is visited, AWRT first compares its title with previously visited pages (i.e. history and bookmark) titles and counts the number of visits of each page. Then, the domain of the currently opened page is compared with previously visited pages' domains and number of visits to each page is counted, as well. A list of related web pages by title and domain is made and sorted by the number of their visits. Finally, the five most visited web pages in this list are recommended to users as related web pages (see Figure 2). Furthermore, more pages can be presented in

the grid table by clicking on the button located at the top of this table and labelled "More."

The block located at the bottom of the side bar presents one of the novel features of AWRT, which is Browsing Behaviour Pages (BBP). History is analysed here based on the frequency of visits and time per visit to predict the most likely web pages that will be visited. When a web page is opened, AWRT looks in the history



Figure 2. AWRT main features: a) Most Visited Pages (MVP), b) Related Pages (RP) and c) Browsing Behavior Pages (BBP)

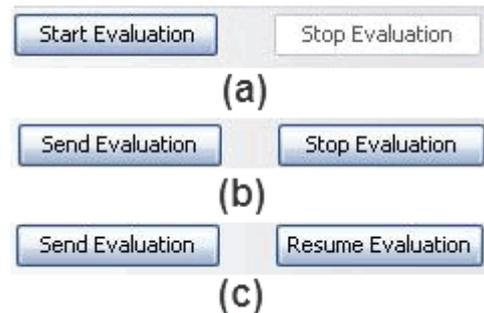
for all web pages visited within two hours of opening the current web page. Then these pages are sorted according to their frequency of visits. The five most visited web pages are presented in the history behaviour table grid (see Figure 2). Consequently, no web pages will be recommended if the current opened web page is visited for the first time. Moreover, more (i.e. up to fifteen pages) pages can be presented by clicking on the button labelled "More" located above the grid table.

IV. METHODOLOGY

The main aim of the study was to investigate whether the proposed adaptive web revisit tool (AWRT) can help facilitate revisiting web pages that have been previously visited. Finding the appropriate way to achieve this goal is challenging due to the differences in users' browsing habits. Various methodological alternatives were under consideration for the evaluation of the proposed experimental tool.

For instance, controlled experimentation was one of these alternatives. However, such a methodology could not be applicable to this study because of several reasons.

The first was the difficulty of setting representative experimental tasks that should be performed by subjects due to the variances in browsing habits. Second, short time sessions could not give meaningful results, as subjects usually need some time to get used to such tools. Gathering users' views using questionnaires and interviews was one of the methodologies considered for testing the aim of this study. However, depending solely



AWRT logging feature: a) evaluation and logging is stopped, b) evaluation and logging processes are started and c) evaluation process is started and logging is temporarily stopped

in such a methodology could not be the most applicable way because important information such as functionality issues, effectiveness, and efficiency cannot be reflected in such a methodology.

Logging users' browsing behaviour for a specific period [44] was believed to be the most appropriate way to evaluate the proposed experimental tool. Adopting such a methodology allows collecting important information about AWRT such as frequency and patterns of usage. Therefore, the logging feature was implemented in AWRT, where users' actions in the browser can automatically be recorded (see Figure 3). A log file containing information such as the ratio of using AWRT to built-in revisit components, frequency of usage, and errors occurred is generated for each user.

Users' privacy and confidentiality were taken into account when developing the logging feature. For instance, recording is initially stopped and can only be started if the button called "Start Evaluation" is clicked (see Figure 3). Furthermore, logging can be stopped at any time by clicking on the button labelled "Stop Evaluation" and resumed by clicking "Resume evaluation." Log files can be sent automatically in AWRT to the experimenter's personal email address by clicking on the button labelled "Send Evaluation."

AWRT was sent to thirty users working in the Information Technology Centre (ITC) at Taibah University at Medina, Saudi Arabia. All of them were Internet Explorer users and had at least ten years' experience in IT. It was sent to them together with a text file describing the installation process and requirements, and a video demonstration describing the usage of AWRT was sent as well. They were asked to use AWRT for at least one month. However, the minimum evaluation period was 16 days and the maximum was 45 days as users were allowed to end the evaluation and send the log

file at any time by clicking on the button labelled “Send Evaluation.”

Qualitative data was also collected by an online questionnaire in addition to the information elicited by log files. Users were asked to fill out this questionnaire after ending the evaluation. It consisted of thirty questions based on the USE questionnaire [45]. All

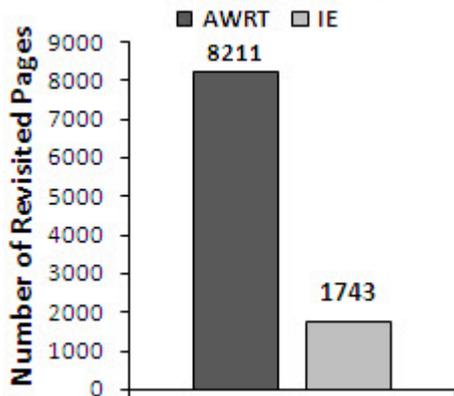


Figure 3. Total number of revisited pages through AWRT and IE

questions used a 1-5 Likert scale to indicate the users’ agreement on each question. A score of 1 indicated “strongly disagree” and 5 indicated “strongly agree.” Questions in the questionnaire were classified into four sections, namely usefulness (eight questions), ease of use (eleven questions), ease of learning (four questions) and satisfaction (seven questions).

V. RESULTS

The total number of recorded web pages during the evaluation period was 17,181 pages. The average total number of pages visited by each user was 572 pages, but an average of 306 pages a day. At first glance, it can clearly be noticed that the majority of visited pages were visited through Internet Explorer (52%). However, 80% of the pages were visited for the first time. These pages were excluded from the analysis to have a valid comparison between revisiting web pages using AWRT and typical revisit features. Furthermore, the collected data demonstrated high percentage of page revisit (57.9%). Also, the results showed the total number of revisited pages using AWRT was dramatically higher than IE. Figure 4 shows that 8,211 pages were revisited through AWRT and only 1,743 pages through IE. Chi-square analysis was applied to the number of revisited pages to investigate the significance of this difference. The results indicated that AWRT was used significantly more for web page revisit than IE ($\chi^2 = 4202$, $df = 1$, $p < 0.05$).

Further analysis was also performed to investigate which of the three features (i.e. MVP, RP, BBP) provided in AWRT was most useful. The total number of visited pages by each feature was calculated. Figure 5 shows that the number of visited pages through MVP was higher than RP and BBP. Meanwhile, BBP was also used more than RP. Chi-square analysis was applied here to investigate whether this difference is significant. The

results demonstrated that the difference of number of visited pages by each feature is significant ($\chi^2 = 806$, $df = 3$, $p < 0.05$).

The obtained data from questionnaires was also analysed to investigate users’ satisfaction on AWRT. To ensure the validity of the questionnaire and its internal consistency, Cronbach’s alpha was applied to the all

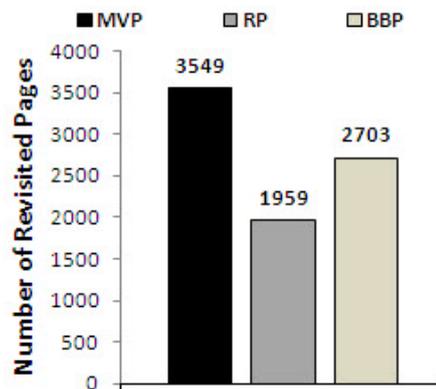


Figure 4. Total number of revisited pages through MVP, RP, and BBP

questions (i.e. overall reliability) and questions in each satisfaction factor independently. The results are shown in Table 1. It can clearly be noticed that Cronbach’s alpha is high in overall and in each factor (i.e. between 0.96 and 0.99). Ease of use had the lowest Cronbach’s alpha (0.96) and the overall reliability was the highest. Therefore, the overall reliability of the questionnaire and each user satisfaction factor is within an acceptable range as they exceeded the standard suggested by [46]. Furthermore, the overall mean of users’ responses towards AWRT was also calculated. The results demonstrated a high rate of users’ satisfaction (see Table 1).

Users’ responses in each satisfaction factor were analysed independently, as well. For instance, the majority of users agreed in most sentences related to usefulness. More specifically, 60% of users strongly agreed when they were asked about whether AWRT helped to be more effective, productive, and meets their needs. Also, 53% strongly agreed when they were asked if AWRT saves time. Furthermore, the percentage of users who agreed to other values of AWRT such as giving more control in daily activities and making tasks easier ranged from 33% to 43%. However, 63% of users were not sure (neutral) about whether AWRT was useful. 27% were not sure whether it did everything they expected. In overall, Table 1 shows that users were to a certain extent satisfied with AWRT in terms of usefulness.

Moreover, the majority of users responded positively to most of the statements related to ease of use. More specifically, the rates of “strongly agree” or “agree” were highest in all statements. For instance, 50% of users strongly agreed when they were asked about whether AWRT was easy to use (question number 9) and simple to use (question number 10). Also, 40% strongly agreed when they were asked about whether it was flexible and whether it can be used successfully. Furthermore, twenty-one (70%) users strongly agreed that it can be used without any written instructions. The percentage of users

who agreed that AWRT was flexible, user friendly, and can be used effortlessly ranged from 43% to 53%. However, 30% and 40% of users were not sure whether it was easy to use and simple to use, respectively, although a high percentage of users strongly agreed with these statements. Furthermore, only five users (16.7%) strongly

TABLE I.

CRONBACH RELIABILITY AND DESCRIPTIVE STATISTICS

Factor	Cronbach's α	Mean	Standard Deviation
Usefulness	0.98	3.78	1.31
Ease of Use	0.96	3.89	0.99
Ease of Learning	0.98	3.89	1.40
Satisfaction	0.98	3.53	1.35
Overall	0.99	3.78	1.19

disagreed that AWRT was flexible, user friendly, requires the fewest steps to accomplish tasks, will be liked by occasional and regular users, and can be used successfully.

Table 1 demonstrates that the overall average of users' response towards the ease of use was considerably high (i.e. the highest with ease of learning). Similarly, users' responses towards all statements related to ease of learning were positive. Specifically, 50% and 46% (the highest percentage of response) of users strongly agree that AWRT was easy to learn and can quickly become skilful in using it respectively. Only 16.7% of users strongly disagreed with these statements and none of them disagreed. Furthermore, 43% and 46% (the highest percentage of response) of users agreed that AWRT can be learned quickly and can easily be remembered how to use it. On the other hand, only 16.7% of users strongly disagreed with these statements where none of them rated as disagreed or neutral.

Surprisingly, users' response towards satisfaction statements, on the other hand, can be considered relatively low when compared to other factors. Table 1 also shows that the overall mean of users' response was the lowest. The percentage of "strongly agree" (SA) was over 40% when users were asked if they are satisfied with AWRT.

However, no major differences were found in the rest of the statements between the percentages of "neutral" and "agree." For example, the number of neutral users in four statements (i.e. statements 1, 2, 4, and 7) exceeds by a maximum of two users or is equal to those who agreed. Furthermore, 50% of users were not sure ("neutral") when they were asked about whether it was fun to use AWRT. However, the percentages of "strongly disagree" (SD) and "disagree" (D) did not exceed 16.7% in all related statements.

VI. DISCUSSION

The results demonstrated that most of the visited web pages were revisited, which confirms the results of previous studies in the literature [1, 2, 43]. In fact, almost

the same percentage of web revisit found by Tauscher and Greenberg was found in this study [2]. The means the development of new approaches that facilitate revisiting web pages is still demanding and worth investigation. The overall results also showed a high rate of AWRT usage when compared to standard features in IE. The number of revisited pages through AWRT exceeded the number of revisited pages through IE by approximately fourfold. Further, the high rate of users' satisfaction towards AWRT was also demonstrated. Automatically recommending users with the most likely pages that are going to be revisited is likely the main reason behind this high rate of usage and satisfaction. On the other hand, overwhelming users with flagging pages or creating a list of pages could negatively affect the usability of revisit tools. For instance, despite the fact that bookmarking is currently the main tool to revisit pages, various studies highlighted that it is not being used significantly.

The detailed analysis demonstrated that the MVP feature was the most used feature in AWRT. Obviously, because the most visited pages are presented here irrespective of the currently opened page. Also, the location of presenting such pages is one of the factors making it mostly used since they are presented at the top of the slide bar and within the eyes' boundaries. Accordingly, if a web page is presented here and in another block at the same time it will most likely be revisited from the MVP block. Nevertheless, one of the limitations of this feature is that it presents difficulties in changing pages because it depends only on frequency of visits and does not take into account the change of users' objectives over time.

BBP, on the other hand, was designed to take into account users' objectives and browsing activities. It was the second most used for revisiting web pages. Specifically, 32% of revisited pages using AWRT were visited via BBP. Despite the fact that users faced some difficulties understanding the way it works in the demonstration session, AWRT was rated as easy to learn. However, a more accurate algorithm may be implemented to enhance the utilization the area used for presenting such pages.

Although the RP feature was the least used in AWRT, the percentage of usage can initially be considered reasonable since it is introduced to users for the first time. Finding related pages by domain was straightforward and users found it accurate. Finding related pages by title, on the other hand, was difficult to implement because of the difficulties dealing with text and some users reported several unrelated web pages. However, the majority of users preferred the concept of this feature. Therefore, adopting a more accurate algorithm would help increase the usefulness and usability of such a feature.

Other factors can be taken into account when implementing these techniques, such as categories of web pages, where pages from the same categories are considered to be related. Furthermore, removing duplicate displays of web pages among the three features would give more space to present more pages. Overall, users' feedback about AWRT and experimental results

indicated that users' modelling techniques, particularly recommendation systems, can drastically change web revisit and can be significantly be employed to develop effective alternatives of standard approaches.

VII. CONCLUSION

This paper presented a novel approach, called AWRT, which was developed to enhance revisiting web pages. In a similar way to the recommender systems of well-known websites such as Amazon.com, it automatically recommends to users pages that are will most likely be revisited. Recommendations in AWRT are based on analysing users' previously opened web pages (i.e. bookmark and history) by taking into account three main attributes. These are frequency of visit, relation, and time per visit. It consisted of the following three features: Most Visited Pages (MVP) which solely depended on frequency of visiting web pages; Related Pages (RP) which depended on frequency of visits and relation to currently opened web page; and Browsing Behaviour Pages (BBP), which depended on frequency of visits and time per visit.

The efficiency and usability of AWRT was measured by adopting logging files and the USE questionnaire. The results demonstrated that AWRT was dramatically more used for revisiting web pages than standard features in typical web browsers. Therefore, recommendation systems such as AWRT can significantly enhance revisiting web pages. However, MVP and BBP were found to be more used for revisiting pages than the RP feature. Hence, further investigation will be carried out to improve AWRT by adopting more accurate algorithms for recommending web pages.

VIII. ACKNOWLEDGEMENT

This research project is funded by Taibah University, Deanship of Research, under Grant number 432/414. I would also like to thank Oussama Al Jendoubi for his help and support in implementing the proposed tool.

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