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Creating Adaptive Web Sites through User Navigation

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Abstract: **Designing well-structured websites to facilitate effective user navigation has long been a challenge. A primary reason is that the web developers' understanding of how a website should be structured can be considerably different from that of the users. While various methods have been proposed to relink WebPages to improve navigability using user navigation data, the completely reorganized new structure can be highly unpredictable, and the cost of disorienting users after the changes remains unanalyzed. This paper addresses how to improve a website without introducing substantial changes. Specifically, we propose a mathematical programming model to improve the user navigation on a website while minimizing alterations to its current structure. Results from extensive tests conducted on a publicly available real data set indicate that our model not only significantly improves the user navigation with very few changes, but also can be effectively solved. In addition, we define two evaluation metrics and use them to assess the performance of the improved website using the real data set. Evaluation results confirm that the user navigation on the improved structure is indeed greatly enhanced. More interestingly, we find that heavily disoriented users are more likely to benefit from the improved structure than the less disoriented users.**

Key words: **WebPages, MP, out degree, user navigation, web mining, programming, Website design**

1. INTRODUCTION

The advent of the Internet has provided an unprecedented platform for people to acquire knowledge and explore information. Despite the heavy and increasing investments in website design, it is still revealed, however, that finding desired information in a website is not easy and designing effective websites is not a trivial task. Galletta et al. indicate that online sales lag far behind those of brick and- mortar stores and at least part of the gap might be explained by a major difficulty user's encounter when browsing online stores.

A primary cause of poor website design is that the web developers' understanding of how a website should be structured can be considerably different from those of the users. Such differences result in cases where users cannot easily locate the desired information in a website. This problem is difficult to avoid because when creating a website, web developers may not have a clear understanding of users' preferences and can only organize pages based on their own judgments. However, the measure of website effectiveness should be the satisfaction of the users rather than that of the developers. Thus, WebPages should be organized in a way that generally matches the user's model of how pages should be organized. Our work, on the other hand, is closely related to the literature that examines how to improve website navigability through the use of user navigation data. Various works have made an effort to address this question and they can be generally classified into two categories: to facilitate a particular user by dynamically reconstituting pages based on his profile and traversal paths, often referred as personalization, and to modify the site structure to ease the navigation for all users, often referred as transformation. In this paper, we are concerned primarily with transformation approaches. The literature considering transformations approaches mainly focuses on developing methods to completely reorganize the link structure of a website. Although there are advocates for website reorganization approaches, their drawbacks are obvious. First, since a complete reorganization could radically change the location of familiar items, the new website may disorient users . Second, the reorganized website structure is highly unpredictable, and the cost of disorienting users after the changes remains unanalyzed. This is because a website's structure is typically designed by experts and bears business or organizational logic, but this logic may no longer exist in the new structure when the website is completely reorganized. Besides, no prior studies have assessed the usability of a completely reorganized website, leading to doubts on the applicability of the reorganization approaches. Finally, since website reorganization approaches could dramatically change the current structure, they cannot be frequently performed to improve the navigability.

Recognizing the drawbacks of website reorganization approaches, we address the question of how to improve the structure of a website rather than reorganize it substantially. Specifically, we develop a mathematical programming (MP) model that facilitates user navigation on a website with minimal changes to its current structure. Our model is particularly appropriate for informational websites whose contents are static and relatively stable over time. Examples of organizations that have informational websites are universities, tourist attractions, hospitals, federal agencies, and sports organizations. Our model, however, may not be

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appropriate for websites that purely use dynamic pages or have volatile contents. This is because a steady state might never be reached in user access patterns in such websites, so it may not be possible to use the weblog data to improve the site structure.

We perform extensive experiments on a data set collected from a real website. The results indicate that our model can significantly improve the site structure with only few changes. Besides, the optimal solutions of the MP model are effectively obtained, suggesting that our model is practical to real-world websites. We also test our model with synthetic data sets that are considerably larger than the real data set and other data sets tested in previous studies addressing website reorganization problem. The solution times are remarkably low for all cases tested, ranging from a fraction of second to up to 34 seconds. Moreover, the solution times are shown to increase reasonably with the size of the website, indicating that the proposed MP model can be easily scaled to a large extent.

To assess the user navigation on the improved website, we partition the entire real data set into training and testing sets. We use the training data to generate improved structures which are evaluated on the testing data using simulations to approximate the real usage. We define two metrics and use them to assess whether user navigation is indeed enhanced on the improved structure. Particularly, the first metric measures whether the average user navigation is facilitated in the improved website, and the second metric measures how many users can benefit from the improved structure. Evaluation results confirm that user navigation on the improved website is greatly enhanced.

In summary, this paper makes the following contributions. First, we explore the problem of improving user navigation on a website with minimal changes to the current structure, an important question that has never been examined in the literature. We show that our MP model not only successfully accomplishes the task but also generates the optimal solutions surprisingly fast. The experiments on synthetic data indicate that our model also scales up very well. Second, we model the out-degree as a cost term in the objective function instead of as hard constraints. This allows a page to have more links than the out-degree threshold if the cost is reasonable and hence offers a good balance between minimizing changes to a website and reducing information overload to users. Third, we propose two evaluation metrics and use them to assess the improved structure to confirm the validity of our model. The evaluation procedure developed in this paper provides a framework for evaluating website structures in similar studies.

2. IMPLEMENTATION

we propose a mathematical programming model to improve the user navigation on a website while minimizing alterations to its current structure. Results from extensive tests conducted on a publicly available real data set indicate that our model not only significantly improves the user navigation with very few changes, but also can be effectively solved. In addition, we define two evaluation metrics and use them to assess the performance of the improved website using the real data set. Evaluation results confirm that the user navigation on the improved structure is indeed greatly enhanced. More interestingly, we find that heavily disoriented users are more likely to benefit from the improved structure than the less disoriented users. In this proposed system following Modules are used

2.1. Web Personalization.
2.2. Web Transformation.
2.3. Maximal Forward Reference.
2.4. Mini Sessions.
2.5. Out-Degree Threshold.

2.1. ***Web personalization:*** Web personalization is the process of "tailoring" WebPages to the needs of specific users using the information of the users' navigational behavior and profile data. Perkowitz and Etzioni describe an approach that automatically synthesizes index pages which contain links to pages pertaining to particular topics based on the co-occurrence frequency of pages in user traversals, to facilitate user navigation. The methods proposed by Mobasher et al. and Yan et al. create clusters of users profiles from weblogs and then dynamically generate links for users who are classified into different categories based on their access patterns.

2.2. ***Web transformation:*** Web transformation, on the other hand, involves changing the structure of a website to facilitate the navigation for a large set of users instead of personalizing pages for individual users. Fu et al. describe an approach to reorganize web pages so as to provide users with their desired information in fewer clicks. However, this approach considers only local structures in a website rather than the site as a whole, so the new structure may not be necessarily optimal. Gupta et al. [19] propose a heuristic method based on simulated annealing to relink web pages to improve navigability. This method makes use of the aggregate user preference data and can be used to improve the link structure in websites for both wired and wireless devices.

2.3. ***Maximal Forward Reference:*** We use backtracks to identify the paths that a user has traversed, where a backtrack is defined as a user's revisit to a previously browsed page. The intuition is that users will backtrack if they do not find the page where they expect it . Thus, a path is defined as a sequence of pages visited by a user without backtracking, a concept that is similar to the maximal forward reference defined in Chen et al. Essentially, each backtracking point is the end of a path. Hence, the more paths a user has traversed to reach the target, the more discrepant the site structure is from the user's expectation.

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2.4. ***Mini Sessions:*** Recall that a mini session is relevant only if its length is larger than the corresponding path threshold. Consequently, only relevant mini sessions need to be considered for improvement and this leads to a large number of irrelevant mini sessions (denoted as TI) being eliminated from consideration in our MP model.

2.5. ***Out-Degree Threshold:*** Web pages can be generally classified into two categories: index pages and content pages. An index page is designed to help users better navigate and could include many links, while a content page contains information users are interested in and should not have many links. Thus, the out-degree threshold for a page is highly dependent on the purpose of the page and the website. Typically, the out degree threshold for index pages should be larger than that for content pages.

3. INPUT & OUTPUT DESIGN

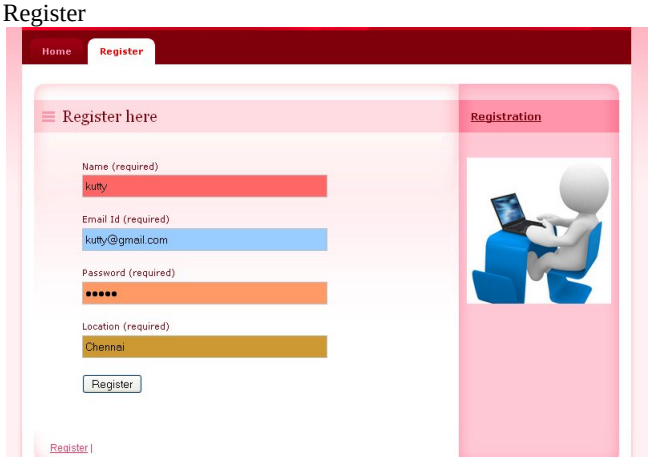
3.1. ***Input Design:*** The input design is the link between the information system and the user. It comprises the developing specification and procedures for data preparation and those steps are necessary to put transaction data in to a usable form for processing can be achieved by inspecting the computer to read data from a written or printed document or it can occur by having people keying the data directly into the system. The design of input focuses on controlling the amount of input required, controlling the errors, avoiding delay, avoiding extra steps and keeping the process simple. The input is designed in such a way so that it provides security and ease of use with retaining the privacy. Input Design considered the following things Objectives of Input Design is

- The process of converting a user-oriented description of the input into a computer-based system. This design is important to avoid errors in the data input process and show the correct direction to the management for getting correct information from the computerized system.
- It is achieved by creating user-friendly screens for the data entry to handle large volume of data. The goal of designing input is to make data entry easier and to be free from errors. The data entry screen is designed in such a way that all the data manipulates can be performed. It also provides record viewing facilities.
- When the data is entered it will check for its validity. Data can be entered with the help of screens. Appropriate messages are provided as when needed so that the user will not be in maize of instant. Thus the objective of input design is to create an input layout that is easy to follow

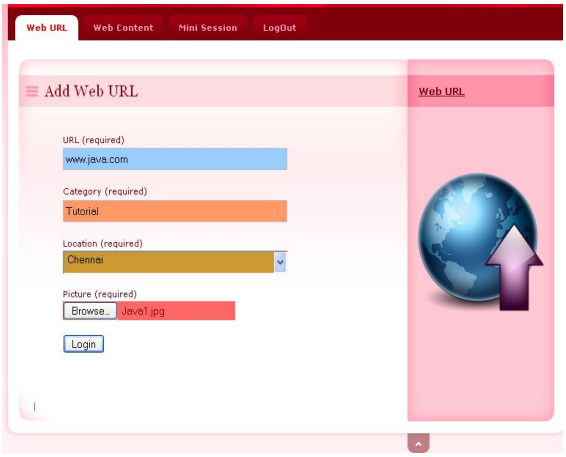
3.2. ***Output Design:*** A quality output is one, which meets the requirements of the end user and presents the information clearly. In any system results of processing are communicated to the users and to other system through outputs. In output design it is determined how the information is to be displaced for immediate need and also the hard copy output. It is the most important and direct source information to the user. Efficient and intelligent output design improves the system's relationship to help user decision-making. Designing computer output should proceed in an organized, well thought out manner; the right output must be developed while ensuring that each output element is designed so that people will find the system can use easily and effectively. When analysis design computer output, they should Identify the specific output that is needed to meet the requirements. Select methods for presenting information. Create document, report, or other formats that contain information produced by the system.
The output form of an information system should accomplish one or more of the following objectives. Convey information about past activities, current status or projections of the Future. Signal important events, opportunities, problems, or warnings. Trigger an action. Confirm an action.

4. SCREEN SHOTS

Register



Add webpage



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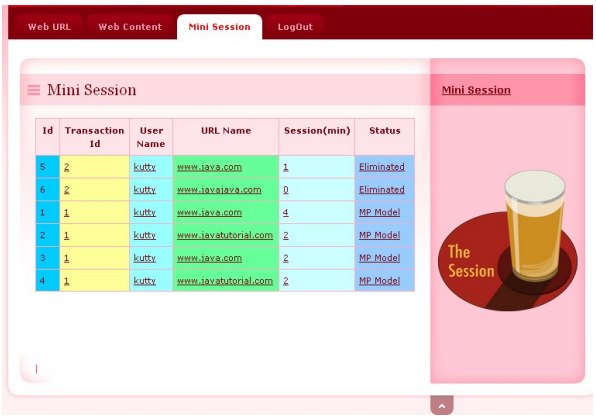
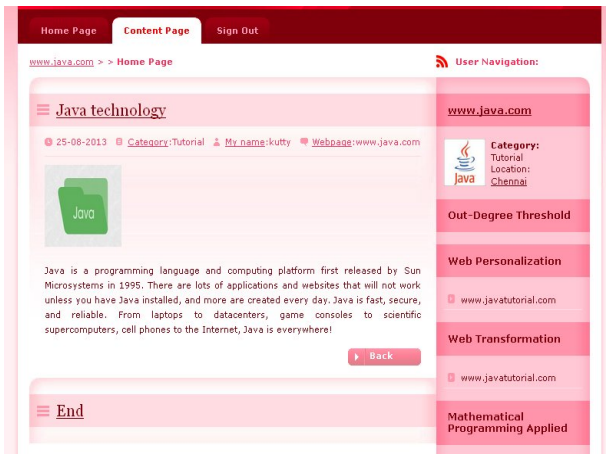
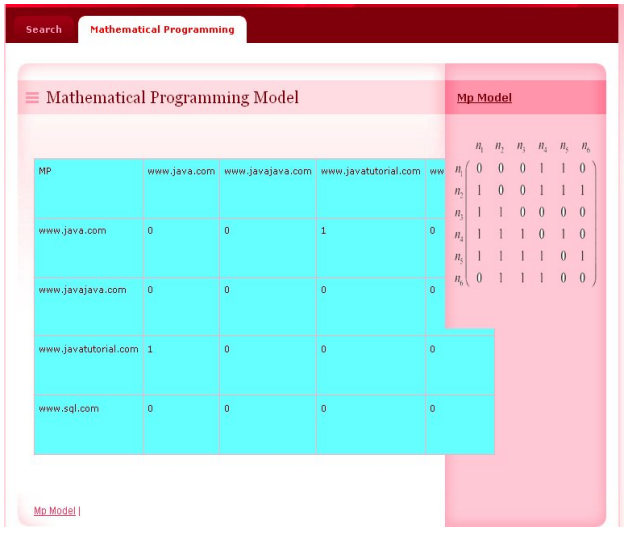
Mini session



Content page



Mathematical Programming Model



5. CONCLUSION

In this paper, we have proposed a mathematical programming model to improve the navigation effectiveness of a website while minimizing changes to its current structure, a critical issue that has not been examined in the literature. Our model is particularly appropriate for informational websites whose contents are relatively stable over time. It improves a website rather than reorganizes it and hence is suitable for website maintenance on a progressive basis. The tests on a real website showed that our model could provide significant improvements to user navigation by adding only few new links. Optimal solutions were quickly obtained, suggesting that the model is very effective to real world websites. In addition, we have tested the MP model with a number of synthetic data sets that are much larger than the largest data set considered in related studies as well as the real data set. The MP model was observed to scale up very well, optimally solving large-sized problems in a few seconds in most cases on a desktop PC. To validate the performance of our model, we have defined two metrics and used them to evaluate the improved website using simulations. Our results confirmed that the improved structures indeed greatly facilitated user navigation. In addition, we found an appealing result that heavily disoriented users, i.e., those with a higher probability to abandon the website, are more likely to benefit from the improved structure than the less disoriented users. Experiment results also revealed that while using small path thresholds could result in better outcomes, it would also add significantly more new links. Thus, Webmasters need to carefully balance the tradeoff between desired improvements to the user navigation and the number of new links needed to accomplish the task when selecting appropriate path thresholds. Since no prior study has examined the same objective as ours, we compared our model with a heuristic instead. The comparison showed that our model could achieve comparable or better improvements than the heuristic with considerably fewer new links.

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