

Improving the Effect of Website Navigation Delay Based on Entropy Analysis of Web Pages

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Abstract:

Website design is easy task but, to navigate user efficiently is big challenge, one of the reason is user behavior is keep changing and web developer or designer not think according to user's behavior. Designing well-structured websites to facilitate effective user navigation patterns has long been a challenge in web usage mining with various applications like navigation prediction and improvement of website management. 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. We have also tested the model on large synthetic data sets to demonstrate that it scales up very well. 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.

Index Terms:

Website design, user navigation, web mining, mathematical programming.

Introduction:

Data mining combines data analysis techniques with high-end technology for use within a process. The primary goal of data mining is to develop usable knowledge regarding future events.

The steps in the data mining process are:

- Problem definition
- Data collection and enhancement
- modeling strategies
- Training, validation, and testing of models
- Analyzing results
- Modeling iterations
- Implementing results.

There are lakhs of user for website since it is large source of information, web site also contain many links and pages every user require different pages at same time or same user may access different pages at different time. As user increases over www we need to make web intelligent we concern here about intelligent website. To make web site intelligent we must know what is content of website, which are users and how website structured all this known as web mining. Web structure mining can be defined as mining of links between pages, which is also called as hyperlinks which enable user to access web sites in form of URL and navigate user. In web structure mining developer uses the data from web usage and change structure of web site, pages which is most visited and user spent more time is linked to the start page.

The goal of a Web site is to meet the needs of its users. As a result, as the interests of its users change over the time, a static Web site that does not change itself will soon become outdated and less useful. Accordingly, a Web site must constantly examine site use, and modify itself accordingly to best serve its users. In other words, Web sites should be adaptive.

An adaptive Web site has been defined as a Web site that semi-automatically improves its organization and presentation by learning from visitor access patterns (Perkowitz and Etzioni, 1998). In this paper, an attempt is made to build adaptive Web sites, which improve their navigation based on access patterns of its users. An approach for reorganizing Web sites based on user access patterns is proposed. Our goal is to build adaptive Web sites by evolving site Structure to facilitate user access.

To be more specific, we aim to build Web sites that provide users with the information they want with fewer clicks. This minimizes the effort on the user's side. By analyzing the usage of a Web site and the structure of the Web site, modifications to the Web site structure are found to accommodate changes in access patterns of its users. These modifications will be suggested to the Webmaster for consideration and implementation.

Motivation for choosing web structure mining is: since web site is big source of information, but users mostly browsing useless page which irritates user and user lost interest from searching data over website. 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; however, the measure of website effectiveness should be the satisfaction of the users rather than that of the developers. Thus, Web pages should be organized in a way that generally matches the user's model of how pages should be organized.

Despite the heavy and increasing investments in website design, it is still revealed, however, that finding desired information in a website is not easy [4] and designing effective websites is not a trivial task [5], [6]. Galletta et al. [7] 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 users encounter when browsing online stores. Palmer [8] highlights that poor website design has been a key element in a number of high profile site failures. McKinney et al. [9] also find that users having difficulty in locating the targets are very likely to leave a website even if its information is of high quality.

Improving site structure in which a well-constructed navigation schemes has an important impact to well rank in the search engines. Ensure that your web design has a proper navigation menu so that your visitors can use the website with ease. This way, they will be able to find out what they were looking for in the website in the first place. Google's search results are provided at a page level but it also likes to have a sense of what role a page plays in the site.

Best Practices for Site Navigation:

Create a naturally flowing hierarchy. As what I've stated earlier, your website should flow naturally where users can access first from general content to the more specific content they want on your site. Use mostly text navigation instead of images or animation. Put an HTML site map page on your site, and use an XML Sitemap file. Webmasters are also advised to have useful 404 page that guides the user back to a relevant section or page with a link back the home page in case site visitor encounters a broken link or types in an incorrect URL. If a search engine comes across such an error, it can have a negative impact on your search engine visibility. Google provides a 404 widget that you can embed in your 404 page to automatically populate it with many useful features.

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 [10], [11]. 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, Web pages should be organized in a way that generally matches the user's model of how pages should be organized [12]. Previous studies on website has focused on a variety of issues, such as understanding web structures [13], finding relevant pages of a given page [14], mining informative structure of a news website [15], [16], and extracting template from web pages [17]. 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 [11]: 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 concerned primarily transformation approaches mainly focuses on developing methods to completely reorganize the link structure of a website. Although there are advocates for website reorganization approaches, there drawbacks are obvious. A complete reorganization could radically change the location of familiar items; the new website may disorient users [18]. The reorganized website structure is highly unpredictable, and the cost of disorienting users after the changes remains unanalyzed.

This is because 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. Finally 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 develop a mathematical programming model that facilitates user navigation on a website with minimal changes to its current structure. This model is particularly appropriate for informational websites whose contents are static and relatively stable over time.

The number of outward links in a page, i.e., the out-degree, is an important factor in modeling web structure. Prior studies typically model it as hard constraints so that pages in the new structure cannot have more links than a specified out-degree threshold, because having too many links in a page can cause information overload to users and is considered undesirable. Our model formulates the out-degree as a cost term in the objective function to penalize pages that have more links than the threshold so page's out-degree may exceed the threshold if the cost of adding such links can be justified, 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 appropriate the real usage. We define two metrics and use them to assess whether user navigation is indeed enhanced on the improved structure. First metric measures whether the average user navigation is facilitated in ht 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.

Related work:

Web usage mining, author in [1] explains about weblogs like who accessed order of page request, total time for page view. This paper includes several pre-processing like; 1: Data cleaning-It is method of removing irrelevant items or logs like removing of file with .gif and .jpg extensions.

2:User identification- It involves USER ID for each user to provide uniqueness even different users are on same IP.

3: Session identification- This is defines according to time i.e. time between page request and page close or time out.

4: Path completion- It is defined as if some information or page is important and mostly accessed but not recorded in logs and not linked cause problem .5: Formatting- It is method of converting transactions or logs it to a format of data mining like removal of numeric value for determining association rules.

Access Information Collection:

In this step, the access statistics for the pages are collected from the sessions. The data obtained will later be used to classify the pages as well as to reorganize the site. The sessions obtained in server log preprocessing are scanned and the access statistics are computed. The statistics are stored with the graph that represents the site obtained in Web site preprocessing. The obvious problem is what should be done if a page happens to be the last page of a session. Since there is no page requested after that, we really couldn't tell the time spent on the page.

Therefore, we keep a count for the number of times that the page was the last page in a session. The following statistics are computed for each page:

- Number of sessions in which the page was accessed;
- Total time spent on the page;
- Number of times the page is the last requested page of a session.

Page Classification:

In this phase, the pages on the Web site are classified into two categories: index pages and content pages (Scime and Kerschberg, 2000). An index page is a page used by the user for navigation of the Web site. It normally contains little information except links. A content page is a page containing information the user would be interested in. Its content offers something other than links. The classification provides clues for site reorganization. The page classification algorithm uses the following four heuristics.

(1) File type:

An index page must be an HTML file, while a content page may or may not be. If a page is not an HTML file, it must be a content page. Otherwise its category has to be decided by other heuristics.

(2) Number of links:

Generally, an index page has more links than a content page. A threshold is set such that the number of links in a page is compared with the threshold. A page with more links than the threshold is probably an index page. Otherwise, it is probably a content page.

(3) End-of-session count:

The end-of-session count of a page is the ratio of the number of time it is the last page of a session to the total number of sessions. Most Web users browse a Web site to look for information and leave when they find it. It can be assumed that users are interested in content pages.

The last page of a session is usually the content page that the user is interested in. If a page is the last page in a lot of sessions, it is probably a content page; otherwise, it is probably an index page. It is possible that a specific index page is commonly used as the exit point of a Web site. This should not cause many errors at large.

(4) Reference length:

The reference length of a page is the average amount of time the users spent on the page. It is expected that the reference length of an index page is typically small while the reference length of a content page will be large. Based on this assumption, the reference length of a page can hint whether the page should be categorized as an index or content page. A more detailed explanation is given below, followed by a page classification algorithm based on these observations and heuristics.

Reference Length Method:

The reference length method for page classification (Cooley, 2000) is based on the assumption that the amount of time a user spends on a page is a function of the page category. The basic idea is to approximate the distribution of reference lengths of all pages by an exponential distribution. A cut-off point, t , for reference length, can be defined as follows.

$$t = -\ln(1 - \gamma) / \lambda$$

where γ = percentage of index pages,

λ = reciprocal of observed mean reference length of all pages.

Algorithm for Site Reorganization:

Based on the cases discussed in the previous Section, the algorithm for site reorganization is outline as follows.

- (1) Initialize a queue Q
- (2) Put children of the home page in Q
- (3) Mark the home page
- (4) While Q not empty

- (5)current page = pop(Q)
- (6)Mark current page
- (7)For each parent p of current page
- (8)Local adjustment according to the cases in the previous section.
- (9)Push children (maybe merged) of current page into Q if they are not marked .

Problem Description:

Difficulty in navigation is reported as the problem that triggers most consumers to abandon a website and switch to a competitor . Generally having traversed several paths to locate a target indicates that this user is likely to have experienced navigation difficulty. Therefore web-masters can ensure effective user navigation by improving the site structure to help users targets faster. This is especially vital to commercial websites, because easy-navigated websites can create a positive attitude toward the firm and stimulate online purchases , whereas websites with low usability are unlikely to attract and reach customers .

Our model allows webmasters to specify a goal for user navigation that the improved structure should meet. This goal is associated with individual target pages and is defined as the maximum number of paths allowed to reach the target page in a mini-session. In order to achieve the user navigation goal, the website structure must be altered in a way such that the number of paths needed to locate the targets in the improved structure is not larger that the path threshold.

While many links can be added to improve navigability, our objective is to achieve the specified goal for user navigation with minimal changes to a website. We measure the changes by the number of new links added to the current site structure. There are several reasons that we should insert minimal links. First, minimizing changes to the current structure can avoid disorienting familiar users. Second, adding unnecessary users cognitive loads and makes it difficult for them to read and comprehend . Third, since our model improves site structures on a regular basis, the number of new links should be kept at minimum such that the links in a website in the whole course of maintenance do not expand in a chaotic manner.

These are cases where users could have reached the targets through existing links, but failed to do so in practice. One reason could be that these links are placed in inconspicuous locations and hence are not easily noticeable. Another reason might be that the labels of these links are misleading or confusing, causing difficulty to users in predicting the content at the target page. Webmasters focus on enhancing the design of these existing links before adding new links.

Problem formulation:

Our problem can be regarded as a special graph optimization problem. We model a website as a directed graph, with nodes representing pages and arcs representing links. Let N be the set of all webpages and i, j , where $i, j \in N$, denote page connectivity in the current structure, with $i, j = 1$ indicating page i has a link to page j , and $i, j = 0$ otherwise. The current out-degree for page i is denoted by $W_i = \sum_{j \in N} N_{ij}$.

From the log files we obtain the set T of all mini-sessions. For a mini session $S \in T$, we denote $tgt(S)$ the target page of S . as explained earlier webmasters can set a goal for user navigation for each target page, which is denoted by b_j and is termed the path threshold for page j . given a mini session S with target page j and a path threshold b_j we can determine whether the user navigation goal is achieved in S by comparing the length of S i.e., $L_m(S)$ with path threshold(b_j) for the target page of S .

Intuitively given path thresholds, we can determine which mini sessions need to be improved and hence are relevant to our decision. The irrelevant mini session are not considered in our model. For a mini session $S \in TR$, it is said to be improved if the website is altered in a way such that the user could reach the target within the associated path threshold after changes are made to the site structure.

Similar to prior studies appropriate out-degree threshold can be specified for webpages. We denote C_i the out-degree threshold for page i . Nevertheless our model “penalizes” a page if its out-degree is larger than the constraint. In effect out-degree C_i indicates the maximum number of links that page i can without being penalized.

Depending on the application of our model, different weights of penalties can be imposed on pages whose out-degree exceeds the respective out-degree threshold. We denote the weight by m and term it the multiplier for the penalty term.

The problem of improving the user navigation on a website while minimizing the changes to its current structure can then be formulated as the mathematical programming model below:

$$\begin{aligned} & \text{Minimize } \sum_{(l,j) \in E} x_{ij}[1-i_j(1-)] + m \sum_{i \in NE} P_i \\ & \text{Subject to} \\ & C_{skr} = \sum_{i,j} a_{sij} x_{ij}; r=1,2,\dots,L_p(k,s) \quad (l,j) \in E \\ & K=1,2,\dots,L_m(s) \end{aligned}$$

The objective function minimizes the cost needed to improve the website structure, where the cost consists of two components: 1) the number of new links to be established and 2) the penalties on pages containing excessive links, i.e., more links than the out-degree threshold (C_i), in the improved structure.

Relevant Mini session:

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 being eliminated from consideration in our MP model.

Dominated mini sessions:

Another reason for the problem size reduction is that many relevant mini sessions “dominate” others with respect to relevant candidate links. Mini session S_p dominates mini session S_q if the set of relevant candidate links for S_q contains all relevant candidate links S_p .

When a mini session is improved in the new structure, the mini sessions that are dominated by this one are also improved. Consequently, the constraints corresponding to dominated mini sessions are redundant and can be eliminated from consideration in the MP model.

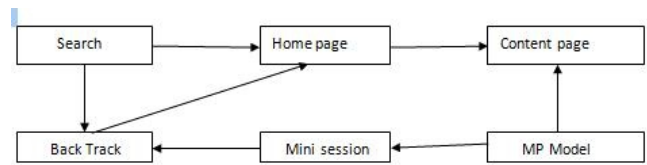


Fig: Architecture

Evaluation of personalization systems:

Evaluation of personalization systems remains a challenge due to the lack of understanding of what factors affect user satisfaction with a personalization system. It seems obvious that a system that accurately predicts user needs and fulfills these needs without the user needing to expand the same resources in achieving the task as he would have, in the absence of the system, would be considered successful. Hence personalization systems have most commonly been evaluated in terms of the accuracy of the algorithms they employ. Hence the evaluation of personalization systems needs to be carried out along a number of different dimensions. The key dimensions along which personalization systems are evaluated include:

1. User satisfaction
2. Accuracy
3. Coverage
4. Utility
5. Explainability
6. Robustness
7. Performance
8. Scalability

Evaluation of improved website:

Perform evaluation on improved website structure to assess whether its navigation effectiveness is indeed enhanced by approximating its real usage. Specifically we partition the real data set into a training set and a testing set. We generate the improved structure using the training data and then evaluate it on the testing data using two metrics:

the average number of paths per mini session and the percentage of mini sessions enhanced to a specified threshold. The first metric measured whether the improved website structure can facilitate users to reach their targets faster than the current one on average, and second metric measures how likely users suffering navigation difficulty can benefit from the improvements made to the site structure. The evaluation procedure using the first metric consists of three steps as follows:

1. Apply the MP model on the training data to obtain the site of new links and links to be improved.
2. Acquire from the testing data the mini sessions that can be improved, i.e., having two or more paths their length i.e., number of paths and the set of candidate links that can be used to improve them.

Path threshold:

It represents the goal for user navigation that the improved structure should meet and can be obtained in several ways. First it is possible to identify when visitors exit a website before reaching the targets from analysis of weblog files. It helps to make good estimation for the path thresholds. Second surveying website structures visitors can help better understanding users expectations and make reasonable selections on the path threshold values. Third from firms collected large amounts of client-side web usage data over a wide range of websites. Analyzing each data sets can also provide good insights into selection of path threshold values for different types of websites.

Out-degree threshold:

Webpages can be generally classified into two categories [29]: 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 out-degree threshold for a page is highly dependent on the purpose of the page and the website. The out-degree threshold for index pages should be larger than content pages. In general out-degree threshold could be set at a small value when most webpages have relatively few links and new links added the threshold can be gradually increased.

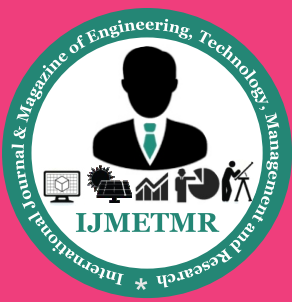
Conclusion:

In this paper we proposed a MP model to improve navigation effectiveness of a website while minimizing changes to its current structure. Our model is particularly appropriate for informational websites whose contents are relatively stable overtime. It improves website rather than reorganize it hence it is suitable for website maintenance on a progressive basis. Our model has a constraint for out-degree threshold which is motivated by cognitive reasons. The model can be further improved by incorporating additional constraints that can be identified by incorporating additional constraints that can be identified using data mining methods.

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