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ABSTRACT

Well-designed Websites are critical to the success of E-commerce. However, many websites does not show satisfactory level of usage. The construction, assessment, and improvement all are essential for the work of design. Most of the studies in the related literature only focus on one of them. There is lack of a framework to integrate them into a complete cycle. One central work is to validate the Web design to ensure to meet the design requirements and performance goal. In this paper, we propose an integrated framework based on concepts of transformation of system development process and formulation of design requirement. The validation of Web site level, similar to compiling and running time check, to authenticate design structure and anticipated performance. The research depicts a systematic and structural way to integrate the work of construction, assessment, and improvement for the design of Web. The integrated approach offers a complete-cycle framework on a continuous improvement basis. The research also sheds the light on several potential research topics to further explore interesting and sophisticated Web issues.

Keyword: Web Design, Assessment, Validation, Structure Modeling

INTRODUCTION

The fast-growing sheer volume of information and resources available on a website has made effective design increasingly critical. Central to website design is accessibility which allows visitors to locate and access targeted (interested) contents using a small number of clicks. In general, visitors are not particularly stick on websites. According to ATW [1], an individual typically accessed three or fewer pages in a visit. This non-sticky behavior, in turn, makes website design increasingly critical. The bottom-line is a visitor is likely to leave a website when he or she cannot access targeted or relevant contents within a limited number of clicks.

In spite of the prevalence of e-commerce, both researchers and practitioners have been greatly challenged by such fundamental questions as "how to design a good website" and "how to improve an existing website design." These questions are critical for firms interested in offering e-channels to serve customers, launching new services, or engaging in e-branding. The design of Web site should take into account the needs of both designers and users. The construction, assessment, and improvement all are essential for the work of design. The construction itself is a transformation process starting from requirement elicitation to Web site creation. The assessment is to measure the quality of the Web site design. Based on the assessment result, expected result, and changes of requirements, the continuous process of review and improvement is imperative.

Web *construction* issue has been extensively studied from various aspects. Various construction guidelines were advocated in the literature, e.g. system functionalities [13] and human computer interactions. W3C (World Wide Web Consortium) provided various guidelines to improve the accessibility of Web content for people with disabilities [16]. Nielsen [11] proposed many guidelines on Web usability in the Alertbox.

Several papers studied Website *assessment* from classifying the key dimensions or aspects for system evaluation by summarizing the literature [3] [15] summarized the literature to propose a framework of twelve dimensions for evaluating Web applications. The evaluation can be form the aspects of Web content (e.g. features) [6] [14] and Web usage (e.g. usability) [5][7] [8].

The *improvement* issue for Web applications has been studied in many different areas. For example, several papers discuss the personalization to ease the usage for the purpose of improvement [2] [10]; some paper focuses on by providing the navigation guidance and various cues to enhance system support [4] [12] [19].

There are few studies on linkage or integration of stages. Matera et al. [9] introduced several principles for promoting web usability during the web application lifecycle. They also discussed three classes of usability evaluation methods, namely, user testing, usability inspection, and web usage analysis. Yen [20] proposed a framework of Accessibility-Popularity (A-P) model to investigate the A-P mismatch on both page-level and site level. Based on the evaluation result, general guidelines were given to balance A-P on all pages in a Web site. Yen et al. [21] proposed a framework to depict preliminary picture of process of design, evaluation, and enhancement. The framework is based on the classification of features of content and design, transformation of constraints and objectives, and four-parameters constraint table.

The literature review above suggests the need for a systematic and integrated approach of analysis, evaluation and enhancement for website designs. In particular, the use of rigorously defined structure and analytical models to investigate website design problems has been limited, if any at all. To a large extent, website design resembles the shelf management problem common to retailers and therefore can be formulated and model as an "optimization" problem. Compared with classic optimization problems, analysis of an

"optimal" website design needs to address additional challenges that include frequent/continuous content updates/changes and access behaviors of visitors co-determining "optimality." Results from prior research highlighted the adequacy and appealing desirability of using graph theory to model and analyze Web related issues. However, most studies focused on particular graphs and lacked systematic analysis of the overall applicability of graph-based modeling in enhancing website design. In this research, we propose an integrated framework to synthesize the main processes of the Web design by validating the main work for requirement review and expected performance.

PRELIMINARIES

The previous work [21], as mentioned in the previous section, provided a preliminary framework about the integrated approach to model, evaluate and enhance the Web design bases on analytical structures. The main ideas include four-layer structure and three transformation processes between the layers as follow -

- *Four-Layer Structure*. (i) Application Layer: elicitation of application domain based requirements (e.g. features, functions) for design of Web sites; (ii) Generic Web Layer : problem formulation based on requirements as objectives and constraints; (iii) Graph Modeling Layer: analysis of problem in mathematical models; and (iv) Generation Layer: the desired output based on the requirement compilation, formulation and analysis.

- *Transformation Processes*. (i) *Characterization*: developing a framework for characterizing website applications and analyzing their respective specifications and requirements; developing the framework to classify and formulate design objectives and constraints from the aspect of both designers and users, and representing them using mathematical formulations; ii) *Classification*: developing the framework to synthesize and map website design models to appropriate graph problems; and (iii) *Consolidation*: developing criteria of bottlenecks identification and shift; developing tradeoff analysis of efficiency, utilization, and profitability; examining users' perceptions and evaluative assessments; analyzing and comparing the difference between the expectation and perception and assessment as well as between the objective and subjective evaluations to generate insights on and recommendations for continued website design improvement.

The above framework summarizes the overall conceptual roadmap without completing the cycle in detail. There are two major questions to be addressed for Web design problem – (1) "does the design truly comply with the *requirements* (e.g. structural properties)" and (2) "whether the design can achieve the *expected result* (e.g. performance)".

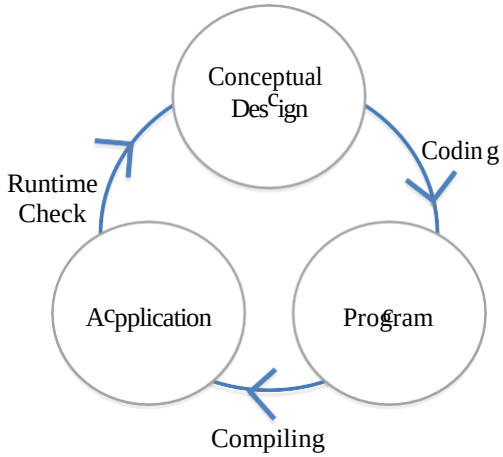

Figure 1. The cycle of programming

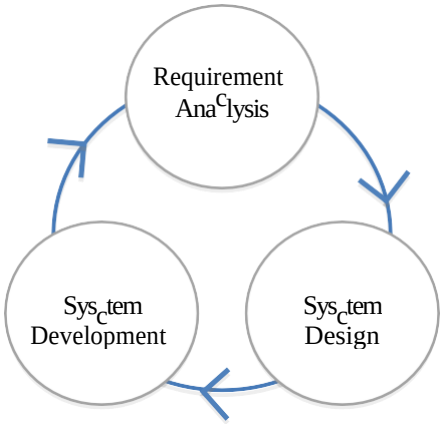

Figure 2. The cycle of system design

Using the programming as an example. The three main forms for programming are conceptual design, program, and application as shown in Figure 1. In the cycle, the compiling part is to ensure the correctness in the syntax and the runtime check is to test the whether the result or output is as expected. We move to the level of Wed design as an example of system design or IS project, the main stages for the process are requirement analysis, system design, and system development as shown in the Figure 2. It is challenging to verify the design correctness, not mentioning the expected result. One common example is gap between user requirements and the delivered system for IS projects [22]. It is very challenging to do the similar thing as compiling and runtime check for program level. The Web design inherits the similar problem to come up a unified framework for Web construction, assessment, and improvement.

The integration of construction, assessment, and improvement is imperative for designing and managing Web application. The cycle of Web construction, assessment, and improvement is shown in Figure 3. In the literature, most of the studies focus on individual stage. However, very few of them cover the linkages between two stages, especially the complete cycle. One main challenge for the integration of three stages to form a complete cycle is due to the lack of unified framework for all three stages. One central piece is missing is to validate the Web design on both design requirements and expected performance.

The idea of validation has been adopted for various Web applications. However, it is limited to page-level technical analysis. For example, WordPress Codex defines validating a website is "the process of ensuring that the pages on the website conform to the norms or standards defined by various organizations" [18]; W3C Markup Validation Service define a validator is "a software program that can check your web pages against the web standards" [17].

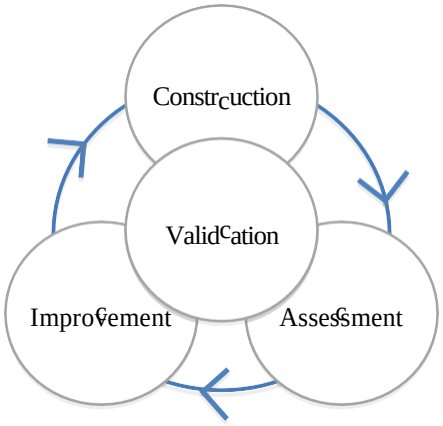

Figure 3. The cycle of Web design

At a nutshell, website design is, to some extent, one type of information system design which includes requirement analysis, functional design, and development. The validation of the design normally comes with compiling and running. The compiling result mainly shows the syntax related problems; Running time errors reflect more about the semantics issues. Web design also goes through similar process – requirement elicitation and analysis, conceptual design, and system development. The validation of Web design will be based on requirement in constraints and objectives, and Web structure properties. The process will include the transformation of the problem description to mathematical optimization classification together with justification on the usage result.

Objectives and Constraints

The identified features and additional requirements are consolidated and then transformed to objectives and constraints. Fulfilling the Web site design goals and requirements is critical. Both of the designer and the user have their own requirement of the Web site design. Some of their requirements are the same. For instance, they all want the download time for the Web site is as quick as possible and the content is as complete as possible so that the user can find whatever they want in a short period of time. However, some of their requirements are not the same. The designers may want, for example, the total transaction volume can be maximized, the Web site should be adapted to dynamic access behaviors of visitors and some agreement pages must be visited before a registration page. While the user may want that the cheapest product can be found as soon as possible, the Web site can be customized to the user's taste and registration and certification can be done as soon as possible. Both requirements from designer and user can be defined as objectives and constraints.

There are a lot of design objectives, such as to minimize searching time for target product, to maximized relevant retrieved contents etc. The design constraints can be the loading time of one page, placing agreement pages before registration pages, etc. Furthermore, these objectives and constraints can be analyzed from different perspectives, for example, from designer's and user's point of view, or from user interface related, Web site structure related and Web site navigation related point of view. Similar to the classification of objectives of Web site design, the constraints can also be described accordingly.

Objectives and constraints can also be classified as one page related or the whole Web site structure related. In terms of one page, the objectives of the design could be minimizing the time loading the graphs on the page and providing limited outgoing links so that the page are not over crammed. In terms of the whole Web site structure, the objectives could be to provide optimal navigation guide, to maximize the accessibility of the Web site and to enable users to reach related information within limited clicks. In terms of one page, the constraints of the design could be centralizing the promotion category and highlighting the promotion information. In terms of the whole Web site structure, the constraints could be inter-page text similarity. Moreover, some page must be visited before some other page.

Problem Description And Formulation

The classification of Web navigation problem can be formed from various aspects. The following is the exemplary framework to illustrate the main ideas. The intention is not trying to provide a complete list of possible components. The framework only serves as a representative instance for explanation and explanation as well.

Here are four main categories in the classification dimensions – *objective function*, *structural constraint*, *navigation requirement*, and *supporting resources*.

- *Objective function (O)*. It represents the problem orientation and the assessment goal, and normally reflects the objectives. There are four very common used assessment types for Web applications, namely search, spanning, sequencing (or scheduling), and flow. Searching related assessment functions are used for retrieval of one or more specific pages (nodes). One example is to find a shortest path (or time) to access a specific page. Spanning type is to traverse some or all pages at a site. Sequencing (or scheduling) type normally is related to decide the order of multiple retrievals for time minimization to other purpose. Flow type is to control or regulate the page accesses of multiple retrievals. Of course, there could be more types of problems to be included.

- *Structural constraints*. This mainly denotes the structure related properties which normally suggest the possible constraints for the problem to be investigated. It can include, for instance, structural category, cost of arc, and out-going degree. The details are as follows.

  - *Structure category (S)* describes Web structure, e.g. tree and directed acyclic graph.
  - *Cost of each arc (C)* denotes the overhead to access the page, which could be the function of page size or other important factor. There could be some considerations or constraints for the cost function, e.g. homogeneous / heterogeneous and symmetric / asymmetric.
  - *Out-going degree (D)* defines the possible number of pages to be connected to. There could be maximal or/and minimum numbers out-going links.

- *Navigation requirement*. It is concerned about the navigation related requirement which may include navigation setting and Sequence relationship.

  - *Navigation setting (N)* reflects navigation complexity from both start and destination possibilities. There could be multiple starting page and destination pages in navigation.
  - *Sequence relationship (R)* represents the constraints between pages, e.g. distance range.

- *Supporting resources (P)* refer to level of resource availability. Cache function is considered as one main supporting resource which can be constrained by size, time, or both.

These four dimensions, more or less, can depict the main description of Web navigation problems. Among these four dimensions, objective function and structural constraint are more fundamental than the other two (i.e. navigation requirement and supporting resources) in terms of the problem description. In other words, it is requited to specify objective function and structural constraint for all the problems; however, navigation requirement and supporting resources are optional unless they are applicable. We may define each dimension (or sub-dimension) using alphanumeric codes or notations for the convenience to denote them. For example, please refer to Table 1. If there is no special needs for navigation requirement and supporting resources, then the default values will be (1,1) for navigation setting, no constraint for sequence relationship, and no cache for supporting resources, which can be omitted in the problem description.

Table 1. Listing of codes for classification dimensions

	Objective Function **(O)**	*Structural constraints*			*Navigation requirement*		*Supporting Resources* **(P)** (cache)
		Structure Category **(S)**	Cost of Arc **(C)**	Out-Going degree **(D)**	Navigation Setting **(N)** (start,	Sequence Relationship **(R)**	
1	Search	Tree	Identical	No Constraint	(1,1)	No Constraint	Off
2	Spanning	Directed Acyclic Graph Structure	Symmetrical Identical	Constraint on Upper Bound	(1,N)	Immediate Sequence Relationship	On
3	Sequencing / Scheduling	Graph	Symmetrical Non-	Constraint on Lower Bound	(M,1)	At most one node between	On (size)
4	Flow	-	Asymmetrical Identical	Constraint on Upper and	(M, N)	At least one node between	On (time)

				Lower Bounds			
5	-	-	Asymmetrical Non-	-	-	No Constraint	On (size & time)

- : undefined

Assessments and Improvement

Assessment, construction, and improvement are three of the major issues for Web design. Assessment methods of Web sites is regarding the evaluation for performance measures based on sites' static (e.g. structure) and dynamic (e.g. flow) properties; construction is relevant to the approaches to creating and changing Web sites by taking into account various requirements or objectives; and improvement strategies concentrate on revision and enhancement subject to specific objectives and constraints. These three issues are closely related to each other and are essential in different stages and focuses in Web design. Assessment criteria are required for both construction and improvement issues. There are a lot of commonalities between construction work and improvement process.

The assessment of Web design is to evaluate the performance to reflect the current status, and to possibly provide the insights for further improvement. There are many approaches for Web assessment. For example, one approach is to investigate the correlation between the expected performance (accessibility) and actual result (popularity) [20] to identify the gap and adjust the accessibility to reflect or to change the popularity. In the literature, there is lack of linkages between the assessment methods and improvement strategies. Besides, both assessment and improvement are closely related to the logic of Wed design. Integrated framework to align design, assessment and improvement is imperative for the Web applications.

The assessment of Web design can be made in different stages and in various aspects of Wed application development. In the planning stage, the main focus of assessment is on syntactic view of design and in the execution (or running) stage, the assessment can be the performance evaluation against the theoretical optimality or practical benchmark.

- *Design review*. The design can be systematically reviewed to ensure the requirements are met and all the important issues (e.g. objectives and constraints) are addressed.
- *Model measure*. The evaluation is based on the comparison between optimal solution and actual result.
- *Benchmark test*. The evaluation is based on comparison between given expected performance and actual result.

We may assess and improve the Web designed from various aspects.

- *Accessibility*. One way is to investigate the correlation between the expected performance (popularity) and actual result (popularity). The improvement can be achieved by adjusting the accessibility to reflect or to change the popularity.
- *Gap*. Based on the problem classification, we can identify the gap between the theoretic result (optimal solution) and the actual usage average. The improvement can be achieved by either revising the objective (or constraints) to align the design to the user needs better, or enhancing the critical elements (e.g. highlighting the specific hyperlinks) to adapt users to the right track.

One exemplary improvement strategy is to shift bottleneck. The "bottleneck identification is one of the major tasks for analysis. The bottleneck pages have the high impact on the information access and navigation in the graph. There can be two levels of perception for assessment and improvement. At a micro level, we can analyze and obtain users' perceptions based on the user log file. This perception can reveal the popularity of different pages and prominent paths all visitors or groups of visitors. At a macro level, we examine visitors' perceptions about and satisfactions with the website design by surveying them immediately after their visits. These perceptions will be examined and categorized to generate insights into business strategies and essential new user requirements to be incorporated in the subsequent incremental website design process. The appraisal of the user's perception is primarily based on the application categorization, usage association, and navigation analysis. We acquire users' feedback and evaluative assessments and compare them with the requirements. We also compare the objective evaluations and corresponding subjective evaluation results. We then can be specific about the design aspects that users value (e.g. interface design vis-à-vis navigation design) as well as identifying the particular evaluation criteria matter most to them (e.g. page accessibility versus page loading time).

CONCLUSIONS

To bridge the gap between designer's expectation and the user' perception, website designers need a methodology to examine the general design requirements and analyze essential user requirements. In addition to key human factors, analysis and evaluation of website structure is critical cornerstone for design guideline. The validation of Web design is critical and challenging. The integration of construction, assessment, and improvement is imperative for Web design. The possible future directions include -

- To further enhance the problem classification by applying the proposed framework for different applications.
- To take into account the various usage data to explore more analytical implications.

- To extend the application scope from individual and isolated Web site to include the the neighbors (i.e. connected Web sites).

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REFERENCES

[1] ATW (1999) 'All things web, how much is too much?', available at http://www.pantos.org/atw/35654.html.

[2] Berkovsky, S. & Freyne, J. (2015) 'Web personalization and recommender systems', *Proceedings of the 21st ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD-2015)*, pp. 2307-2308, Sydney, Australia.

[3] Chiou, W., Lin, C. & Perng, C. (2010) 'A strategic framework for website evaluation based on a review of the literature from 1995–2006', *Information & Management*, Vol. 47, No. 5-6, pp. 282–290.

[4] Cho, Y.H., Kim, J.K. & Kim, S.H. (2002) 'An intelligent web recommendation system: A web usage mining approach', *Expert Systems with Applications*, Vol. 23, pp. 329-342.

[5] Conte, T., Massollar, J., Mendes, E. & Travassos, G.H. (2007) 'Usability evaluation based on web design perspectives', *ESEM '07 Proceedings of the First International Symposium on Empirical Software Engineering and Measurement*, pp.146-155.

[6] Hanson, V. & Richards, J. (2013) 'Progress on website accessibility?', *ACM Transactions on the Web*, Vol. 7, No. 1, pp. 1–30.

[7] Lee, Y. & Kozar, K. (2012) 'Understanding of website usability: Specifying and measuring constructs and their relationships', *Decision Support Systems*, Vol. 52, No. 2, pp. 450–463.

[8] Luo, J., Ba, S. & Zhang, H. (2012) 'The effectiveness of online shopping characteristics and well-designed websites on satisfaction', *MIS Quarterly*, Vol. 36, No. 4, pp. 1131–1144.

[9] Matera, F. Rizzo, F. & Carughi, G.T. (2006) 'Web usability: Principles and evaluation methods, *Web Engineering* (Eds: Emilia Mendes and Nile Mosley), Springer.

[10] Mobasher, B., Dai, H., Luo, T. & Nakagawa, M. (2001) 'Effective personalization based on association rule discovery from web usage data', *Proceedings of the 3rd International Workshop on Web Information and Data Management*, ACM Press, Atlanta, GA, USA, pp.9–15.

[11] Nielsen, J. (2015) 'Alertbox', available at http://www.nngroup.com/articles/.

[12] Shahabi, C., Kashani, F.B., Chen, Y.-S. & McLeod, D. (2001) 'Yoda: An accurate and scalable web-based recommendation system', *Proceedings of the 9th International Conference on Cooperative Information Systems*, Springer-Verlag, pp.418–432.

[13] Spiliotopoulos, T., Papadopoulou, P., Martakos, D. & Kouroupetroglou, G. (2010) *Integrating usability engineering for designing the web experience: Methodologies and principles*, IGI Global.

[14] Ting, P., Wang, S., Bau, D. & Chiang, M. (2013) 'Website evaluation of the top 100 hotels using advanced content analysis and eMICA model', *Cornell Hospitality Quarterly*, Vol. 54, No. 3, pp. 284–293.

[15] Treiblmaier, H. (2007) 'Web site analysis : A review and assessment of previous research, *Communications of the Association for Information Systems*, Vol. 19, pp. 806–843.

[16] W3C (2015) 'Web accessibility initiative (WAI)', available at http://www.w3.org/WAI/.

[17]W3C Markup Validation Service (2015)s 'Web page validator', available at https://validator.w3.org/docs/why.html#why_pros.

[18] WordPress Codex (2015) 'Validating a website', available at https://codex.wordpress.org/Validating_a_Website.

[19] Yen, B.P.-C. & Wan, Y.-W. (2010) 'Design and evaluation of improvement method on the web information navigation – A stochastic search approach', *Decision Support Systems*, Vol. 49, pp. 14-23.

[20] Yen, B.P.-C. (2006) 'The design and evaluation of accessibility on web navigation', *Decision Support Systems*, Vol. 42, No. 4, pp. 2219–2235.

[21] Yen, B.P.-C., Hu, P. J.-H. & Wang, M. (2007) 'Towards analytical approach to effective website designs: A framework for modeling, evaluation and enhancement', *Electronic Commerce Research and Applications*, Vol 6, pp.159-170.

[22] Zhang, V., Yen, B.P.-C. & Huang, M. (2010) 'An exploratory study of the gap between client expectations and client perceived performance of the delivered information system', *Proceedings of 14th Pacific-Asia Conference on Information Systems (PACIS)*, Taipei, ROC, July 9-12.