A Tool for Assessing the Consistency of Websites*

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Abstract: Usability is becoming an increasingly important design factor for web sites. However time and budget contstraints for web projects prevents the hiring of usability professionals to conduct tests that are costly and time consuming to perform. A number of automatic usability assessment tools have been developed most of which offer reports on a per-page basis. However, they fail to provide inter-page assessments to test, for example the consistency of the site. Consistency refers to the extent to which a set of pages share a common layout. This work presents *CAT*, a Consistency Analysis Tool that, besides providing static, page-based usability measures, strives to assess the consistency of a website using Java and XSLT. The tool is based on a consistency model which is updated every time a page has been processed. Consistency testing involves collating the page with this model, reporting mismatches with the consistency attributes and adapting the model as new features are encountered for the first time.

1 INTRODUCTION

Usability is becoming an increasingly important design factor for websites. This is partly due to the high competition between websites. Indeed, the usability of a website not only determines the success of the company but also of its products. In a physical environment customers are unable to assess the usability of a product until after they have already bought it. However in the Internet users experience the usability of a website before they see the product and before they have bought it. Furthermore most users are impatient and strive for instant gratification of their needs and requirements. If they find a website difficult to use or cannot find what they are looking for, they will not take the time to solve the problem as they can easily switch to the competitor's website (Nielsen, 2000).

However, a lot of the smaller companies often do not have usability professionals to assist them in their web-design and many companies are not even aware of the importance of usability for the success of their website and potentially their company. Additionally many websites are developed under time constraints and on a very tight budget. This prevents the hiring of usability professionals to conduct tests that are costly and time consuming to perform particularly for iterative design(Scholtz et al., 1998).

Based on this observation distinct automatic usability assessment tools have been developed (e.g. (Chi et al., 2000), (Oskoboiny, 2001), (WebCriteria, 1999), (Team, 2000)). Most of these tools only offer reports on a per-page basis however, some important usability guidelines imply inter-page assessment. This paper focuses on consistency as a main usability measure. Consistency assesses to which extent a set of pages share a common layout (e.g. fonts, background-color etc.). Although, the use of Cascading Style Sheets (CSS) can promote consistency some aspects can only be enforced by strict adherence to the site's conventions. However, often no mechanism is in place to enforce these conventions.

This paper presents *CAT* a Consistency Analysis Tool that besides providing static, page-based usability measures, strives to assess the consistency of a set of pages that form a website. It is based on an adaptive consistency model that allows to "instantiate" the predicates (i.e. the values used for the consistency as-

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sessment) as the pages are processed.

CAT is based on Java and XSLT and the latest version of the tool can be found at http://www.atarix.org/cat/.

The remaining part of this document is structured as follows: Usability guidelines and the consistency model are discussed in section 2, *CAT*'s architecture is described in section 3, section 4 describes a *CAT* sample evaluation, related work and the tool itself are discussed in section 5 followed by the conclusion and future work in section 6.

2 USABILITY GUIDELINES

The impact of usability on websites is much higher than on traditional software. For e-commerce sites the website itself is the company and therefore, the user interface becomes the marketing materials, the store front and interior, the sales staff and the post sales support. Consequently, a user interface with a bad usability design can jeopardize the success of the whole company (Nielsen, 2000). In fact the actual design of a website in terms of usability and especially download times can have a serious impact on users' perception of the overall quality of the company's services (Bhatti et al., 2000).

When interacting with any system people develop their own theories (*mental models)* in order to understand the casual behaviour of the system. The ease with which users are able to form a correct model is influenced by a number of factors including consistency, which relates to a likeness in behaviour that has arisen from similar situations previously experienced (Dix et al., 1992).

This work focuses on the following web-usability categories.

Consistency. Consistency is one of the most important usability characteristics. In a user interface consistency implies that the same action and commands always have the same effect (Nielsen, 1993). For example each site should contain a consistent style and layout for images, fonts, colours and functionalities. This helps users to establish a pattern of the site structure and has a substantial impact on learning time, performance speed, error rates and user satisfaction. Thus consistency increases the likelihood that users look at and revisit the site as it facilitates fast and easy access to the services they require. Additionally providing a common "look and feel" for a site helps to unify all web pages together. This is important for establishing a professional look because users trust professionalism (Brannon and Sellati, 2000). The *CAT* consistency model is described in more detail in section 2.1.

Accessibility. Accessibility refers to the ease with which users can access the web-content. It is affected by users' physical abilities and differences in hardware and software platforms. The former refers to any kind of disability that makes it difficult for a person to use traditional computer input and output devices. In the United States alone this affects approximately 30 million people (Nielsen, 2000), predominantly those with vision, hearing, dexterity and short-term memory problems. Furthermore the average age of the population in many countries is increasing, causing a general increase in users with physical deficits as a result of aging. Therefore few organizations and especially e-commerce businesses can afford to deliberately miss the market sector of physically impaired users (Brewer, 2000). A possible way of enhancing the accessibility of a web-page is by using HTML *alt* attributes for all non-textual elements to provide an alternative presentation to those who cannot view these elements (Chisholm et al., 1999).

Form Use. Forms are a popular way to collect information from website users. However form usability, especially for e-commerce sites, can have serious business implications because badly designed forms discourage users and often lead to incorrectly submitted information which is dissatisfying for the user as well as for the site administrator (Nielsen, 2000). For example, to ensure that all text fields are correctly identified by screen readers for visually impaired users, the HTML *label* element should be used because it is implicitly associated with exactly one text field (IBM, 2001).

Performance. According to (Nielsen, 2000) "fast response times are the most important design criterion for web pages" (Nielsen, 2000, p.42). Slow download times have been shown to have a negative effect on the users' perception of the company because they tend to blame the company's lack of resources rather than their network connection or their server for the delay. Furthermore users associate poor performance with poor security measures (Bhatti et al., 2000). Research has shown that system response times of less than one second are necessary to enable users to navigate freely through a website. Therefore websites should be designed to minimize download times by keeping page sizes to a minimum (no more than 2KB) and graphics and multimedia effects should only be used if they enhance the user's understanding of the information presented. Providing *height* and *width* attributes for all images and tables can also reduce down-load times because the browser does not have to recalculate these measurements (Nielsen, 2000).

Navigation. One of the main problems of the WWW (World Wide Web) is that users can easily become disoriented (*lost in hyperspace*) because there are no restrictions on how to move through the information space (Mukherjea and Yoshinori, 1997). It is therefore essential to provide users with navigation support because if they are unable to locate the infor-

mation they are looking for they will leave the site. The fundamental information that every navigation interface should prove is: the current location, which locations have already been visited and which locations can be visited from the current position. Usability studies have shown that users prefer navigational interfaces that are similar to those of other sites. Standardization (e.g. standard link colours) saves users the time and effort to learn a new interfaces when visiting a site for the first time because they are able to rely on their existing mental models (Nielsen, 2000).

Readability. Readability refers to the ease with which users are able to read the information presented on the page. Usability studies have shown that most web-users scan new web pages for main content indicators e.g. headlines and bullet points before they decide to read the page. Furthermore it has been demonstrated that users take 25% longer to read information on a computer screen compared to reading it from a hard copy. Consequently, web pages should be designed for optimal scanability by breaking long texts into paragraphs with separate headings and by using bullet points where possible. For optimal legibility all text should be presented in high contrast with a maximum line length of 8cm as this corresponds to a comfortable eye span for most readers (Nielsen, 2000),(Lynch and Horton, 2001).

For a complete list of all usability guidelines evaluated by the tool, please refer to the *CAT* online version[1].

2.1 CONSISTENCY MODEL

CAT is based on a consistency model that is specified by a number of values specified for presentation features. The consistency features measured by the tool include: colour (background and font), font-size and typography. Furthermore all sites should provide a standard navigation menu(Brannon and Sellati, 2000). Therefore a website can be said to be consistent if the same values for most of the above features have been used throughout the site. It is permissible to introduce some inconsistencies, e.g. background-colours, to distinguish between different areas of the site however these variations should be limited to one or two features (Cook, 1997).

Unless the designer has provided some consistency values, the model is initialized by measuring the values of the above described consistency features on the home page. For illustrative purposes, table 1 shows some examples of consistency guidelines that are tested by the tool. These values are stored in memory. When the next page is assessed, by selecting a link from the home page, the model measures consistency by performing boolean comparisons between the consistency values of the previous page and the current page. The more boolean comparisons are true, the higher the consistency of the design.

3 CAT'S ARCHITECTURE

CAT is built from five main components: an interface, an HTML2XHTML converter, a consistency model manager and a tester. The former is a set of JSP pages that provide the interface to access the other components. The converter transforms an HTML document into an XHTML document[2]. The consistency model manager records the parameters needed to assess the consistency. Finally, the tester is an XSLT file that contains XSLT patterns for each of the usability recommendations that have been described in the previous section.
The processes presented in figure 1 are:

1. *CAT* begins by prompting the user to provide the URL of the home-page of the site to be assessed. The tester retrieves this page and converts it to an XHTML page with the help of the converter.

2. This XHTML document is sent to the consistence model manager. This component generates the XSLT patterns that assess the consistency. These patterns are generated dynamically from the current state of the model each time a page is assessed.

3.The XHTML document and the new XSLT patterns that assess the consistency of the page are sent to the tester. The tester updates the XSLT document that performs the usability test with the new patterns. The updated document is used to transform the XHTML document to obtain a reporting XML document.

4. The XHTML document is processed in order to extract the available links from the page.

5. The result document is presented to the user together with a list of links available in the current page (back to point 1).

The usability tester is the core component of *CAT*. The guidelines that are checked by the tool are grouped into six categories (consistency, accessibility, form usability, performance, readability and navigation). Each guideline is realized as a template that contains patterns to select the required target nodes that determine the usability of the document. For illustrative purposes, the following template checks whether all images and graphics contain *alt* attributes:

<xsl:value-of select="count(//
[extra:toLower(local-name())='img' and
not(./@*[extra:toLower(local-name())='alt'])])"/>*

XPath processes target nodes case sensitively however HTML tags are case insensitive. To overcome

[1]The CAT online version can be accessed via http://www.atarix.org/cat/.

[2]This class uses the JTidy library (see: http://sourceforge.net/projects/jtidy/ for further details).

Table 1: Consistency guidelines and values evaluated by *CAT*.

Features that should be kept constant	**HTML check**
Font sizes (Brannon and Sellati, 2000)	The tool memorises and compares the different values that have been specified for the *font* node *size* and *point-size* attributes, the *style* node *font* attributes and the *style-font* attributes.
Font colours (Brannon and Sellati, 2000)	The tool memorises and compares the different values that have been specified for the *font* node *color* attributes, the *style*-node *color* attributes and the *style-color* attributes.
Font faces (Brannon and Sellati, 2000)	The tool memorises and compares the different values that have been specified for the *font* node *font* attributes, the *style* node *font-family* attributes and the *style-font-family* attributes.
Background Colour (Brannon and Sellati, 2000)	Depending on how the background has been specified, the tool memorises and compares either the *bgcolor* or the *background* attribute value of the *body* node or the *background* value of the *style* node.
Structural Links (Nielsen, 2000)	The tool memorises and compares the different *href* attribute values of those *a* nodes that have such an attribute and whose parent node does not have text or only contains '\&nsp;'

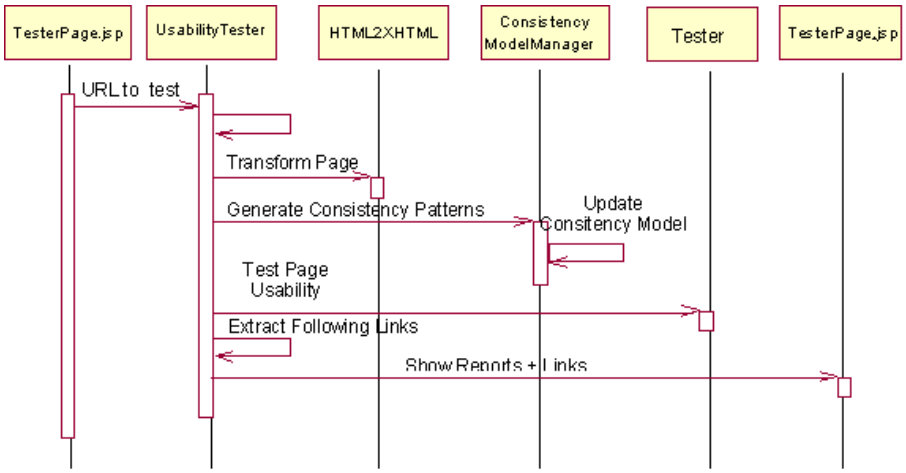

Figure 1: Interaction diagram that illustrates the common usage pattern.

the problem of having to define each possible spelling of the target node in the pattern, the stylesheet transforms every source document node into lower cases before applying the XPath notation. Therefore the above pattern proceeds by selecting all nodes below the root node, denoted by a '//*', and passing them to the *toLower* function to convert the nodes into lower cases. Only those nodes which produce an *img* output are selected.

The next part of the pattern checks whether the current node, the *img* node, does not have an *alt* attribute by selecting all attributes of the current node, denoted by a './@*', checking whether the lower case name of the attribute is *alt* and negating this part of the pattern, denoted by a *not*. Finally the XSLT *count* function is used to count the number of selected nodes. The remaining patterns of the XSLT stylesheet proceed in a similar fashion.

4 *CAT* SAMPLE EVALUATION

The University of Manchester website has been used to illustrate how usability, in particular consistency of web pages is evaluated by *CAT*[3]. The tool starts by evaluating the usability of the home page. Because it is the first page to be evaluated, the consistency of the page cannot be assessed as the tool is unable to compare the current page values to any previous values.

However, the tool is able to assess inter-page usability. For example, the accessibility of the page is impaired because eight images do not have *alt* attributes and seven of the *alt* attribute texts provided are shorter than 2 or longer than 10 words. Furthermore, the page contains scripting language without an alternative presentation making it impossible to view this part of the page in a browser that does not support scripting language.

Concerning form usability, two guideline violation have been found because the page contains a form without a submit and a reset button. However, closer inspection of the page shows that this form is in fact the 'Fast Finder' pull down menu and therefore, does not require a submit or reset button. Currently, the tool is unable to differentiate between different kinds of forms. The performance, i.e. the loading time, of the page could also be improved by including height and width specifications for all page elements (e.g. tables and images) as they have been omitted for 7 elements.

Furthermore, the tool records three readability guideline violations. The first violation concerns the use of a horizontal line which turns out to be very short and therefore does not impair the readability of the page. The second readability guideline violation concerns the specification of the main layout table and the header, both of which have been specified wider than 500 pixels. Consequently, users with smaller screens are unable to view the home page without having to scroll sideways. Although, *CAT*'s assessment result indicates too many structural links on the page (26 instead of the preferred 5-7 links), these violation can be dismissed because home pages should display a higher number of links than its sub-pages to provide more initial navigation options.

The next page to be evaluated is the *Undergraduate Courses* sub- home page which can be reached by selecting the 'http://www.man.ac.uk/study/ugrad/' link from the home page. This time consistency can be evaluated and the results show that the font-sizes, -faces and -colours of the current page differ from those of the home page. The same applies to the navigation menu. The only feature that has been kept constant is the background colour which has the default colour white. Consequently, the consistency of the current page compared to the home page is very low. The evaluation results for the other usability categories are similar to those recorded for the home page. The only major difference is the percentage of links contained in the current page as it is only 10% compared to 27% recorded for the home page. The former is well within the recommended maximum of 20% link text for sub-pages and indicates that this page has far more content than the home page, which is indeed the case.

The consistency of the *Student Life* page, which can be reached by selecting the *life1.html* link from the *Undergraduate Courses* page, is far higher than has been recorded on the previous page. For example, the font-sizes and -colours and the background-color are all the same as in the previous page. On the other hand, the font-face has not been kept consistent, because the previous page contained a paragraph written in italics. Furthermore, the navigation menu has been altered by adding 5 structural links.

Overall, the above example shows that *CAT* is a reliable tool for evaluating the usability, particularly the consistency of web pages. Although, occasionally the guideline violations registered by the tool do not affect the usability of the particular page e.g. the omission of the reset and submit button for the *Fast Finder* pull-down menu. Furthermore, *CAT* is currently unable to differentiate between the weighting of the different consistency values. For example, whether the change of font-faces between the *Undergraduate Courses* and the *Student Life* page only affects a paragraph, which was in fact the case, or the whole text. Additionally, the URLs of the links available on the current page, that are displayed together with the evaluation results, are often meaningless and it would be more user friendly to display the link descriptions instead. However, these shortcomings will

[3]The University of Manchester website can be found at: http://www.man.ac.uk/.

be addressed in future versions of *CAT*.

5 RELATED WORK AND DISCUSSION

The majority of automatic evaluation methods concentrate on the statistical analysis or visualization of usage patters in server logs (e.g. (Chi et al., 2000)). Such evaluations consist largely of traffic-based analysis (e.g. pages-per-visitor or visitors-per-page) and time-based analysis (e.g. click paths and page-view durations) which need to be interpreted by an evaluator to identify usability problems. However these methods are problematic because web-server logs provide only incomplete traces of user behaviour (e.g. do not capture use of back button) and timing estimates might be incorrect because of network delays (Ivory et al., 2001).

Another approach is WebCriteria's Site Profile which evaluates websites by simulating a user's information-seeking behaviour within a model of an implemented site. The tool assumes an idealized user model which navigates through the website following an explicit, pre-specified path and measures usability metrics such as page load and optimal navigation times (WebCriteria, 1999). However the approach is unable to account for the effect of various web page attributes, e.g. the amount of text presented on each page or the layout of the links (Ivory et al., 2001).

The fullest automation support according to Ivory et al. is provided for guideline review inspection methods (Ivory et al., 2000). Such methods automatically detect and report violations of usability guidelines and try to suggest ways of correction. Other methods compare quantitative web page measures (e.g. number of links or graphics) to predefined thresholds (Ivory et al., 2001).

An example is the *Web Static Analyzer Tool (SAT)* which checks the static HTML code of a website according to a number of pre-defined usability guidelines, e.g. whether all graphics contain *alt* tags or whether each page contains at least one link. Currently the tool is only able to evaluate individual HTML pages but not a whole site. However plans exist to extend the tool to inspect an entire site in order to identify potential problems in the interaction between pages (Team, 2000).

The W3C (The World Wide Web Consortium) have developed their own HTML Validation Service which assesses HTML and XHTML documents for conformance to their recommendations and other standards. They also offer a *CSS Validation Service* and an *XML Schema Validator* for checking cascading style sheets and XML schemas for conformance to their recommendations. The tools are able to check documents by a given URL or by uploading files and provide feedback for all guideline violations found in the document. However like the *WebSAT* the tools are currently only able to check individual pages or documents (Oskoboiny, 2001).

Most of the above tools measure usability in a per-page basis. By contrast, *CAT* strives to measure consistency among distinct page belonging to the same web site.

The problem with automatic guideline review inspection tools such as *CAT* is that they are only able to assess usability aspects that are inherent in the HTML syntax and that can be tested automatically. Other guidelines for example the ease with which users understand instructions and error messages or how well users can navigate around the site are not evaluated (Nielsen, 2000). These aspects of usability are very difficult to assess automatically because they involve complex cognitive, social and cultural processes that determine the interpretation of textual, visual, audio messages, the selection of relevant information and learning (Brajnik, 2000).

The question is, how effective is *CAT*, i.e. how well do the usability problems highlighted by the tool determine the overall usability of the site? Brajnik pointed out that the lack of a standard evaluation methodology to determine the effectiveness of assessment tools prevents the evaluation and comparison of the quality of the different tools currently available. However the definition of such a standard methodology depends on clearly defined models of usability which so far have not been developed (Brajnik, 2000).

Therefore, the only method currently available for evaluating the effectiveness of automatic assessment tools is by comparing the usability problems found by the tool with the results of usability inspection methods and user testing. A high degree of overlap between the findings of the tool and the traditional evaluation methods would indicate that the tool is at least to some extent effective. However, a low degree of overlap would not necessary mean that the tool is ineffective as it could be possible that the usability problems found by the tool are different from those found by the manual usability tests. In fact, usability findings for the same interface can vary considerably between different evaluators even if the same evaluation techniques are used. For example, Molich et al. found only 1% overlap for results among different usability testing teams that evaluated the same user interface. Because of these difficulties effectiveness testing has not been included in the current study (Molich et al., 1999).

Ivory et al. criticized automatic usability assessment tools that are based on usability guidelines(Ivory et al., 2001). The reason is that designers often have difficulties implementing such guidelines especially if the guidelines conflict with each other (Ivory et al., 2001). Ivory et al. assume that this is caused by

the lack of agreement among designers about which guidelines are correct (Ivory et al., 2001). Their study showed that page-level metrics (e.g. number of words, colours, fonts and graphics per page) can to 85% predict if a site will be highly rated by judges and users. However the results also showed that the importance of certain usability metrics e.g. the composition, layout and overall characteristics differ among large and small website as well as among different categories such as education, community and finance. Therefore, Ivory et al. concluded that there are several ways of developing well-designed and highly usable websites. Furthermore, the quality of the design is determined by a combination of different usability metrics depending on the nature of the site (Ivory et al., 2001).

6 CONCLUSION AND FUTURE WORK

To the best of our knowledge no usability assessment tool currently available is able to measure interpage consistency of websites. However, as Nielsen (Nielsen, 1993, p.90) pointed out, "consistency is one of the most important usability characteristics". Those features of a site that are noticed first by website users is not the title but the overall layout of the design elements of the page. Consistency not only aids users to navigate around the site but also increases their confidence in the information presented because they associated a unified design with professionalism (Brannon and Sellati, 2000). Furthermore, increasing the consistency of intranet sites can enhance productivity. For instance it has been estimated that the redesign of Sun's intranet site could save each employee as much as 5mins per week which amounts in an overall saving of $10 million dollars per year through avoiding lost productivity (Lynch and Horton, 2001).

Future extensions of the tool might include consistency testing for a set of pages. I.e. the current page is evaluated against consistency patters derived from a group of pages rather than only the previous page. To reduce the time and effort needed to perform maintenance activities the tool could be extended to indicate the location of usability violations in the syntax and suggest possible ways of correction.

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