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Structuring Guidelines for Web Application Designers

A Meta-model

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Abstract: Companies develop and maintain complex web sites. Literature provides them with many guidelines for these tasks. However this knowledge is disseminated in many information sources and difficult to apply. This paper is an attempt to address the following research question: How to structure the existing guidelines helping website designers in order to facilitate their application? The contribution is twofold: i) we propose a meta-model allowing a rich representation of these guidelines, ii) we feed this model with several hundreds of guidelines thanks to a deep extraction and structuration. Future research will consist in enriching the UWE (UML-based Web Engineering) method with this knowledge base leading to a quality based approach.

1 INTRODUCTION

Companies develop and maintain complex web sites that allow them to communicate easily and dynamically with their customers, suppliers, partners, etc. In 2008, according to Krigsman, 24% web projects fail to be delivered within budget and 5% were unable to confirm the final cost of their web development project. Moreover, 21% fail to meet stakeholder requirements and nearly a third of web based projects (31%) were not delivered within the agreed timescales (Krigsman, 2008). More recently, a research, conducted by McKinsey and the University of Oxford on more than 5400 IT projects, concluded that 45% of large projects are over budget, 7% are over time and 56% delivered less value than predicted (Bloch, 2013). The reasons vary: unclear objectives, lack of business focus (missing focus), shifting requirements, technical complexity (content issues), unaligned team, lack of skills (skill issues), unrealistic schedule, reactive planning (execution issues) (Bloch, 2013), inconsistent stakeholder demands, and insufficient time or budget (Krigsman, 2008).

Web sites and web applications are in fact software applications. In this sense, the classical application methodologies may be used manually or with the help of computer aided software engineering (CASE) tools. However, the very specific nature of these applications led to the proposition of more dedicated approaches. Indeed, during the two last

decades, research in Web Engineering brought a rich contribution composed of methods and techniques to support Web applications development. These methods such as UWE, WebML, or others are generally founded on a model-driven development paradigm, and provide models and transformation rules to handle several web applications' aspects such as data, navigation, interaction, and presentation. However and despite the research and the tooling efforts, very few developers adopt these methods and many continue to apply ad-hoc practices.

The main reason is that these approaches suffer from lack of guidance. Even if web application designers refer to these approaches, they do not have sufficient knowledge and help in implementing them efficiently. As a consequence, the resulting applications are neither user-friendly nor easy to maintain.

We argue that the current approaches are well structured. However they need to be enriched with guidelines helping designers in the numerous decisions they have to make during the web application development. Therefore, we have collected the different sets of guidelines proposed in the literature and organized them along different dimensions. In particular, this structure allows us to link the guidelines with the quality objectives (maintainability, performance, functionality, security, etc.) and with the relevant steps of the web application design (content design, navigation design and presentation design).

This article is organized as follows. Section 2 describes how we collected and selected the guidelines, and a short experiment we conducted on how methods and guidelines are followed in websites construction. Based on the survey conclusions, Section 3 motivates and describes our research question. Section 4 describes the meta-model we propose in order to represent the guidelines in a useful way. Section 5 analyses the set of resulting guidelines. Section 6 is dedicated to related works on guidelines. Finally, the last section concludes and sketches future research directions.

2 AN EXPERIMENT ON METHODS AND GUIDELINES USAGE

Before defining the research question, we performed a quick inventory on how well web design best practices and guidelines are followed by existing websites. The objective was i) to analyze whether existing practices and guides are used and ii) identify how to facilitate their adoption and hence avoid ad hoc approaches. Thus, we first collected 475 guidelines from several sources and confronted them with three websites: the web site of our university department (deptinfo.cnam.fr), the website of a French newspaper (lemonde.fr) and a well-known e-commerce web site (amazon.fr). We first describe briefly the collected guidelines and then their verification on the three websites.

2.1 Collecting the Guidelines

World Wide Web Consortium (W3C) is the main international standards organization for the World Wide Web. This consortium puts together around 400 organizations. They developed Web Content Accessibility Guidelines (WCAG) with the goal of proposing a single shared standard for web content accessibility that meets the needs of individuals, organizations, and governments (Web Accessibility Initiative). Two versions of WCAG were published until now. The first one was introduced in 1999. It contains 14 large guidelines. Each main guideline is composed of atomic guidelines addressing the same topic. The second version was published in 2008. It contains 12 guidelines organized into four categories, targeting four desirable characteristics of websites: perceivable, operable, understandable, and robust.

WCAG defines three levels of conformance, respectively A, AA and AAA. Some of the related

guidelines could be automatically checked whereas others require manual checking. Authors in (Trulock, 2008) conducted a case study on Irish websites showing that web designers are aware of web accessibility but they concentrate their efforts on ensuring validation of automatically controlled checkpoints and ignore those requiring additional manual testing.

The guidelines of WCAG focus only on accessibility. Thus, we collected other guidelines which address all the characteristics of web site quality. The literature contains guidelines for specific web sites (for children for instance) as well as rules available for all sites.

2.1.1 Identifying the Relevant Sources

For collecting guidelines from literature effectively, we use some keywords when searching, such as “website guideline”, “guideline for website”, “guideline security web application” in title and content of document, from main electronic libraries and databases in computer science: IEEE Xplore, Springer, ScienceDirect, ACM, and DBLP. As an example, based on the keywords “web” and “guideline”, we have 1273 results from IEEE, 273 results from ScienceDirect and 168 results from DBLP. With Springer and ACM, we have much more results in many domains, so we had to refine the results and choose results with high relevance (as computed by the search engines). Then we defined inclusion criteria for selecting sources (primary studies) and rejecting the other ones. The inclusion criteria are presented in the table below (Table 1).

Table 1: Inclusion criteria.

Criterion	Description
C1	The study focuses on guideline definition for web sites
C2	The study mentions quality characteristics of web sites
C3	The paper is recent, i.e. published since 2000
C4	The paper proposes original guidelines (does not only mention guidelines from other studies)

We found several guideline lists published since 2000. However, these documents are sparse and address many domains. One objective is to gather them, categorize, and model guidelines. Thus they will be more usable for supporting web application developers. Some guidelines are general and others are dedicated to specific domains: education, international, or for particular ages (children or

seniors). As an illustration, the guidelines of AgeLight Company (AgeLight LCC, 2001) are divided in six categories: layout and style, color, text, general usability testing, accessibility and disabilities, user customization. Web sites for old people are the research object of a number of studies (Xie, 2011) (Sun, 2010). Meloncon et al., in contrast, concentrated on guidelines for children (Meloncon et al., 2010). Maguire focused on e-commerce international sites (Maguire, 2011). Some papers focused on the characteristics of quality directly, such as (Chiuchi, 2011) which targeted portability and efficiency. (Radosav, 2011) capitalizes on the 14 guidelines from WCAG, so we did not collect them. Finally, we took into account fourteen sources. Their analysis is described below.

2.1.2 Extracting the Appropriate Guidelines

Our systematic search followed by a scan of sources allowed us to exhibit fourteen papers containing relevant guidelines. The next step consisted in studying all the guidelines and selecting the helpful guidelines. In each source of guidelines, we found some obsolete guidelines or some recommendations which were out of our scope. For example, in (U.S. Department of Health and Human Services, 2006), guidelines in the last part (part 18), such as “Use an iterative design approach” or “Solicit test participants’ comments” were not selected, since they are too general or dedicated to testing. So we eliminated them from the list.

We found 14 sources with 475 guidelines (an excerpt is listed at Annex 1). The number of guidelines of each source is presented in Table 2. In

some cases, we split some guidelines, hence the number of selected guidelines may be higher than the number of guidelines proposed in the paper.

Some sources propose general guidelines. Others are more specific. For example (Bargas-Avila, 2010) concentrates on web forms or (Chiuchi, 2011) focuses on portability and efficiency.

Some guidelines are too complex, so we had to divide them into two parts or more. For example the guideline for images in (Chiuchi, 2011) is separated into two atomic guidelines: “The preferred use of JPEG and GIF images” and “The resolution of image should be set correctly inside the tags”.

2.2 Analyzing the Guidelines Usage

To analyze how well the guidelines are applied in practice, we defined four levels namely: Yes, No, Partial and NN. Yes means that the site satisfies completely the guideline, No means that this site does not satisfy it, Partial means that this site partially meets the guideline and NN means that “We don’t know”, since either the guideline cannot be applied to the site or we don’t have enough information. The result is synthesized at Figure 1. Each guideline obtains the grade 1, 0.5, 0 point for Yes, Partial and No respectively. After applying all guidelines to the three websites, each guideline obtains a grade between 3 and zero or is equal to NN. Thus, 206 guidelines are verified on the three selected sites (totalizing 3 points). 33 guidelines reach 2.5, 46 guidelines obtain 2 points. 60 guidelines obtain between 0.5 and 1.5. 47 guidelines obtain 0, meaning that they are not respected on the three selected sites.

Table 2: Source, number and scope of guidelines.

Source	Proposed guidelines	Selected guidelines	Scope
(AgeLight LCC, 2001)	53	35	General
(Bargas-Avila, 2010)	20	20	General but concentrating on web forms
(Xie, 2011)	7	10	Old people / medical information
(Chiuchi, 2011)	17	15	General / focusing portability and efficiency
(Carnegie Mellon University)	7	8	University
(U.S. Department of Health and Human Services, 2006)	196	209	General
(Leuthold, 2008)	9	9	Blind people
(Lokman, 2009)	13	14	General
(Maguire, 2011)	20	8	International site
(Meloncon, 2010)	21	11	Children
(Microsoft Developer Network)	50	49	General
(Ministry of Community and Social Services of Ontario, 2012)	11	11	General
(Ozok, 2004)	20	20	General
(Sun, 2010)	31	31	Old people

But let us remind that 3 guidelines are dedicated to international or children sites, and thus are not required in the three tested web sites. Besides them, there are 83 guidelines obtaining the NN value. For guidelines which have NN value, many of them are related to the security aspects. To check if they are fulfilled, we require the admin authority, so we cannot conclude about these guidelines.

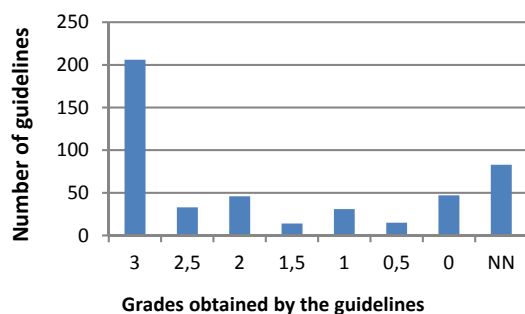


Figure 1: The distribution of guideline grades.

As an illustration, the guideline G115 “considering both levels: ‘high’ and ‘low’ of cultural context for satisfying both viewpoints” or G176 “Limit navigational topics” are not relevant for the three web sites. Others may be irrelevant, such as G217 “Inform users of long download times” or G247 “Limit homepage length” since we had high speed connection for our tests.

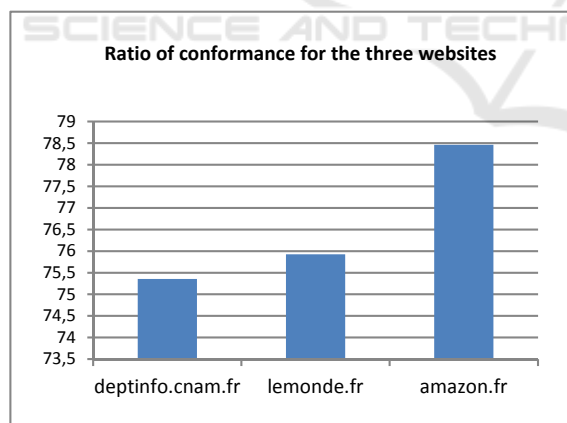


Figure 2: Results for the three websites.

Figure 2 compares the scores obtained by the three websites if we consider the rule: the more guidelines the web site complies with, the better score it obtains. deptinfo.cnam.fr obtains the score of 264.5 while lemonde.fr obtains 287 points. Finally, amazon.fr is the best one with score of 300.5. However, deptinfo.cnam.fr has 124 NN guidelines, whereas lemonde.fr has only 97 NN guidelines and amazon.fr

has 92 NN guidelines, so if we compare ratios, deptinfo.cnam.fr achieves 75.3%, lemonde.fr 75.9% and amazon.fr is the highest with 78.5%.

These figures show that either these guidelines are not considered as references or these websites still face quality problems. As an example, let us mention G345 “Provide auto-tabbing functionality” for increasing users’ convenience and G362 “Using photographs of people” for increasing users’ reliability. The three websites are not aligned with these two guidelines. That means that these guidelines which were validated through complex processes are not sufficiently known by web site designers.

3 RESEARCH QUESTION

From the mid of 1990s, methods and approaches have been created for helping developers to build web applications more easily and constructively. The Object-Oriented Hypermedia Design Method (OOHDM) was one of the first methods proposing a rigorous process from requirements elicitation to implementation including navigational and interface design (Schwabe, 1995). The method relies on object-oriented principle and proposes notation mainly derived from UML. The transition from models to specification is not supported and thus requires a considerable effort.

The Web Modelling Language (WebML) is a model driven web engineering method dedicated to data-intensive web applications (Ceri, 2000). WebML is one of the most used web engineering methodologies. It is supported by a development framework, Ratio5 (Acerbis, 2005) that is fully integrated to the Eclipse framework. Several extensions of the first version have been proposed offering a rich modelling approach for developers. However, the method relying very few on standards, it led to a proliferation of proprietary notations increasing the method complexity.

The UML-based Web Engineering (UWE) methodology (Hennicker, 2000) is a model-driven Web Engineering approach. It relies heavily on UML and is extensively related to standards. The model driven orientation allows generating platform specific implementation through dedicated transformation rules. Model driven approaches are based on four levels of abstraction: the computer independent model (CIM), the platform independent model (PIM), the platform specific model (PSM), and the code. Some methods address only the CIM level, other methods focus on PIM level. In the same way, some

methods deal with the transformation of CIM to PIM (e.g. NDT, OOWS), others address the transformation of PIM to PSM (e.g. WebML, UWE) and others incorporate the transformation of PSM to code (e.g. OOADM, UWE) (Aragon, 2013). Even if these methods offer a real support, they are still not used by practitioners probably since they are complex and they do not provide designers with sufficient guidance.

We argue that most methods do not provide their users with sufficient guidance in the design and development process. Either in the same approaches or in other sources, researchers propose many guidelines in order to help designers and developers. These guidelines may be very helpful to support them.

Thus the research question we address in this paper may be defined as follows: “How to structure all the existing guidelines helping website designers to understand and apply them?” To answer this question the experiment presented in Section 2 helped us to elicit the main characteristics of these guidelines. We then defined a meta-model allowing us to represent this knowledge. Finally we categorized the selected guidelines based on our meta-model. This categorization aims to facilitate their reuse.

4 GUIDELINE CAPITALIZATION: A MODEL-BASED APPROACH

In the literature, we find different ways to describe guidelines: in (Chiuchi, 2011), they are represented by three attributes: Category, Name and Content. Meanwhile in (Ekberg, 2010) a guideline has three parts: design/application solutions, objective and description. We argue that this descriptive information is not sufficient to facilitate the reuse of guidelines by web application designers. In particular, the latter must find easily the guidelines using different criteria. For example, in case of designing a web application for blind people: which recommendations do they have to take into account? If developers want mainly to facilitate the maintainability of the web application: which guidelines aim at this objective? Etc.

We first propose a model helping capitalizing and structuring the guidelines. The meta-model is depicted at Figure 3.

Following the general description of patterns for decision processes (Harrison, 2007), we propose to link each guideline with the following categories:

- The source where the guideline was found,
- The quality characteristics and sub-characteristics that the guideline addresses,

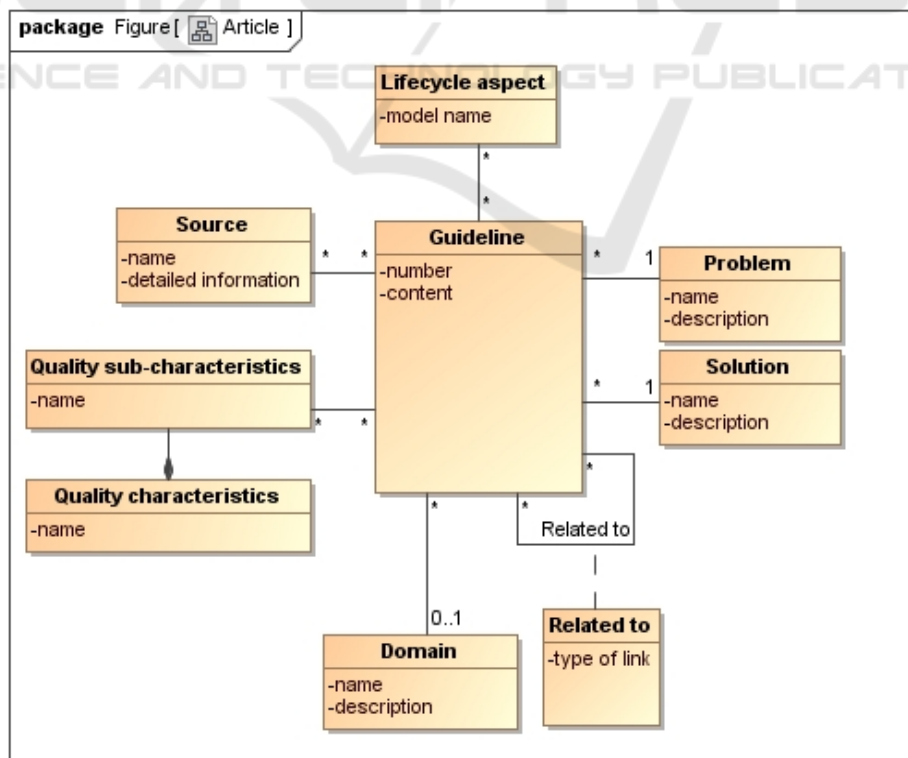


Figure 3: The meta-model of guidelines.

- The problem it aims to solve,
- The solution proposed,
- The particular domain concerned if any,
- The lifecycle aspect, meaning which web application model (content model, navigation model, presentation model) it deals with.

This structure will constitute a knowledge base for automatic reuse through a web application design tool. The meta-model is represented as a UML class diagram at Figure 3. The *related to* relation between guidelines allows us to represent potential links between guidelines. Thus the attribute type of link may take the values “in contradiction with”, “specializes” or “similar to”.

Each guideline solves a problem; however several guidelines may tackle the same problem. The solution of the guideline describes the rules to be applied. As explained above, in our process, we split some guidelines such that each resulting guideline recommends one and only one solution. The domain may be general or it may be a specific one. The quality characteristics (functional suitability, performance/efficiency, compatibility, usability, reliability, security, maintainability, portability) and sub-characteristics refer to ISO25010 for software quality. For space reasons we may not list all of them. Some guidelines are common to several sources, hence the multiplicity of the relation here is many-to-many. Finally, the lifecycle aspect consists of three elements: Content, Navigation, and Presentation.

In order to illustrate, let us describe the guideline G37: “For body copy, the recommended faces for the web, in order of preference, are Verdana, Arial and Helvetica. The browser should use Verdana first; if it is not available, use Arial and then Helvetica. If none are available, use another Sans serif font”.

Number: #37

Content: For body copy, the recommended faces for the web, in order of preference, are Verdana, Arial and Helvetica. The browser should use Verdana first; if it is not available, use Arial and then Helvetica. If none are available, use another Sans serif font.

Problem: Choosing appropriate font for a website

Domain: web for university (even if it can also apply to other types of site)

Lifecycle aspect: Presentation

Quality Sub-characteristics: User interface aesthetics

Quality Characteristic: Usability

Solution: Choose Sans serif font, namely Verdana, Arial and Helvetica.

Source: (Carnegie Mellon University)

5 GUIDELINES ANALYSIS

In this section, we provide the reader with an analysis of the guidelines according to the different dimensions of our meta-model. Let us remind that our selection process led to the constitution of a set of 475 guidelines (the guidelines can be found at <http://deptinfo.cnam.fr/~wattiaui/Guidelines.html>).

If we analyze them from the lifecycle dimension (Content/ Navigation/ Presentation), we counted 203 guidelines for Presentation, 291 guidelines for Content and only 40 guidelines for Navigation. Some guidelines address more than one model. Hence the total exceeds 475 (Figure 4).

The 475 guidelines were mapped with quality sub-characteristics. Some guidelines are mapped with several sub-characteristics. The characteristic Usability, with sub-characteristics Operability and User interface aesthetics is the most involved one. It is easy to explain since many papers address interface aspects (User interface aesthetics) and aim to build easy-to-use interfaces (Operability).

Many guidelines are about font (G37, G42, G49, G50, etc.) and color (G6, G8, G39, G41, G86, G185, G186, etc.) of websites. White is the color which is not recommended (G9, G39, G189, etc.).

We can detect some contradictory guidelines, since some guidelines aim at different goals. In the guidelines of a university (Carnegie Mellon University) the documents should be opened in new windows (G35), probably for legal responsibilities. It is opposite to guideline G101 (AgeLight LCC, 2001) which recommends not to open external links in new windows, since it can cause user distracting.

Guideline G37 recommends using only Sans-serif font, but meanwhile G85 accepts serif font in web site for printing.

Some guidelines are dedicated to different types of users, but finally they have same contents. As an illustration, Sun et al. (Sun, 2010) focused on website for old people; meanwhile Meloncon et al. (Meloncon, 2010) concentrated on web applications for children. Old people and children are two types of users which have some specific characteristics in comparison with others (e.g. not being able to understand complex content).

The guideline about Security of web applications in MSDN of Microsoft (Microsoft Developer Network) contains about 50 sections. Many of them address Integrity (prevent unauthorized access) (in 38 sections) and Confidentiality (data are accessible only to those authorized) (in 18 sections). This is due to the fact that Integrity and Confidentiality are important for web applications which are designed for many

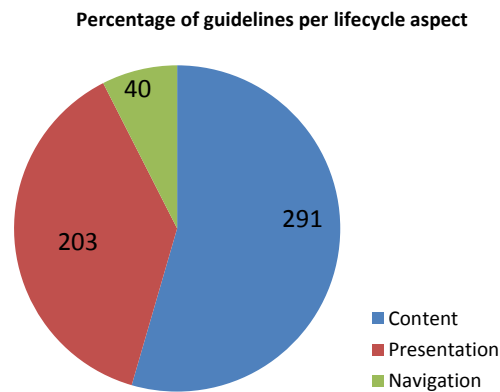


Figure 4: Percentage of guidelines per lifecycle aspect.

kinds of users and also are the targets of attacks.

Among the eight quality characteristics, Compatibility is not mentioned at all, since guidelines focus on the site itself, and not on the relation of the site with other sites or other applications (scope of Compatibility).

6 RELATED WORKS

In this section, we synthesize the literature on guidelines for web site design. We organized this state of the art in two categories: first the approaches which propose guidelines and, second, the approaches which involve such guidelines.

6.1 Design for Guidelines

One of the most famous works delivering guidelines for web site design is Web Accessibility Initiative (WAI) of W3C (WAI, 2008). It is a collection of standards, guidelines, and techniques for making accessible products in four categories: websites, authoring tools, browsers, and web applications. Each category has a bunch of guidelines for constructing web design and for improving accessibility. Other sources of guidelines were listed in the paper and enrich considerably the W3C recommendations.

Khlaisang is an example of research illustrating how these guidelines may be either validated or elicited (Khlaisang, 2015). The author developed user interface guidelines and a prototype for evaluating educational service websites. Based on source sites of Thailand Cyber University Project (TCU), he studied the use of sites, the website structure, the user interface design and conducted usability tests of the site. Resulting from these experiments, he presented a model of suitable website for TCU service. Starting

from this website, model, he designed and developed a prototype of site. The paper also mentions similar approaches.

6.2 Design by Guidelines

Besides works creating guidelines, other works used existing guidelines for proposing ways to improve quality of websites.

Leuthold et al. (Leuthold et al., 2008) designed enhanced text user interfaces for blind Internet users. Starting from the guidelines of web content accessibility guidelines (WCAG), they proposed enhanced text user interface (ETI) helping blind users in spending less time to complete tasks, making fewer mistakes and expressing greater satisfaction when surfing the website. This system contains nine guidelines. For blind users, this system is more usable than normal GUI.

Another work building on WCAG guidelines is (Sloan, 2006). Using e-learning as an example, they propose a framework that guides web authors and policy makers in addressing accessibility at a higher level, by defining the context in which a Web resource will be used and considering how new alternatives may be combined to enhance the accessibility of the web site.

After a brief description of the 14 guidelines of WCAG (version 1), Radosav et al. discussed the choice of colours for adjusted web design (Radosav, 2011). They classified colour into several groups and concluded that colours, which cannot be differentiated by people with colour discrimination disability, should not be placed next to each other.

For space reasons, we cannot provide a more detailed literature review. As a conclusion, research in this field is prolific and aims at i) proposing guidelines for web site designers, ii) enriching existing ones, iii) implementing guidelines into more comprehensives approaches, iv) evaluating guidelines through experiments. To the best of our knowledge, we did not find any paper proposing a meta-model allowing us to put together the different guidelines as a first step for their reuse in an automatic way.

7 CONCLUSION AND FUTURE RESEARCH

The companies grasp the importance of having usable and efficient web applications. Thus, their development and maintenance is of high importance. The academic literature on the subject contains hundreds of guidelines aiming at helping web site

designers. The research question we addressed in this paper may be expressed as follows: How to structure the existing guidelines helping website designers in order to facilitate their application? As a first contribution, we defined a meta-model allowing us to describe each guideline with six dimensions: the problem it addresses, the solution it proposes, the lifecycle aspect it deals with, the target quality characteristics, the source it comes from, the potential links (similarity, contradiction, specialization) with other guidelines. Our search and selection process allowed us to define 475 such guidelines and to feed our meta-model with them. This required the mapping of them with the relevant quality sub-characteristics. As a first evaluation of these guidelines, we checked whether they were compliant with three very different web sites.

This research suffers from some limitations. Thus, it is rather easy to check the contradiction between guidelines attached to the same quality characteristics and/or sub characteristics. However, contradictions may also occur between guidelines associated with different quality characteristics. Moreover, some guidelines may become obsolete due to new technical opportunities. It is not easy to ensure an easy update of guidelines.

Future research will explore three directions: first the definition of a grammar for expressing problem and solution components of guidelines; second, the implementation of these guidelines in a CASE tool implementing UWE web application design method; third, a validation of the approach through an experiment with web site designers, in order to evaluate how the guidelines help them when using the CASE tool.

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APPENDIX

Annex 1: Excerpt from the set of guidelines.

Num ber	Content	Sub-characteristics	Source	Related to other guidelines	Lifecycle	Specific
1	Left justified text, text line should not be long	User interface aesthetics	[8]	Similar to G70	Presentation	Old people
6	Support users flexible operations (adjustable font size, color conversion)	Accessibility	[8]		Presentation	Old people
7	Ensure links change color after visit	Operability	[8]	Similar to G63	Presentation	Old people
20	Provide a site-map	User error protection	[8]		Navigation	Old people
21	Search engine should have to check and correct misspelled function	Operability	[8]		Content	Old people
30	Consider page download speed - create 'small' pages	Time behaviour	[8]		Content	Old people
31	Do not require 'double clicks'	Accessibility	[8]		Presentation	Old people
32	All images should be JPGs, GIFs or PNGs. JPGs are used for photos. Graphics should use GIF or PNG formats	Functional appropriateness	[15]		Content	University
33	Images have a resolution of 72 dpi and are in either RGB or indexed color modes	Adaptability	[15]		Content	University
36	Links should be relevant text. Do not link words like "here" "this page" etc.	Operability	[15]		Content	University
48	Main background color should be brown, not light blue	User interface aesthetics	[17]		Presentation	
55	Including hyperlinks within longer pages so viewers can "jump" with a single click	Accessibility	[6]		Navigation	
76	Should not use exceptionally bright, fluorescence or vibrant colors	User interface aesthetics	[6]		Presentation	
95	Archive old articles, while maintaining the actual page URL	Functional completeness	[6]		Content	
99	Trying to link to sites at the highest possible level, in the case "page not found"	Fault tolerance	[6]		Navigation	
103	If using tables, provide an alternate text-only version of page	Replaceability	[6]		Content	
106	Site should have multi language versions	Fault tolerance	[6]		Content	
110	Getting the spelling right for the correct market	Operability	[10]		Content	International site
117	Should build auto response service informing that they will receive a full reply within 24 or 48 hours	Functional correctness	[10]		Content	International site
191	Use concrete words, active verbs, and concise sentence structure	Availability	[10]		Content	International site
246	Ensure the homepage looks like a homepage	Learnability	[9]	Similar to G25	Content	Children site
		Appropriateness	[13]		Presentation	
		recognizability				