Techniques for Developing More Accessible Web Applications: a Survey Towards a Process Classification

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ABSTRACT

The Web has become one of the most important communication media, since it is spread all over the world. In order to enable everyone to access this medium, Web accessibility has become an emerging topic, and many techniques have been evolved to support the development of accessible Web content. This paper presents a survey on techniques for Web accessibility and proposes a classification into the processes of ISO/IEC 12207 standard. The survey was carried out applying systematic review principles during the literature review. The results include analysis obtained from the synthesis of 53 studies, selected from an initial set of 844. Although the survey results indicate a growth in research on techniques for design and evaluation of Web applications, they also indicate that several development activities have been poorly addressed by scientific research efforts.

Categories and Subject Descriptors

H.5.4 [**Information Interfaces and Presentation**]: Hypertext/Hypermedia; D.2.0 [**Software**]: Software Engineering; K.4.2 [**Computers and Society**]: Social Issues

General Terms

Human Factors

Keywords

Information Accessibility, Information Design, Web accessibility, Universal Web Usability, Universal Web Design

1. INTRODUCTION

The growth in the number and variety of Web applications has placed the Web as one of the most important technologies for the development of the so called "Information Society". The use of standard technologies, accessible from a number of devices, makes the Web a promise for providing universal information access.

However, if information contained in Web applications is not properly designed, it may lead to many access barriers. The barriers may prevent users with special needs from accessing Web content and performing communication using it. Tim Berners Lee[1] has stated that "*The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect*".

The challenge of developing Web content accessible by everyone has motivated the evolvement of a number of techniques to address Web accessibility issues. In last years, many researches on Web accessibility have been reported. The studies are distributed in many different areas such as Hypermedia, Software Engineering, Multimedia, Human-Computer Interaction (HCI) and other related fields.

Although there are many techniques for supporting the development of accessible Web applications, many developers are not aware of them [12] and many organizations do not properly apply them. In a survey carried out by our research group in 2007, with the participation of 605 Brazilian people involved with Web site projects, it was noticed that 48% of the respondents do not use any accessibility evaluation method. In the same survey, 39% of the respondents answered they have no knowledge about the W3C recommendations for accessibility, and 30% answered that have only basic knowlegde about them.

Besides the lack of knowledge about existing techniques, in this paper we have detected a lack of techniques for supporting Web development activities considering accessibility, like requirements elicitation, navigational design and others.

The purpose of the present study was to identify the existing techniques for developing accessible content in Web applications, and to point out research gaps found in the literature. The survey and analysis of the papers were done based on principles of a systematic review method [11].

In order to get a process oriented view, the techniques reported in this paper were classified according to the development processes they may support. The classification was done using the software development processes of ISO/IEC 12207 standard[9].

This paper is structured as follows: Section 2 gives a brief introduction on Web Accessibility concepts and presents concepts of Web development processes used in the classification performed in this study. Section 3 describes the methodology applied in the survey. In Section 4 we discuss the main results obtained from the survey as well as the classification, and finally in Section 5, we present the conclusions and future work.

[1]W3C Director and inventor of the World Wide Web

2. WEB ACCESSIBILITY AND WEB DEVELOPMENT

The growth of the use of Internet through ubiquitous devices, and the use of Web resources by people with disabilities or with any other kind of restrictions have been a strong motivation to the development of techniques to produce accessible Web content. The main goal of developing accessible Web applications is to make possible for everyone to use, to understand the content of the pages, and to communicate using Web based resources, despite disabilities or technological restrictions.

Web Accessibility is the ability for a person using any user agent (software or hardware that retrieves and renders web content) to understand and fully interact with a website's resources. The idea behind Web accessibility is based on more than just the implementation of standards; it embodies the idea that everyone has the right to be included in society, regardless disability, geographical location, language barriers, or any other factor [18] [16].

Research projects on Web accessibility have addressed a variety of issues related to Web access by disabled people and users with special needs. Many advances have been done to enable Web access by users with motor disabilities, visual and auditory impairments, and other disabilities. The increase of new assistive technologies, such as screen readers and alternative devices, has presented new challenges for developing applications that meet universal usability requirements. Older adults have also received much attention by researchers, as a very fast growing group of Web users with special needs.

Making pages accessible for blind people is one of the most common issues in accessibility. In general, when pages are not properly designed, blindness may become almost a synonymous of inaccessibility [8]. Screen readers used by the blind may only "display" information that can be read as text. Consequently, images without alternative text, bad tables and other bad designed elements may become barriers for these users. Figure 1 shows an example of the lack of alternative text for an image and bad distribution of text in a table[2] that make it inaccessible for the blind. Figure 2 shows the same page in a graphical Web navigator.
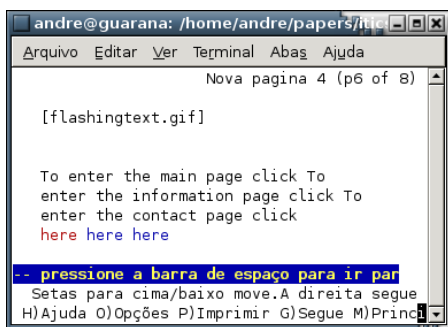
Figure 1: Example of an inaccessible page in a text-only navigator

Increasing recognition of the importance of both information accessibility and universal access to information tech-

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[2]links were designed to appear in a separated line below the indications, and so it is impossible to distinguish which "here"corresponds to the "click" command
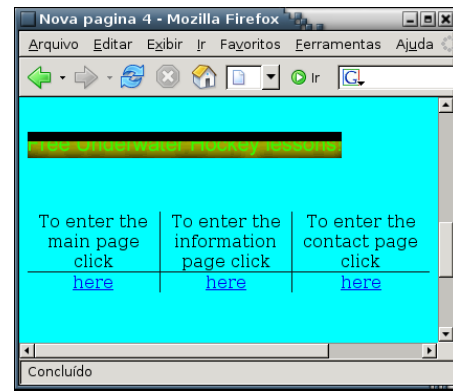
Figure 2: Example of an inaccessible page in a graphical navigator

nologies have also been driven by legislation in several countries like theu US, Portugal and UK. One of the most representative legislation concerning accessibility is the US government legislation Section 508 [19].

Industry and academy have established several accessibility standards. In the context of W3C[3], the development of guidelines for accessible Web content has involved members from many organizations around the world [3]. One of the most important W3C accessibility standard is a set of guidelines consolidated in the document WCAG (*Web Content Accessibility Guidelines*). The first version of WCAG [20] has been published as a W3C recommendation in 1999, and the working draft of the second version (WCAG 2.0) [21] was under review up to the moment this paper was written.

Web Accessibility guidelines are very important to help developers to create accessible Web applications. However, they are not enough to fully support step by step each activity involved in the Web development process.

The majority of research on Web accessitility techniques has been related to accessibility evaluation. Many developments related to accessibility evaluation have been done, but researchers have noticed out many other relevant gaps. Besides evaluation, methods and techniques for supporting accessibility in other Web development activities have been investigated in researches. There are reports regarding to the development of accessibility techniques for requirements elicitation, interface design, navigation design, architecture design, and other Web development process activities. These activities are very important to develop quality Web applications, and accessibility should be considered when carrying them out. The process of understanding, controlling, and improving the quality of Web applications requires the use of appropriate development methods, models and techniques [14].

The observation of the main aspects of the Web applications (navegability, use of hypermedia technologies, aesthetics and continuous evolution) gives Web Engineering methods special features, which make them slightly different from methods for developing conventional applications.

In this paper, we describe a study about the main characteristics of Web development methods in order to arise the primary issues to propose a classification of development activities to be followed in the survey.

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[3]World Wide Web Consortium - http://www.w3c.org

Fraternali & Paolini [5] state that the design of Web applications should consider three essential aspects: structure, navigation and presentation. These aspects were taken into account in the proposed classification since they provided means to include specific Web-related design issues.

We have chosen ISO/IEC 12207 standard [9] as the model to guide the classification of techniques. ISO/IEC 12207 standard establishes a high level architecture for software life-cycle. The architecture is a set of processes and relationships among processes. Each process corresponds to a set of activities. Figure 3 illustrates the ten process groups included in the standard.

As the standard is defined as a process framework (or meta-process), it is able to incorporate features from different Software Engineering processes, including Web development methods.

For our classification, one change was done in the model to better fit Web development methods. We have separated distinct **Software design** activities ([ENG.5] in Figure 3), according to the essential aspects stated by Fraternali & Paolini [5]. We decided that the classification of techniques for the process of Software design should be separated into four sub-categories: architectural design, navigational design, interface design and content design.

In next section, we present the method that was applied to conduct the literature survey and the steps taken during the development of this study.

3. SURVEY DESCRIPTION

The accomplishment of literature surveys should be carefully planned and performed in order to reach representative results. The Systematic Review method [11], which was adapted from medicine researches, has been increasingly used in Software Engineering studies. This study covered the majority of the aspects of a systematic review, except the definition of search strings method.

A systematic literature review is a means of identifying, evaluating and interpreting all available relevant work to a particular research question, topic area, or phenomenon of interest [11].

Systematic reviews require considerably more effort than traditional reviews. A systematic review process involves several discrete activities. Essentially, these activities are concentrated into three main meta-activities: planning, conducting, and reporting the review [11].

Planning the review is very important to the development of the work. It involves the following activities:

1. Identification of the need for a review
2. Development of a review protocol.

Conducting the review consists of activities related to the search, selection, analysis and synthesis of the studies. The stages associated with *conducting* the review are:

1. Identification of the research
2. Selection of primary studies
3. Study quality assessment
4. Data extraction & monitoring
5. Data synthesis

Reporting the review is a single stage phase. It involves the summarization of the systematic review and the publication of the results.

In fact, this study did not cover all aspects of a complete systematic review. Systematic reviews are strongly related to finding experimental studies. As many researches on Web accessibility techniques are very recent, it would not be possible to find many experimental studies, as may be verified in the description of the results in Section 4. Besides, the wide range of research works expected to be included would not be adequate to the strict research question definition required by the Systematic Review Method.

In the following subsections, we present the steps taken during the survey and provide details about the methodology.

3.1 Review Protocol

A review protocol defines the methods that will be used to undertake an specific systematic review. A pre-defined protocol is necessary to reduce possible research biases [11].

The review protocol described below was based on the guidelines indicated by Kitchenham [11], and was used to guide the whole survey process.

Objective: the main goal of this review is to identify research studies on Web development techniques for accessibility. The motivation for this research is to indicate a panorama of the state of art on Web Accessibility development techniques. Besides identifying existing research, this study also involves the classification of techniques according to the software process activities they are supposed to help.

Research Question: "What techniques are available to support Web development activities to construct more accessible Web pages"?

Source search method: sources are supposed to be retrieved by Web. Manual search was not considered in this research.

Keyworkds: Web accessibility, Web universal usability, universal Web design

Sources List: journals and conference proceedings available on Digital Libraries on the Web. Journals and conference proceedings indexed by *IEEE Xplore*[4], *ACM Digital Library*[5], *Springerlink*[6], *Science Direct*[7], *IBM Journals*[8] and *Wiley Interscience*[9] were consulted.

Inclusion and exclusion criteria: papers considered in the review process should be available on the Web in electronic format, be written in English and describe techniques for accessibility for any phase of the Web development process. Papers describing exploratory studies, development of assistive technologies or automatic page transformation techniques should not be included, because they are not directly related to techniques to be used by developers.

Quality assessment criteria: considering how implementable each technique reported is. Early proposals of techniques with no indication on how to implement them should be excluded.

The review protocol was developed by one of the researchers and was revised by two other researchers involved in this study.
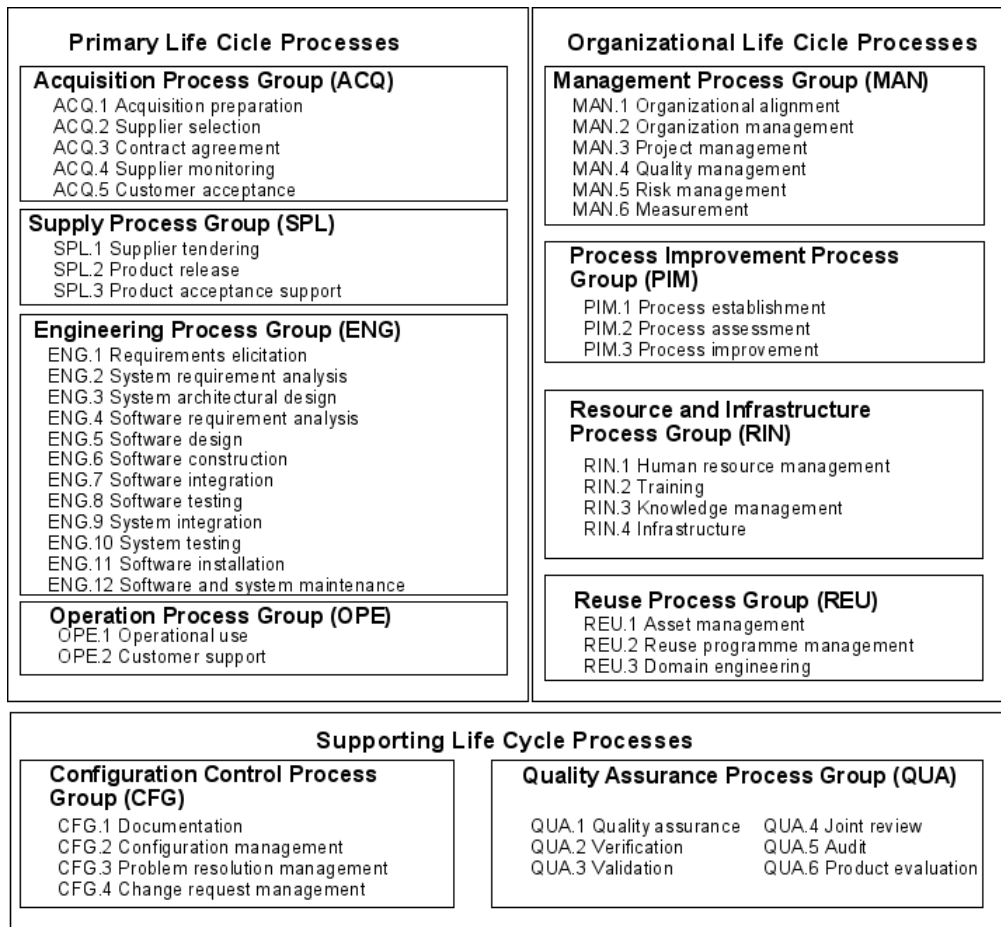

Primary Life Cicle Processes

Acquisition Process Group (ACQ)
ACQ.1 Acquisition preparation
ACQ.2 Supplier selection
ACQ.3 Contract agreement
ACQ.4 Supplier monitoring
ACQ.5 Customer acceptance

Supply Process Group (SPL)
SPL.1 Supplier tendering
SPL.2 Product release
SPL.3 Product acceptance support

Engineering Process Group (ENG)
ENG.1 Requirements elicitation
ENG.2 System requirement analysis
ENG.3 System architectural design
ENG.4 Software requirement analysis
ENG.5 Software design
ENG.6 Software construction
ENG.7 Software integration
ENG.8 Software testing
ENG.9 System integration
ENG.10 System testing
ENG.11 Software installation
ENG.12 Software and system maintenance

Operation Process Group (OPE)
OPE.1 Operational use
OPE.2 Customer support

Organizational Life Cicle Processes

Management Process Group (MAN)
MAN.1 Organizational alignment
MAN.2 Organization management
MAN.3 Project management
MAN.4 Quality management
MAN.5 Risk management
MAN.6 Measurement

Process Improvement Process Group (PIM)
PIM.1 Process establishment
PIM.2 Process assessment
PIM.3 Process improvement

Resource and Infrastructure Process Group (RIN)
RIN.1 Human resource management
RIN.2 Training
RIN.3 Knowledge management
RIN.4 Infrastructure

Reuse Process Group (REU)
REU.1 Asset management
REU.2 Reuse programme management
REU.3 Domain engineering

Supporting Life Cycle Processes

Configuration Control Process Group (CFG)
CFG.1 Documentation
CFG.2 Configuration management
CFG.3 Problem resolution management
CFG.4 Change request management

Quality Assurance Process Group (QUA)
QUA.1 Quality assurance
QUA.2 Verification
QUA.3 Validation
QUA.4 Joint review
QUA.5 Audit
QUA.6 Product evaluation

Figure 3: ISO/IEC 12207 Processes

3.2 Conducting the review

After developing the Review Protocol described in Section 3.1, the review was conducted. The review conduction was done by one researcher, and all activities were supervised by two others. The whole process of the systematic review was described in a technical report [7].

During the activity of *identification of the research*, the researchers performed searches in the sources identified in the Review Protocol.

The execution of the search using the keywords presented in Section 3.1, performed on September 13th, 2006, returned 844 papers: 275 from IEEE Xplore, 360 from ACM Digital Library, 146 from SpringerLink, 43 from ScienceDirect, 10 from Wiley Interscience and 10 from IBM journals.

Next, we performed the selection of primary studies[10]. Due to the definition of a wide search string, the search returned a very large number of papers, which has lead to a very hard manual selection work. The selection was done based on the observation of the inclusion and exclusion criteria after reading the title and the abstract of each paper. From the 844 papers found, 149 papers were selected.

The selection of primary studies was followed by the study quality assessment. After reading the title and abstract of all papers, the full text of the selected papers were read. During

this evaluation, each paper was examined in order to verify whether it properly describes a technique, and whether the technique is implementable or not. Poster papers, work in progress and other studies that did not sufficiently comply with the quality requirements were excluded from the review. After evaluating the 149 selected papers, 53 ones were selected to the review.

Subsequently, the work of data extraction was executed. In this phase, all the data regarding to each technique and its implementation were stored in a database. For the studies that reported some kind of experimental validation, a short description of the experiment was also registered. During the data extraction, the reviewers also classified each study according to ISO/IEC 12207 standard.

Finally, the data extracted were analyzed and were synthesized in tables and graphics. The full set of data is available in the technical report containing the whole documentation of the review [7]. In next section, we describe the main results obtained from the survey.

4. SURVEY RESULTS AND CLASSIFICATION

The primary question of this review aims to identify what studies have been published about Web development techniques for accessibility. Along with the identification of ex-

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[10]Studies to be more carefully read

isting studies, the review also intends to give enough information to propose a classification of such techniques according to the processes of ISO/IEC 12207 standard [9].

In this section, we present the main results obtained from the analysis of the studies and their classification. In Subsection 4.1 we present an analysis on the evolution of research on Web Accessibility through years. In Subsection 4.2 we present the classification of the Web development techniques.

4.1 Evolution of Research on Web Accessibility

From the initial set of 844 studies selected in the first search, we found many that many that were not related to Web accessibility. Along with the study selection, in which the title and abstract of the papers were read and analyzed, we also filtered papers that did not concern about accessibility. The number of papers related to Web accessibility felt down to 396 after this filtering.

Publications about Web accessibility were found in a variety of journals and conference proceedings related to Hypertext and Hypermedia, Web, Software Engineering, Human-Computer Interaction and other areas.

An important evidence of the studies found in the search is about their themes. There is a very wide range of fields of studies on Web accessibility. One of the main topics covered by a number of studies is related to user tests and experimental derivation of guidelines. A number of studies reports on researches involving blind, low-vision and users with other impairments. Studies with older adults are also the theme of a large number of papers.

Besides studies involving users, a lot of studies related to evaluation and repair tools, transformation gateways, end-user tools and other techniques for developers have been reported. Exploratory studies aiming to evaluate the accessibility of a given set of pages have also been the target of many research studies.

We have analyzed the evolution of the publications on Web development techniques for accessibility. For this analysis, we considered 53 papers selected in the review. Figure 4 presents a view of the number of publications on this topic from 1998 to 2006.
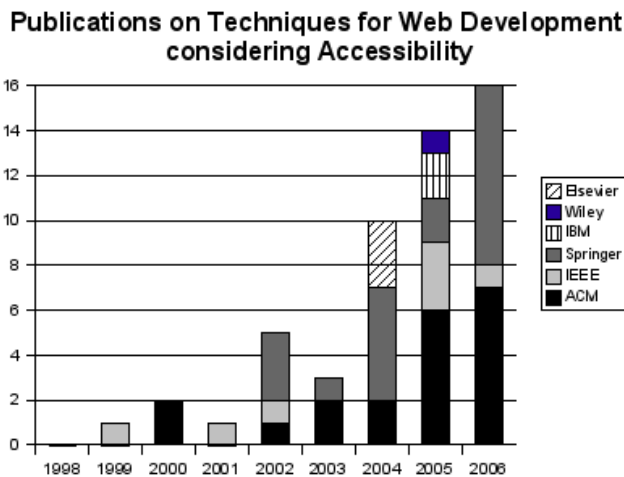

Figure 4: Number of publications on Techniques for Web Development for Accessibility through time

It is possible to verify in Figure 4 that few studies about techniques for accessibility had been published until 2002. Up to this date, most studies were related to guidelines and evaluation and repair tools. Ivory [10] has enumerated several studies related to automation of usability evaluation in a survey published in 2001, and several studies regarding to automated accessibility evaluation were also reported.

From 2004 to 2006, it is possible to observe that the number of studies on techniques for accessibility has been growing considerably. Besides the growth in number, we observed an increase in diversity of the studies. There are more studies related to more Web development activities, such as metrics, content design, interface design and others.

The growth of the number of studies related to Web development techniques for accessibility indicates that research on Web accessibility tends to become more consolidated. The need of addressing accessibility requirements arouse new techniques to help developers to take into account accessibility in their projects.

In next subsection, we present a summary of the results obtained in the surveyed studies and the proposed classification of these studies according to ISO/IEC 12207 [9].

4.2 Classification of Web Development Techniques for accessibility

During the data extraction activity a form was filled in for each study included in the review. In this form the main data about each study were collected.

Each technique was classified into one or more ISO/IEC 12207 processes. Techniques classified in **Software Design Process** were divided into: architectural design, navigational design, interface design and content design, according to Web development issues discussed in Section 2.

It was also registered whether each technique had an associated automated tool to support its use. Around 55% (29 of 53) of the studies reported the existence of some kind of automated tool to support the proposed technique.

We also verified whether the studies reported some kind of experimental validation of the proposed technique. Around 42% (22 of 53) of the studies reported some kind of experimental validation. The majority of the studies used restricted case studies to validate their techniques, usually involving few developers.

Shull [15] indicates that the use of experimental procedures is very important to ensure the reliability of Software Engineering methods and techniques. The small number of studies reporting rigorous experimental validation points to the need of using more disciplined methods in research on techniques for Web accessibility.

Following, we describe the main conclusions about the classification of the studies in this review. The analysis contains a general description of the studies classified into each process of ISO/IEC 12207 [9]. In Figure 5, the number of studies related to techniques for each process is shown. The figure shows that activities that are addressed by the greater number of papers are interface design and test activities.

The complete list of papers containing all the data extracted from the studies was not included in this paper because of space restrictions. The full list of studies, and the tables containing the full extracted data are available in a technical report [7]. Next, we provide a general description of the papers included in each process category and highlight some of the most relevant papers.

Techniques for ISO/IEC 12207 processes
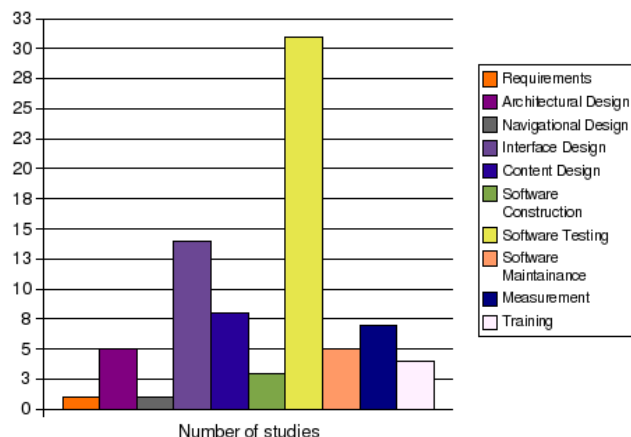
Figure 5: Number of publications on Web accessibility techniques for different processes

Requirements Engineering: in this study, we decided to refer to the activities related to Requirements Engineering as a single set. These activities involve the processes of Requirements Elicitation, System Requirements Analysis and Software Requirements Analysis. The main purpose of Requirements Engineering activities is to gather the customer needs and document them.

Only one selected study was classified as a Requirements Engineering technique. Sloan et. al [17] delineates that the requirements elicitation for accessibility should involve the identification of the user characteristics, the documentation of domain requirements, technological requirements and performance requirements. This study also contains techniques for Interface and Content Design.

The elicitation and documentation of system requirements are very important tasks during the development of software in general. Developing new techniques for accessibility requirements engineering could provide more disciplined methods for ensuring accessibility in Web applications. Many interesting research could be done on techniques for requirements elicitation for dealing with people with different types of disability and for the elderly. Effective documentation of accessibility requirements could also be further investigated.

Masuwa-Morgan [13] points out potential contributions of using techniques based on ontologies to support the requirements documentation. However, this study was not included in the review, because it was not still implementable.

Architectural design: the purpose of architectural design is to divide software into smaller elements (such as modules, components, classes, for example).

Five studies were classified as techniques for Architectural Design. The techniques proposed approaches that involve, for example, the use of *separation of interface and code*, the use of *composition of interface components* and the use of *models to guide the architectural design*. Semantic Web based frameworks to support the development of accessible Web applications were also addressed.

The use of accessibility aware Web application architectures may have a large impact on the possibilities for improving the accessibility of applications. Although techniques such as the use of templates and the use of Semantic Web are explored by several research works, they are not effectively used in practice.

Research on experimental studies on the application of architectural design approaches to accessibility could provide interesting contributions to the field. The impacts of accessibility of applications created by means of software components are also an interesting theme to be investigated.

Navigational design: is the activity responsible for defining the navigation structure of Web applications.

Only one selected study was classified as a technique for Navigational Design. Ahmad [1] proposes a method for measuring the 'navigation burden' of a Web application. This technique may be helpful to determine the effectiveness of the navigational structure.

Many accessibility problems in Web applications are related to bad navigational design. The development of techniques to help designers to identify accessibility problems in navigation early in the design would prevent them from implementing troublesome navigational interfaces.

Several interesting questions still arise as potential research goals. How can accessibility issues be modeled in navigational models and schemes? How can navigation models be designed to be adapted to different browsing approaches? Answering these questions could make accessibility issues related to navigation to be addressed early in the design of a Web application.

Interface design: its purpose is to carry out activities in order to design usable interface components. This is one of the Web development activities that most impacts on accessibility, since many accessibility problems are related to the interface.

Fourteen studies were classified as techniques for Interface Design. Studies cover a wide range of techniques, including *guidelines definition* for blind, low vision and elderly and systems to support guidelines management. Additionally, other studies describe the use of tools to simulate the visualization of interfaces for blind users, and others describe the use of abstract representation of user interfaces. Another interesting contribution is the definition of interface design patterns for older adults [22].

Investigation on interface design patterns has been a promising research field in HCI. Further investigation on design patterns considering accessibility can provide good contributions to developers and designers. The gap between the perception of accessibility by technical and non-technical designers is also an important research issue. How could interface design methods help graphic designers to produce more accessible Web pages?

Content design: most of the Web development methods agree that Web applications are mostly content-driven. Consequently, the use of effective content design techniques is crucial.

Eight studies were classified as techniques for Content Design. Studies covered general issues concerning the design of accessible content, like *simplification of the use of natural language* and use of *semantic annotations*.

Other important works report on problems with image and table design. Ault [2] proposed a set of guidelines for describing graphics for blind and low-vision users. Filepp [4] suggests a markup language for helping the description of tables.

Further development on design of complex content structures, such as images, tables and forms may still be a potential field for contributions. Other important research gap is related to the use of natural language processing to perform the simplification of language use.

Defining techniques for helping the accessibility assurance of Web content stored in Content Management Systems (CMS) is also a very interesting research challenge.

Software construction: mainly corresponds to the codification of software components. The construction of Web applications involves the implementation of the business logic, interface and navigational structure.

Three studies were classified as techniques for Software Construction. One of the studies proposes techniques for implementation considering accessibility guidelines. The other two propose special markup languages for the implementation of accessible applications.

Interesting research gaps on Web applications construction considering accessibility may derive from the use of techniques to generate applications based on models. Researches combining the inclusion of accessibility issues in design activities and code generation could provide good results.

Software testing: is responsible for identifying defects in software products. In the context of Web accessibility, it corresponds to activities of accessibility evaluation.

Thirty one studies were classified as techniques for accessibility evaluation. Most of them are related to manual and automated *guidelines driven* evaluations. Techniques for *choosing and comparing accessibility evaluation tools* were also reported. Other types of techniques included *barriers walkthrough*, *test case driven evaluation* and diverse techniques for *test with end users*.

Although research on accessibility evaluation has been widely explored, there are still many problems to be addressed. Further research on methods and tools for evaluating dynamic Web content may provide interesting results. Another atractive field is the investigation on how to help to implement cheap user test approaches in organizations.

Software and system maintainance: corresponds to the process of modifying any part of a software. It can be conducted for correcting problems, or to make modifications asked or suggested by users.

Five studies were classified as techniques for software maintainance. The majority of the studies are focused on helping developers to identify and repair pages with accessibility problems. The studies use approaches such as *tree-map visualization* and *reverse engineering*.

Many repair methods have been developed in the context of Web accessibility research. However, the enormous number of existing inaccessible Web pages is a big source for investigating methods for maintenance and for experimental studies with developers. Developing effective repair methods is a very important aid for boosting the modification of inaccessible pages into more accessible ones.

Measurement: its purpose is to collect and to analyze data related to the products developed and processes implemented within the organization and its projects [9].

Seven studies were classified as techniques for measurement. All the studies are related to metrics for evaluating the accessibility of Web applications, and techniques for interpreting evaluation data.

Several works pointed out approaches that include the use of user derived coefficients to accessibility barriers to get better metrics. Although, much research related to experiments with users to determine good coefficients still have to be done.

The Measurement process defined by ISO/IEC 12207 involves the use of other metrics related to organizational issues. A potential field of study on measurement techniques is related to the investigation on the use of metrics on productivity and costs considering Web accessibility in organizations.

Training: involves activities which aim to develop new abilities to developers and designers. Training developers and other workers to understand Web accessibility is essential to have success to implement accessibility in organizations.

Four studies were classified as techniques for training on Web accessibility. One study described the use of an automatic evaluation tool and a "bad" web page to help the training of students in Web accessibility. The other studies are related to the implementation of *undergraduate and graduate courses* on Web accessibility.

The implementation of training in academy and industry sites is very important to the dissemination of Web accessibility concepts [6]. The development of new Web accessibility education techniques is a very interesting research field. Most of the works point that the inclusion of accessibility in regular programming and design related courses is also a very good field for investigation.

Many ISO/IEC 12207 processes were not addressed by the studies included in this survey. Although each process has special features, and some processes are more related to accessibility than others, we believe that the development of techniques for addressing these processes are potential research topics.

For example, there are several issues concerning the documentation of accessibility during the Web development process. What kind of techniques should be used to properly document Web applications in order to ensure accessibility? What techniques should be aggregated to Software Configuration Management to ensure accessibility when software changes occur? What issues should be considered to ensure that the software acquired from other organization is accessible?

5. CONCLUSIONS

Web accessibility has emerged as a very important topic within Web development. The analysis of the number of research studies on Web accessibility identified showed that there has been a growth of the interest on this theme.

The panorama obtained from this study is very important to guide the implementation of techniques in organizations.

Along with the panorama, this study has also identified many research gaps. Answering questions suggested in this paper may be the motivation for many new research projects.

Developing new Web accessibility techniques helps not only developers and organizations to construct high quality Web applications, but also promotes the development of a more inclusive Web, contributing to build of a more "accessible" information society in a next future.

As next steps, we intend to carry out a complete systematic review on experimental studies about techniques for specific Web development activities considering accessibility.

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