METRICS OF VISUAL COMPLEXITY

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Abstract

The World Wide Web has become the mean of distribution and use of information by individuals, teams, organizations and communities. Visually Impaired web users, being part of the society need to have the same ease of access as all other users. Such access, however, is limited, difficult and sometime impossible for them. This is due to the fact that the way information is presented on the web is becoming more and more complex making it even harder for disabled people. The ability to evaluate a web page usually affects the way someone is actually going to use the site. Getting an overview of a web page helps both the sighted and Visually Impaired people understand what the page is all about.

This project aims to develop a tool designed to support Visually Impaired people evaluate a web page before actually using it. That tool will minimize the gap that exists between sighted and Visually Impaired users by giving the former ones feedback on the visual complexity of a document and specifically a web page.

We first describe the problems that Visually Impaired web users face while accessing a web page. Then, with the help of an experiment we identify the metrics and factors that distinguish a web page as visually complex. The definition of visual complexity helps design a model that gets implemented to develop the program that supports Visually Impaired users by giving a correct feedback on the complexity of the page.
Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.
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1 Introduction

“Worldwide, there are more than 750 million people with disabilities. As we move towards a highly connected world, it is critical that the Web be usable by anyone, regardless of individual capabilities and disabilities.”

--Tim Berners-Lee, Director of the W3C and inventor of the World Wide Web (W3 Press)

1.1 Visually Impaired people and the Web

The World Wide Web has “become a tool for business, communication, learning, leisure, and a whole host of anticipated and unanticipated activities across a broad spectrum of the population” (Germonprez, 2003). This widely spread tool is a resource of all kinds of information for all the above purposes. Accessibility to these resources “is considered an entitlement by the majority of the industrialized world” (Asakawa, 2005). With some keyboard hits and mouse clicks people are able to access vast amounts of information from distant parts of the world (Asakawa, 2005).

Especially for Visually Impaired people, access to the web brought them closer to the rest of the society. They can get information that they could not before. Being part of the society, Visually Impaired people, need to have the same ease of access as all other users. Therefore, easy accessibility to the internet is crucial. Such access, however, is limited, difficult and sometimes impossible for Visually Impaired people.

The way information is presented on the web is becoming more and more complex making it even harder for disabled people. “Interfaces such as JavaScript and Flash are integrated into Web pages” (Asakawa, 2005) leading to more visually complex pages than screen readers can deal with. As web technology improves, screen readers
and related software applications try to upgrade as well. However, trying to catch up does not mean that they support all of the most recent developments, meaning that these applications will not always aid Visually Impaired users.

As mentioned before, the presentation of information is getting more and more complex in both functionality and usability. By not following the right design (IBM; Nielsen) and accessibility (W3C WCAG) guidelines, web pages become inaccessible for Visually Impaired people and impracticable for all types of users. On the other hand, even though design guidelines might be followed, web pages sometimes become overloaded in content. In order for designers to present all this information as best they can and following accessibility and usability guidelines, they create a page with a large number of tables, menus, links, lists and many more. The resulting web page has composition and structure that even sighted users might take more than the usual time to process.

The ability to evaluate a web page usually affects the way someone is actually going to use the site. Getting an overview of a web page helps both the sighted and Visually Impaired people understand what the page is all about. When a sighted user reaches a web site, he can scan through it and evaluate it. By estimating its complexity in both design and content he can approximate the time he is going to spend on it and also decide whether he really wants to spend time on the specific site. On the other hand, Visually Impaired people can not do that. If they want to get an idea of what the page is all about or how it looks they have to read the entire page. Screen readers like Jaws (JAWS) can provide overview information when the user accesses for first time a page. Sometimes (Yesilada et al, 2003) this information is misleading and the user does not face what he expects. This happens because designers do not always follow the right guidelines for accessibility and use different coding conventions to represent elements such as headings. Hence, impaired users have to deal with all kinds of complicated web site structures from the moment they face the site.
1.2 Hypothesis

As this research will show, the complicated page structures depend on the page composition. The page layout is the way the different elements are presented. The position and the amount of links, menus, text, tables, images and many more are the factors of web page visual complexity and the way of interaction and presentation will be explained in the following chapters.

So, why should there not be a way to help Visually Impaired people get an overview or an idea of what to expect when they reach a web page? This project aims to develop a tool designed to support Visually Impaired people evaluate a web page before actually using it. That tool will minimize the gap that exists between sighted and Visually Impaired users by giving the former ones feedback on the visual complexity of a document and specifically a web page. The hypothesis is that page complexity is based upon the composition of elements in that page and that the best way of defining visual complexity and creating models of complexity is to ask Web users what makes a page complex.

1.3 Aims and Objectives

The aim of the research is to identify the factors and metrics that affect the complexity of a page. It will answer questions such as:

- How a visually complex page is presented
- How a visually complex web page is designed
- What are the main factors of visual complexity on a web page
- How can you recognize a visually complex page

Visual complexity of a web page must be defined with the help of the metrics. The objective is to design a model and implement it to produce a tool. This tool will help
Visually Impaired people to evaluate a web site by providing some information either by giving an overview of the web page or some document structure information. With that, a level of visually complexity of an html document can be summarized and returned helping the user.

In order to do the above, Web users are going to be used to identify the metrics. A supplementary aim is to use standard knowledge elicitation techniques, such as card sorting, to draw out from those users the factors described in the project aims.

### 1.4 Contributions

With the help of this project, visual complexity of web pages could be defined, identifying the metrics that affect visual complexity of a page. With the definition, visually simple and complex pages could be recognized and pointed out following the appropriate classification. Moreover, a tool was designed to support Visually Impaired people distinguish a visually complex or simple HTML page from the moment their screen reader reaches the page.

In satisfying the project aims, we successfully used knowledge elicitation techniques. Card sorting and triadic elicitation techniques are going to be described in the Background chapter and will show how much important was their use in the experiment. We succeeded in extracting the Web user’s implicit knowledge that helped build the model.

### 1.5 What will follow

Background research, Chapter 2, helps understand visual disability and web page visual complexity. With information on visual disability we can get an idea on what problems Visually Impaired people face when they use the web and with visual
complexity we can understand what is been written around that area, which is the base of this research. Knowledge on visual disability and web page complexity will help on formulating the project’s argument.

An experiment to understand how and why sighted internet users identify a web document as visually complex was the next step of the research. Chapter 3 presents the experiment along with the techniques that were used, methodology and analysis of the results.

The experiment results lead to the definition of visual complexity. In Chapter 4, visually complex or simple web pages are identified with the design of the model which gets implemented in Chapter 5. Testing and evaluation of the tool is described in Chapter 6, along with any problems that were faced and suggestions that thought after the testing.

Finally, conclusion and future work is given in Chapter 7, with a discussion on what the project accomplished and addressing the possible future of the tool.
2  Background

This chapter will examine how the web is accessible to Visually Impaired people, how important is their easy access to the information provided through the internet and what problems they face while using the internet. These problems will lead to the purpose of this thesis: to identify the factors of visual complexity and provide a model, and following a tool, that will offer support by describing the visual complexity level of a web page that they try to use. The methods that were used on identifying the factors of page complexity with the help of Web users are also going to described in this chapter.

2.1 Visually Impaired people and Web Accessibility

As all internet users know, the internet technology is getting improved every day and the presentation of information is getting more subjectively complex in content and design. Even if “structure techniques such as lists, tables and frames and multimedia elements such as image maps, video and virtual reality” (Powel, 1997) increase the functionality, usability and information richness for sighted people, they increase the complexity of the web pages and the accessibility problems that Visually Impaired people face as well.

With the technology’s development, more and more software are designed to help Visually Impaired people access their computer systems. These include voice recognition systems, screen readers, screen magnifiers, Morse code input devices and alternative keyboards (Nguyen, 1996). However, few of them aim the users in easily accessing the internet. Some of them, such as Henter-Joyce’s Jaws (JAWS) and Window-Eyes (Window-Eyes), are kept on top of the market because they have been developed and improved along with the advancement of the Web trying to help Visually Impaired people the best they can.
Screen readers are software applications used by individuals who are blind that interprets what is displayed on a screen and directs is either to speech synthesis for audio output, or to refreshable Braille for tactile output (Seeman, 2004). Some screen readers have relied on the visual representations of web pages as the basis for audio rendering. Internet Browsers create the visual presentations and screen readers do the audio renderings of the presented page. An important thing is that these applications do not understand what they are reading in terms of the document’s structure (Poon, 2001). Therefore, ability to move between main page elements, such as paragraphs and links, is limited. This becomes impossible when the document’s structure becomes even more visually complex.

In addition, most of the screen readers nowadays, access the HTML source code, which enables them to provide better support. However, the page’s design focus on the visual presentation which makes audio interaction even harder (Yesilada, 2003). In order to prevent the above from happening, rules for web content accessibility have been formulated, such as the World Wide Web Consortium (W3C), the Royal National Institute for the Blind (RNIB), the American Foundation for the Blind (AFB) and many more. These guidelines indicate the checkpoints for designers and are all covered under the W3C Web Content Accessibility Guidelines (WCAG) (W3C). Again, even if regulations are now effective to push designers towards the creation of accessible content, the accessibility guidelines are not always followed; something that keeps the problems in existence.

### 2.2 Web Page Visual Complexity

As it was described previously, the way information is presented on the web is becoming more and more complex making it even harder for disabled people to
access it. Through the literature, visual complexity of an HTML document is described through web site complexity, accessibility and usability frameworks.

There are studies that try to reveal the web page design metrics that predict whether a site is highly rated with respect to complexity (Ivory, 2000; Ivory, 2001; Germonprez, 2003;). These studies relate web site design guidelines with complexity explaining that the way a web site is presented depends on the way the page itself is designed and what elements (metrics) are used.

Ivory et al. (2001 and 2000) with a large collection of web sites did in two studies a quantitative analysis on the web page attributes (e.g. number of fonts, images, and words). The web sites were judged based on content, structure and navigation, visual design, functionality, interactivity, and overall experience and were selected from categories such as financial, educational, community, health, service and living. They found that web page “web pages and sites differ from each other on many dimensions, such as layout quality, screen coverage and information quality” (Ivory, 2000). Also, metrics concerning page composition, such as word count, link count, and graphic count, page formatting, such as emphasized text and text positioning and overall page characteristics, such as page size help to predict with 63% accuracy whether a page can be assigned with high or low rating from human judges (Ivory, 2001).

Germonprez and Zigurs (2003) propose three major dimensions of factors and their associated factors that impact the complexity of a web site. These are cognition, content and form and as they show “the content that is located at the site and the manner in which the web site is constructed” (Germonprez, 2003) affects how users perceive a web site.

The above researches are the most related to our project. However, the most significant difference is that during the above studies, participants or judges were
using the web sites. Hence, the studies relate the metrics with usability and try to come up with frameworks that help web site design for better accessibility and usability and to “develop tools to help designers assess and improve the quality of their web sites” (Ivory, 2001).

It is important to state that a web site is a collection of web pages. A website is made up of a web page or web pages. One can think a web site as a file folder. A folder contains and organizes information and documents. These documents are similar to web pages. Each web site has a main web page. The links from this page are separate web pages and hence all these pages together make up the web site. Some web sites, such as personal, consist of a single page because there are no links that lead to other pages within the same ‘folder’. Therefore, a single web page can be considered as a web site. For our research we focused only on analyzing the structure of the web pages.

Other studies focus on Visually Impaired people and try to find ways to increase the web accessibility such as Semantic Web. In Yesilada et al. (2003) show that Visually Impaired people web users could also benefit from semantic web technologies demonstrating possible approaches to achieve that through annotation. They introduce an annotation pipeline that can be used to annotate Web pages by using different parts of the ontology (Yesilada et al, 2003). Seeman’ study (2004) talks about the Semantic Web Accessibility Platform (SWAP) which “creates alternative renderings of sites that enable people with diverse needs to smoothly and easily access the content”.

2.3 The Problem

In this thesis, we explore the possibility to identify the factors that have to be present on a web page that an individual evaluates as visually complex. The aim of this
project is to come up with a simple tool that calculates the visual complexity of an HTML document. This will support Visually Impaired web users to get an idea of what to expect, to be able “scan” and “glance” a web page.

It is important to note that this research does not try to identify a web site’s visual complexity but focus on the web page only. As was described in the introduction, a website consists of web pages. The main difference is that when we talk about complexity of a web site we mean how all the individual web pages can be accessed and how they are presented on the web site. As Germonprez and Zigurs proposed on their study, a well design web page structure decreases web site complexity. In our study we will focus on the web page design and the structure of the page. The problem is to identify the characteristics that make a design visually complex or not. As it will be proved in the following chapters, a web page uses paragraphs, tables, lists, menus and many more to portray some of its content. The more of these elements are used, the more visually complex a page becomes.

2.4 Knowledge Elicitation

People that use the web face all different types of web page designs. The page composition of each web document differs mostly due to the different web site categories such as education, community, living, and finance (Ivory, 2001). Thus, they formulate an opinion on when a page is visually complex, not only with respect to usability issues but to structural issues as well. These opinions are usually considered as implicit knowledge for the user and are these that we are interested in for our research. To capture this tacit knowledge a specific technique was used during the experiment that will described on the next Chapter. Therefore knowledge acquisition techniques were followed to help us elicit knowledge from the users (Epistemics, 2003). There are several types of techniques that are currently used, but for our experiment the Sorting Techniques were used to capture the way people
compare and order different concepts (web pages) which will lead to the “revelation of knowledge about classes, properties and priorities” (Epistemics, 2003), the classification for each web page. There are two kind of sorting techniques, the card sorting and triadic elicitation. Both were used during the experiment which will be described in Chapter 3.

2.4.1 Card Sorting

Card sorting technique is the simplest form of sorting. During this procedure, the user is given a number of cards each displaying the name of a concept. The user or expert has the task of repeatedly sorting the cards into piles such that the cards in each pile have something in common (Epistemics, 2003). By voicing what each pile has in common, or the difference between each pile, or description of the characteristics of each pile, the user is making explicit knowledge he or she has about the things on the cards. This is what we wish to do with complexity in Web pages: to find what are the attributes of the Web page by which any one is judged simple or complex?

Here, the experts were the participants and the cards were each web page that was used for testing. With the continuous sorting the user was unintentionally giving information on the attributes and values to describe the characteristics of each web page describing the reasons for complexity.

2.4.2 Triadic Elicitation

Along with the card sorting techniques, triadic elicitation is often used. During this technique, the user is asked on what he thinks is similar and different about three randomly chosen concepts and in what way are two of them similar and different. This is also known as Three Card Trick, because three concepts are used and trick to elicit attributes that are not immediately and easily articulated by the user (Epistemics, 2003). Using three randomly web pages the participant could answer the
above questions giving out his thoughts articulating even more than during the card sorting.

2.5 Background Summary

As this chapter showed, in order to start our project we had to look at three areas:

1. How Visually Impaired users access a web page, which helped us find that it is difficult without the overview or glance at a page’s content.
2. What is been written around the notion of web page complexity. We found that complexity is a well known but little understood phenomenon.
3. What is knowledge elicitation and how is used as a technique for finding out knowledge about an area of interest.

This project’s strategy is to use 3 (knowledge elicitation) to find out about 2 (visual complexity) and then apply it to design a model for 1 (Visually Impaired users).
3 Experiment

In this chapter, we will talk about the experiment that has been done. The aim of the experiment was to formulate a model for the factors of visual complexity of a web page. Moreover, the experiment would test the initial hypothesis that web page visual complexity depends on the page composition, page formatting and overall page characteristics. The usability and effectiveness of the web pages were not tested, just the way they look.

This experiment was a formative evaluation on the initial hypothesis. With this type of evaluation, rapid feedback and support was given on the first stages of the model design. Knowledge acquisition techniques, as described in Chapter 2, were used to help unfold any unexpected factors and metrics and how everyday users comprehend visual complexity. That way not only the hypothesis will be tested but help design a more effective tool.

During the rest of the chapter, we will explain what we wanted to test, the procedure and approach and what were the results and suggestions that were generated after the analysis of the experiment results.

3.1 Hypothesis

As was described during previous chapters, web page visual complexity relates with page design. Web page design depends on metrics such as the page composition and layout, page formatting and overall characteristics, including tables, images, links, colors and many more. The initial hypothesis of this experiment is that the visual complexity of a web page is related to the way the above metrics are presented on the user through the structure of the Hyper Text Markup Language (HTML) document and by the amount of each element that is used on the page.
For example, a page like MSN (www.msn.com) can be widely identified as more visually complex than a page like MINT Research Group (mint.cs.man.ac.uk). As the Figure 3.1 below shows, MSN is a site overloaded with information, links, images using small fonts and intense colors, in which lot of tables and small fonts are used to represent the content following usability and design guidelines. A list of counts can be seen on Table 3.1, where one can see the amount of each element, such as lists, tables, columns, rows, words, and links. In addition to the factor count, we can see the intense colors, the advertisements, long menus and variety of information.

Figure 3.1 MSN Web Page – Page element overload
On the other hand a page like Mint Group, Figure 3.2, that focus on one subject using small menu, a logo and few paragraphs is considered more visually simple. Table 3.2 shows the number of each element that is used on the page. One can see the difference between the counts of MSN page.

**Table 3.1** Estimation on Count of Elements presented on the MSN page

<table>
<thead>
<tr>
<th>Elements and Counts of each Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Links: 100</td>
</tr>
<tr>
<td>Images: 10</td>
</tr>
<tr>
<td>Tables: 1</td>
</tr>
<tr>
<td>Rows: 4</td>
</tr>
<tr>
<td>Columns: 9</td>
</tr>
<tr>
<td>Forms: 4</td>
</tr>
<tr>
<td>Lists and Items: 28 115</td>
</tr>
<tr>
<td>TOTAL WORD COUNT: more than 600</td>
</tr>
</tbody>
</table>

On the other hand a page like Mint Group, Figure 3.2, that focus on one subject using small menu, a logo and few paragraphs is considered more visually simple. Table 3.2 shows the number of each element that is used on the page. One can see the difference between the counts of MSN page.

**Figure 3.2** MINT Research Group – concentration on one subject
Therefore, we believe that visual complexity of a web page depends on the number of elements that are used on the document, the way they are presented and the variety or focus of subject of the specific page. The test will try to support this hypothesis and give some more specific details on how internet users judge visual complexity. From these data the aim is to define visual complexity and develop a metric for visual complexity.

### 3.2 Methodology

#### 3.2.1 Technique

As was described in Chapter 2, the technique that was used to extract knowledge from the users was the knowledge elicitation. The technique and the way it was used in the experiment were analyzed in the background chapter.

#### 3.2.2 Participants

For our study, we used twelve participants and are referred in the rest of the report as P1-P12. The background knowledge of each participant was different. Some of them were using the internet on a daily base and others not. However, almost all of them...
used it weakly. The important thing to note here is that six of the participants were computer scientists and had familiarity and knowledge on HTML code, web page design, and web site usability. The other six participants were non-computer scientists but used the internet at least couple of times per week.

The participants were sighted people. This was necessary since we are trying to come up with a tool that will give to Visually Impaired people what sighted people have; the ability to evaluate the visual complexity of a page before using it or spending time on it.

### 3.2.3 Materials

The testing materials for this experiment were twenty web pages and are shown on table below. These pages were presented to the users in colored hard copies. This is due to the fact that we are looking on web page visual complexity and not on the web site visual complexity. Since some of the pages could not fit on a size A4 sheet, using print-screen methods I printed each page in mostly two parts and stick them together. The web pages were first chosen by me and then randomly numbered as S1-S20 as the table indicates. The pages were selected to be representative of sectors such as public information, business, academic, entertainment, leisure, web services such as search engines and personal home pages. All types of complexity were tried to be included in the set and to do that I tried to evaluate them by myself having in mind our hypothesis.
<table>
<thead>
<tr>
<th>Site#</th>
<th>Web Page Name</th>
<th>Web Page Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vodafone UK</td>
<td><a href="http://www.vodafone.co.uk">http://www.vodafone.co.uk</a></td>
</tr>
<tr>
<td>2</td>
<td>IPG - The Informatics Process Group</td>
<td><a href="http://www.cs.man.ac.uk/ipg/">http://www.cs.man.ac.uk/ipg/</a></td>
</tr>
<tr>
<td>3</td>
<td>MINT Group</td>
<td><a href="http://mint.cs.man.ac.uk/index.html">http://mint.cs.man.ac.uk/index.html</a></td>
</tr>
<tr>
<td>4</td>
<td>Amazon</td>
<td><a href="http://www.amazon.co.uk">http://www.amazon.co.uk</a></td>
</tr>
<tr>
<td>5</td>
<td>BBC UK</td>
<td><a href="http://www.bbc.co.uk/">http://www.bbc.co.uk/</a></td>
</tr>
<tr>
<td>7</td>
<td>Computer Science Manchester</td>
<td><a href="http://www.cs.manchester.ac.uk/">http://www.cs.manchester.ac.uk/</a></td>
</tr>
<tr>
<td>8</td>
<td>Google Search Results</td>
<td><a href="http://www.google.com/search?hl=en&amp;q=Visual+Complexity">http://www.google.com/search?hl=en&amp;q=Visual+Complexity</a></td>
</tr>
<tr>
<td>9</td>
<td>IMG Group</td>
<td><a href="http://img.cs.man.ac.uk/">http://img.cs.man.ac.uk/</a></td>
</tr>
<tr>
<td>10</td>
<td>John Rylands Library</td>
<td><a href="http://www.rylibweb.man.ac.uk/">http://www.rylibweb.man.ac.uk/</a></td>
</tr>
<tr>
<td>11</td>
<td>Manchester Online</td>
<td><a href="http://www.manchesteronline.co.uk/">http://www.manchesteronline.co.uk/</a></td>
</tr>
<tr>
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</tr>
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<td><a href="http://www.nationalrail.co.uk">http://www.nationalrail.co.uk</a></td>
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<td><a href="http://www.simonharper.info">http://www.simonharper.info</a></td>
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<td>Umber Group</td>
<td><a href="http://umber.sbs.man.ac.uk/dbbrowser/">http://umber.sbs.man.ac.uk/dbbrowser/</a></td>
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<tr>
<td>19</td>
<td>Dr. Stevens Robert</td>
<td><a href="http://www.cs.man.ac.uk/~stevensr/">http://www.cs.man.ac.uk/~stevensr/</a></td>
</tr>
<tr>
<td>20</td>
<td>Yahoo</td>
<td><a href="http://www.yahoo.com/">http://www.yahoo.com/</a></td>
</tr>
</tbody>
</table>

Table 3.3 Web Pages that were used for the experiment.

### 3.2.4 Procedure

The experiment procedure was conducted in four parts. There were twelve individual meetings with the participants, so no one could hear each other’s comments. All experiments took place on a room with big tables so the pages could all fit on the visual level of the participant. On the beginning of each interview an introduction was read to each participant explaining the purpose of the experiment and a brief description on and asking permission for voice recording (Appendix A). The questions that were asked during each interview can be also found on Appendix A.
Part 1

After arranging the pages on the tables, the participants were asked to have a look on all twenty pages and then sort them carefully by giving to each page a number from one to twenty, with one being the simplest and twenty the most visually complex site. Questions such as “why did you choose to sort the like that?” and “what are the main differences that made you sort them that way?” were asked after he finished sorting the pages.

Part 2

Following, the user was forced to choose the pages that are neither simple nor complex. Then, he was asked to put the rest pages in two piles. One was the “simple” pile, the visually simple pages as were judged by the participant and the other was the “complex” pile, the visually complex pages. That way, three piles were made with simple, medium and complex pages.

The questions “what are the major differences between the simple and complex piles” and “what made you put each site in the simple and not in the medium pile” were asked to force the participant articulate even more the characteristics of each category.

Part 3

During the third part of the experiment, the participant was shown each pile separately and asked to first answer questions such as “what makes these sites simple/medium/complex”, and “what do these pages have in common” to make them describe the pages even more. Then he was asked to sort each pile with one to be the
less simple and keep sorting towards the complex end. This part happened three times, once for each pile.

Part 4

The last part of the experiment was based on the triadic elicitation. All pages where mixed together and I randomly chose three pages and asked the participant to select two of the three pages that he thinks are most similar. This forced choice was followed with questions such as “what these two have in common”, “what are the differences with the third one”, “which one is the most simple”, and “which the most complex one and why”. This procedure was happened at least three times for each participant. The number of repetition was depending on the user’s boredom threshold.

3.3 Results

The results are presented in two types, the data from the sorting and the answers of each participant that were recorded.

3.3.1 Interview Outputs

The comments of the participants while sorting the pages or describing them are going to be summarized in three categories. The simple category will show what most of the participants described as visually simple pages along with some of their comments. The medium and complex categories are going to follow the same structure.
3.3.1.1 Visually Simple Web Page

Information
The information or the text that a user has to read on a simple web page is not too much. All the text usually fits on one screen and no scrolling is needed. If the information is too much, it is organized in either categories or paragraphs. The text is organized in such a way that relative information is grouped together making the reading of the page more comfortable. In addition, the information that is presented is not diverse since it focuses on one theme such as education, business, etc.

Menus
The menu bars on an uncomplicated web page are short, self explanatory and usually just one. The simplest pages either do not have a menu bar or have only one on the site of the page. This menu is organized in such a way that the user finds what he wants from the first looking because is always short or it is not overloaded with irrelative information.

Links
In a simple page, the links are represented in a variety of ways. They are either presented as a list with some explanatory text, as a group inside a box with a headline on top of that box or even along with a picture which describes what that link will show. In all the ways, the links are short and easy to read and understand.

Images
In a simple page, pictures are always related to the subject of the site. These can be a logo or pictures to represent a specific area or even just as a decoration. One can find pages that have only pictures and still be simple. This happens because the text in those pages is kept to a minimum and the pictures are used as links or description for a specific subject of the page. That way, the user focuses only on the pictures. Advertisements in simple pages are not usually used. When advertisements exist, are
placed on spaces that can hardly affect the user, since they are not the first things to catch his attention.

Colors and Fonts
The background colors on a simple page are usually light colors. When intense colors are used then the information or pictures that are presented are kept to a minimum. Fonts on simple pages did not matter the visual complexity of the page since none of the participants made any comment about font size while describing a simple page.

Some of the participants’ comments are:

- ‘The simple pages do not have too much content or text and it fits in the screen’
- ‘Those pages focus on one theme only…and the whole content is relative to the site’. For example, educational or personal pages focus on the research they do or provide personal information. Hence, the information that is presented is specific and relative to each other.
- ‘Information is concentrated and grouped so that relative information is together and easily found’. This happens in pages such as school pages or business where information is grouped within separate small tables. The text and links inside each table concentrate on the same subcategory.
- ‘The simple pages have one picture, some text in the middle and a short menu, all in a tide and well representative way’.
- ‘They have text, simple links or a short menu’.
- ‘Even if it has too many small pictures the whole context is concentrated in a single view (no scrolling)’. Web pages, like the John Rylands, use small pictures to distinguish different information categories but still the whole page fits in the screen.
- ‘Links are inside a box or next to pictures that make you help to understand more what is going on’.

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‘Simple pages are separated in points where each point does not have too much information or text to read’.

‘These menus are small and organized’.

‘A balance between links, text and pictures’. For example, on web pages like MINT Research Group, or UMBER there is not an overload on the amount of links, pictures and text but there is a balance between them.

‘The tasks that you can do are limited’. In most of the simple pages the user can read the text on the page and go through the links that are on it only. There is no input or forms to feel out.

### 3.3.1.2 Visually Complex Web Page

**Information**

The text that a user has to read is too long that most of the times he has to scroll, something that makes him unpleasant. In most of the complex sites the information that is shown includes a variety of subjects. That is why the site becomes more complex. The diversity of information that is presented makes the user more complicated because he has to go through all the information to find what he is looking for, even if there is a big chance of finding what he needs.

**Menus**

A complex page might also include long menus. These menus are full of smaller subcategories of links. Participants, as following comments will show, do not like long menus, because it is a lot of necessary information that has to read. As was described by the participants, complex pages might have more than one menu. These can be on both the side of the page and even on the top. The top ones are shorter and presented either as tabs or a line with the main links of the page.
**Links**
Another factor that makes the sites complicate is the links. There is an enormous number of links in every complex site. These are either in the menus, throughout the text or even as pictures. Links that are presented through a picture can be complicate when the pictures are not self explanatory. That way the user will not know what to expect. Links that are throughout the text and not in an organized way leads to a complex page as well because he has to read the text and take notice of the links the same time.

**Images**
As was mentioned before, images play a significant role on the presentation of a web page. Participants consider images to affect a lot the visual complexity of a web page. All of the participants differentiate the images into three categories: advertisements, logos/page descriptive and decoration. Pages used advertisements were always considered complex but those with smaller picture size were less complex. Pages with logos were complex only when the logo was confusing or with combination of advertisements and other decorative pictures. Logos or category-descriptive images itself were not considered to visually complicate the page. Images that were used as decorative or to help signify a subcategory were said to complicate the page when they were big and pointless.

**Colors**
Intensity and variety of colors are some of the main characteristics that participants used while describing visually complex pages. As they noted, pages that use a lot of different colors for fonts, headlines, tables, menus and backgrounds tire and confuse them, making them to spend more time on the page that they want.
**Forms**

Another characteristic for the complex pages were the forms or inputs that they have. The participants noticed that on those pages there is at least one place that a user has to fill out something or to enter some keywords to perform a search.

Some of the participants’ comments are:

- ‘I do not like when I have to scroll, it means that I have a lot of things to read on that page to find what I want’.
- ‘Wherever I look there are links…I have to be careful where I click’. Web pages like the MSN or Amazon have long menus and lot of links that divert you to relative or not pages.
- ‘It needs a lot of input from user’. On the complex pages a user can fill out forms, put keywords for search within the web site or for external pages.
- ‘They focus on a lot of ideas and you can perform all of them’
- ‘Lot of pictures that are irrelevant with the text’, such as advertisements or decorative pictures.
- ‘The bright colors also make a site to look complicate’.
- ‘The combination of pictures and texts is the hardest’. When there are lot of pictures placed within the text, makes the page even more overloaded and hence more complicated.
- ‘More text with more links or with more menus in different places’. Web pages like Amazon or Manchester Online have more than one menus which makes the page look more loaded with information.

### 3.3.1.3 Visually Medium Web Page

A medium page was described to be neither simple nor complex. Some participants said, “these pages tend to be either simple but have some complicated details or complex but have some things that make the site simpler”. These things that
differentiate them from simple or complex are the colors, the organization of the text, the links and the pictures.

Medium complexity pages that tend to be simple have:

- ‘A lot of text that can be read in one direction with almost no pictures’. Web pages like Google Search Results make the user read only vertical. There are no lists of links such as menus on either side of the page, making even easier for the user to read the page.
- ‘The background color is usually white that does not confuse the user at all but there are lot of links’.

There are medium complexity pages that have:

- ‘A minimum number of links and text’
- ‘The background color is too intense that makes the user to be more carefully with the site’.
- ‘Simple page because the user only reads some text on the same vertical direction but the fact that it has lot of links throughout the text makes the site more complicate’.
- ‘The user can perform a lot of tasks by filling out the list but the text follows the same reading direction and the colors are not intense that help the user to focus only on the list that has to fill out’.

Sites that can be complex but are categorized as medium complexity have:

- ‘A combination of pictures and text, but they are either not overloaded with pictures or text’.
- ‘These sites also might have a variety of information and provide the opportunity to complete different tasks but they are organized using colors and big tables which make the user more comfortable’.
- ‘Information is grouped in bigger tables with larger fonts and background colors that are not too intense but match with the whole context’.
3.3.2 Data

The sorting data from each part are presented in the following two tables. Vertically are the twenty sites and horizontally are the twelve participants. Table 3.4 shows the first sorting from each participant. Table 3.5 shows both part two and three from the experiment. Colors are used to easily distinguish the three categories. S stands for simple, M for medium and C for complex. Next to the initial is the ranking that each participant gave to the corresponding site.
### Table 3.4 Experiment Part 1 – Web Page Sorting

| Participants/Sites | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | S13 | S14 | S15 | S16 | S17 | S18 | S19 | S20 |
|--------------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| P1                 | 7  | 19 | 3  | 17 | 15 | 20 | 6  | 2  | 11 | 1   | 16  | 5   | 18  | 9   | 8   | 13  | 4   | 10  | 12  | 14  |
| P2                 | 12 | 2  | 3  | 16 | 11 | 5  | 13 | 6  | 9  | 14  | 20  | 10  | 20  | 18  | 7   | 15  | 7   | 4   | 1   | 16  |
| P3                 | 9  | 10 | 1  | 20 | 17 | 12 | 11 | 8  | 4  | 3   | 19  | 3   | 15  | 11  | 4   | 18  | 2   | 7   | 2   | 17  |
| P4                 | 6  | 19 | 7  | 17 | 8  | 18 | 4  | 2  | 14 | 1   | 20  | 5   | 9   | 3   | 10  | 15  | 13  | 16  | 12  | 11  |
| P5                 | 4  | 19 | 12 | 15 | 8  | 20 | 9  | 1  | 11 | 3   | 7   | 2   | 16  | 5   | 13  | 14  | 17  | 10  | 18  | 6   |
| P6                 | 5  | 17 | 4  | 16 | 12 | 19 | 13 | 6  | 10 | 1   | 14  | 3   | 9   | 20  | 2   | 18  | 7   | 6   | 15  | 11  |
| P7                 | 14 | 4  | 2  | 13 | 17 | 11 | 15 | 6  | 8  | 7   | 20  | 10  | 17  | 12  | 8   | 17  | 5   | 3   | 1   | 19  |
| P8                 | 9  | 20 | 4  | 11 | 13 | 20 | 10 | 8  | 2  | 5   | 16  | 6   | 13  | 18  | 1   | 11  | 3   | 17  | 7   | 13  |
| P9                 | 12 | 5  | 2  | 20 | 16 | 11 | 14 | 9  | 8  | 1   | 15  | 13  | 19  | 10  | 3   | 18  | 7   | 6   | 4   | 17  |
| P10                | 11 | 15 | 2  | 19 | 14 | 13 | 10 | 1  | 5  | 7   | 18  | 6   | 20  | 12  | 4   | 17  | 8   | 9   | 3   | 16  |
| P11                | 10 | 9  | 2  | 15 | 14 | 13 | 12 | 3  | 8  | 1   | 19  | 5   | 20  | 11  | 6   | 17  | 7   | 4   | 16  | 18  |
| P12                | 9  | 13 | 3  | 16 | 17 | 15 | 12 | 7  | 10 | 1   | 20  | 16  | 19  | 11  | 8   | 14  | 5   | 4   | 2   | 18  |

### Table 3.5 Experiment Part 3 & 4 – Categorization and Ranking

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<tr>
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<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
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<th>S18</th>
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<td>C4</td>
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<td>M7</td>
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<td>S3</td>
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<td>M3</td>
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</tbody>
</table>
3.4 Analysis

In order to come up with conclusions from the experiment an analysis of the data and the participants’ comments was followed. For the rankings that were collected, descriptive statistics were made with the help of Microsoft Excel. The results are shown next. For the comments and descriptions that the participants gave, a summary of each complexity category is made after the statistical analysis.

3.4.1 Descriptive Statistics

Since the number of participants that were used during the experiment was too small, a statistical test could be difficult to produce significance results. Therefore, descriptive statistics were made using the page sorting and ranking. With the data from Table 3.4, the mean and median was found for each page (S1-S20). The results are shown on Table 3.6 and one can see that the mean and median values for each page are close with the most ±1 difference. This implies that the participants’ rankings are not unusually different, meaning that for each page participants use similar rankings. Therefore, each participant’s rankings and comments are significantly important to be used on identifying the factors for visually complexity.

<table>
<thead>
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</tr>
</tbody>
</table>
3.4.2 Results Conclusions

Going through the participants’ comments and rankings that they used we can see that each web page had an overall similar rank, either as categorization or as number. Of course, there are exceptions such as pages IPG (www.cs.man.ac.uk/ipg), National Rail (www.nationalrail.co.uk), Umber (umber.sbs.man.ac.uk/dbbrowser/) and Dr. Stevens Homepage (www.cs.man.ac.uk/~stevensr/). These pages were judged differently from the participants. For example, National Rail (S14) was ranked as visually simple, medium and complex from the twelve participants, even though has mean that categorizes it as visually complex (mean = 11 from Table 3.6). This is due to the familiarity with the testing web pages and to knowledge of HTML designing. Since half of the participants are Computer Scientists, they designed at least one web page and know about usability, functionality and design. From the rest participants, all of them use internet on a daily or weekly basis making them more familiar with the pages that were tested on.

The initial hypothesis for the metrics of web page visual complexity was supported after analyzing the data. The main metrics or factors that participants identify first when look on a page are the text, menus, links, lists, pictures, advertisements and the colors of the page. Then they look on how these elements are presented on the page.
by focusing on the position of each element and the way of information organization using tables and colors.

Following are the main characteristics and combinations for visually simple, medium and complex pages with some pages that were used in the experiment and are going to be used here as examples.

3.4.2.1 Visually Simple Web Page

A visually simple page can be identified when a user looks on the way the different components of the page are presented and the amount of each element that is used. These are the information and the text, in general, the menu bars, the links, the pictures and the colors of the page.

Simple pages were described to have information that concentrates in one subject, such as educational, research, personal etc. Even if information focuses on one subject it is categorized in subcategories using tables, boxes, small lists. Links are also organized in lists within the main content, as menus or even inside smaller tables. They always kept to a minimum number of less than forty links and the text used to represent a corresponding link was short and explanatory. Images on visually simple pages can be small pictures that describe a subcategory, a page logo or small pictures that are used for separating the content. When advertisements are used, the simple page tends to be more complex towards the medium complexity. The fact, though, that the advertisements are less than three and are small and placed on the side or the bottom of the page makes it less complex and even simple. It is important to note that the simple pages fit on the screen and no scrolling is needed.
The figures below show three of the web pages that the most (see mode) participants place them in the simple category. They are shown with increasing visual complexity to understand the main characteristics of a simple page. The visually simplest pages are the ones like John Rylands Library (Figure 3.3) where there are only nine pictures, smaller than the screen page and text that comes up to 40 words only. These images are both links and representation for the subject or a category of information that follows if someone clicks on it. As the figure shows, the page uses very dark background color. This affected some of the participants and especially one of them that numbered it as 14. However, the fact that the other elements on the page are kept simple makes the overall page one of the visually simplest pages.

![Figure 3.3 John Rylands Library – The Visually Simplest Page](image)

Next come web pages like Umber Research Group (Figure 3.4). This page has links throughout the text, needs scrolling and uses background colors other than white. However, the fact that all the links are categorized in smaller lists and subcategories
makes the links look fewer and organized. For the categorization, the designer uses bullet points to group the links, some explanatory text next to each link and headline for each group. This makes the page to look even more structured and hence less visually complex. The green and yellow colors are not intense and provide an enjoyable environment for the sighted reader.

![Image of UMBER Research Group – A visually simple page](image)

**Figure 3.4** UMBER Research Group – A visually simple page

Another type of web pages that is described as visually simple is one shown on Figure 3.5, the Google Search Result web page. This document presents more text
than the previous two pages. The usual right hand side menu is a horizontal tab list on top of the page. What makes it more complex than the rest simple pages is the amount of text and links that it contains. However, the overall ranking of the page is simple because all the text and links are categorized within paragraphs and white background is used though the page.

Figure 3.5 Google Search Results Page – Visually Simple Page with high rank
3.4.2.2 Visually Medium Web Page

Medium visual complexity on web pages depends on the colors and on the organization of the text. The participants noted that these pages can not be categorized as simple or complex but they tend to be either one.

Medium complexity pages that tend to be simple have a lot of text that can be read in one direction, almost no pictures, white or light background color that does not confuse the user at all and a lot of link.

For example, pages like the IMG Group web page (Figure 3.6) is categorized as medium complexity but tends to be simple. This document presents more text than the ones in the simple categories along with big images. The usual menu is a horizontal tab list and the links that the page has inside the context are less than five and presented in a list. What makes it more complex than the rest simple pages are the figures that contains and the amount of text that the user sees when he enters the page for a first time. The fact though that the pages has only one menu, few links and light colors makes the page to be described as visually medium with simple tendency.
Also, on sites like the Library’s Catalogue (Figure 3.7), the user can perform a lot of tasks by filling out the list something that makes it look complicate for the user. On the other hand, the text follows the same reading direction, the colors are not intense that help the user to focus only on the list that has to fill out and links are just the buttons of the forms and a small menu on the top of the page.
Sites that can be complex but are categorized as medium visual complexity have a combination of pictures and text, but they are overloaded with either pictures or text. These sites also might have a variety of information and provide the opportunity to complete different tasks but they are organized using colors and big tables which make the user more comfortable. For example, in sites like the Computer Science Department (Figure 3.8), the information presented includes variety of subject all related with education, a big amount of text and links and two menus. However, the information is grouped under subcategories separating both text and links. The links are organized under each subject presented in a small list. The two menus are kept small and pictures are used to separate each subject that is presented only.
3.4.2.3 Visually Complex Web Page

The characteristics of visually complex pages are the long pages, big number of text, links, images, tables and menus. The main factor that is always present on complex pages is the diversity of information. These pages provide, also, a lot of options to the user, from reading and searching to buying products. Hence, the user can complete a lot of tasks in a single web page. Unavoidably, these pages have to combine overloaded text, pictures and colors in a single page to support all these ideas.

The big amount of different subjects that are presented on the page is the main cause for a page to be described as visually complex. This is due to the fact that the more
subjects that are shown, the more elements (or main characteristics) have to be used to group the information in a functional way that follows usability and accessibility guidelines. These are longer menus, longer page, bigger and more tables and more descriptive text. Advertisements are always used on these pages through small and big pictures. The long menus are actually huge list of links that covers all the different information. Small or big tables are used with headlines including text, links and decorative pictures.
For example, a page like MSN (Figure 3.9) is separated in columns and then relative information is grouped in small tables. These tables have a lot of content and links which makes it even harder for the user to read the entire page or find what he wants. In addition, the same page uses dark colors that make the page look even more difficult.

Figure 3.9 MSN – Visually Most Complex Page
On the other hand, pages like AMAZON (Figure 3.10) are still confusing due to the amount and variety of information and the different menus and tabs but are less complicate than MSN. This is due to the colors it uses and the fact that the whole page is spread throughout the screen, something that gives the user a space to read more comfortable.

Figure 3.10 AMAZON – Visually Complex Page


4 Tool Design

The aim of the design of this tool is to enable Visually Impaired people to get an idea of how much structured or loaded a web page is from the moment they reach it. This can happen with the sighted users, where they evaluate the visual complexity of a page from just scanning through it.

The experiment from Chapter 3 proved our initial hypothesis and helped come up with the factors for visual complexity along with definitions for visual complexity of a web page. This chapter will introduce a basic definition for visual complexity of a web page, clarify when a web page is considered to be visually simple or complex and then describe the framework that was used for the tool implementation.

4.1 Definitions

4.1.1 Web Page Visual Complexity

Visual complexity of a web page depends on the presentation of a web page’s elements and therefore by the density and diversity of the factors that are presented.

By diversity we mean the variety of factors such as information, links and pictures that are presented. For example, a community web page, such as Manchester Online (Figure 4.1) is considered to have high diversity of information since it presents a lot of different information in just one page, such as business information, local events, weather and many more.

By density we mean the amount of each element or factor that is used on the web page. For example, Manchester Online web page (Figure 4.1) has high density of links, advertisements, tables, frames, and colors.
4.1.1.1 Visually Simple Page

A simple page is one where the density and diversity of the page’s elements is low and the way the elements are presented follow the descriptions of a simple page as were described before. By low, we mean that all the page’s elements are kept to a low number.

4.1.1.2 Visually Complex Page

A complex web page is defined to be the page where the density and diversity of the page’s elements is high. The more of the above factors are combined with high density and diversity, the more complicate the site becomes.
4.2 Tool features

Page Elements
The first step on understanding the layout and the structure of a web page is to identify the elements that are used on the page’s presentation.

These are:
- Text/Content
- Links
- Menus
- Tables
- Lists
- Images
- Font Sizes/Color
- Colors

Density
Since the two main characteristics of visual complexity are the density and diversity of the page’s elements, the next step in the evaluation of a web page is to find the density of the factors that are listed above. As was described in previous section, the density is described through the amount of the different metrics. Therefore, counting of each one will be the tool’s next feature.

In order to find if the page is overloaded with text, a word count should be found. Then, link count and the linked list count are essential, since links are the next most important characteristics on a page. Linked list count also includes the menu count but the tool will attempt to differentiate the links inside a menu. Images also affect the complexity of the page and image count is vital. The classification of the image type will be explained in the following sections. Table count is also important in identifying the structure of the page.
The following table (Table 4.1) shows how the density of each element can be found:

<table>
<thead>
<tr>
<th>Page Element</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text</td>
<td>Word Count</td>
</tr>
<tr>
<td>Link</td>
<td>Link Count</td>
</tr>
<tr>
<td></td>
<td>Linked List Count</td>
</tr>
<tr>
<td>Menus</td>
<td>Menus Count</td>
</tr>
<tr>
<td></td>
<td>Count Links inside each menu</td>
</tr>
<tr>
<td>Tables</td>
<td>Table Count</td>
</tr>
<tr>
<td>Images</td>
<td>Image Count</td>
</tr>
<tr>
<td>Fonts</td>
<td>Count of different font used</td>
</tr>
<tr>
<td>Colors</td>
<td>Count of different colors used</td>
</tr>
</tbody>
</table>

**Table 4.1 Density of a Web Page’s Elements**

**Diversity**

The next important part on the complexity definition is the diversity of the page’s elements. The diversity of the elements is the amount of different types of the same metric that are presented on the web page.

Starting with the text/content metric, the number of *different subjects* should be identified. As the experiment showed, the type of the web page affected the amount of different information that was presented. “The nature of information is important, in that it is one of the causes of information overload” (Germonprez and Zigurs, 2003; Thuring et al., 1995). For example, a community or news web page had more subjects than a home page or a research group. Therefore the amount of information was much more in the community or news page because there are more subjects to cover, from shopping to weather information.

Following is the link metric, where link diversity can be counted by finding the amount of different types of links that are presented. Links can be advertisements or
relative to the page. Then the count of each type is taken care through the density factor.

Both density and diversity of images are crucial for visual complexity of a web page. Images on a web page can be advertisements, logos, or descriptive and relative to the page. This differentiation of the image type is the diversity feature of the tool. In addition, there can be various sizes of images on a page. The number of different sizes of the images is also going to be counted within the diversity feature.

<table>
<thead>
<tr>
<th>Page Element</th>
<th>Diversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text</td>
<td>Count of Different Subjects</td>
</tr>
<tr>
<td>Link</td>
<td>Count of Different Types (Advertisements or relative to page)</td>
</tr>
<tr>
<td>Images</td>
<td>Advertisements or Descriptive, Count of different Sizes</td>
</tr>
</tbody>
</table>

Table 4.2 Diversity of a Web Page’s Elements

Positioning

After identifying the density and diversity of the web page’s elements, the way in which these are organized on the page is the next step for completing the puzzle for the complexity categorization. This can be the hardest part of the tool because the position of each element must be recognized. After that a model for a general position of each element must be put that will decide whether the whole structure of the page results to a complex page.

The positioning or organization of the page’s elements was decided not to be implemented on the tool because it would take a lot of time in the implementation; something that we did not have. However, a simpler method of finding whether there is more text than links or whether the links are organized in lists was used. This was to calculate the ratios of $\text{linked word count over unlinked word count}$ and the ratios of $\text{linked list word count over linked word count}$ to determine if there are more unlinked
text than links and if more links are organized in lists. This could help to identify the organization part of the web page, which was a big factor in complexity.

### 4.3 Tool features

The experiment helped identify the factors that affect visual complexity of a web page. Density, diversity and way of organization of the elements are the main features that have to be identified first. Taking, then, in consideration these factors, an outline can be followed to assign complexity level to each page. The following table shows when a web page is considered to be simple, medium or complex with respect to the amount of elements that are presented.

It is important to note that the table below (Table 4.3) shows more the density feature instead of all the features that were described before since the density can be implemented within the project’s time limit. The numbers that are used for the assignment were found after an approximate count on the sample sites that were used on the experiment.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Visually Simple</th>
<th>Visually Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Links</td>
<td>&lt; 40</td>
<td>&gt; 90</td>
</tr>
<tr>
<td>Images</td>
<td>&lt; 20</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>Forms/Inputs</td>
<td>None</td>
<td>Any number</td>
</tr>
<tr>
<td>Total words</td>
<td>&lt; 600</td>
<td>&gt; 600</td>
</tr>
<tr>
<td>Different subjects</td>
<td>None</td>
<td>&gt; 0</td>
</tr>
<tr>
<td>Linked words/ unlinked words</td>
<td>&lt; 0.4</td>
<td>&gt; 0.5</td>
</tr>
<tr>
<td>List words/ linked words</td>
<td>&gt; 0.5</td>
<td>&gt; 0.5</td>
</tr>
</tbody>
</table>
Positioning | Links not allover the text, Text is grouped in paragraphs or in tables, Short menus placed on one site of the page. | Links allover the text, Pictures around the page, Text is grouped in paragraphs or in tables, Colors are intense, fonts are small, no headlines, Long menus and usually more than one |
---|---|---

**Table 4.3** Complexity Framework
5 Model Implementation

This chapter will focus on the implementation of the tool. The tool is implemented using ‘Java’ which is an object-oriented programming language. As we were discussed in the introduction and background chapters, Visually Impaired Web users use screen readers and the main problem on an easy access of the page depends on the presentation of the page that is how the HTML document is structured. Therefore, in order to decide whether a page is visually complex or not, the HTML file must be analyzed. We decided to read the HTML file from Java code and use the Document Object Model (DOM). DOM is a set of platform and language neutral interfaces that allow a programmer to access and modify the content and the structure of HTML documents (Idris, 1999). Since Java implementations of these interfaces are not provided, we used an HTML parser, which implements these interfaces. “A DOM HTML parser is a Java program that converts the HTML documents into Java object model” (Idris, 1999). With the parser we were able to access the objects that are instantiated by the parser instead of reading information directly form the HTML document from our code.

In this chapter, we will talk about the Document Object Model, then the HTML parser that we used for our program and then we will discuss our Java program and how the features and frameworks discussed in Chapter 4 were implemented in our code.

5.1 Document Object Model

The Document Object Model (DOM) is an application-programming interface (API) for HTML and XML documents. It defines the logical structure of documents and the way a document is accessed and manipulated. With the Document Object Model, programmers can build documents, navigate their structure and add, modify or delete
elements and content. Anything found in an HTML or XML document can be accessed, changed, deleted or added using the Document Object Model. As a W3C specification one important objective is to provide a standard programming interface that can be used in a wide variety of environments and applications. (Robie, 2000)

The Document Object Model is based on an object structure that closely resembles the structure of the document it models. For instance, if we consider this table, taken from an HTML document: (example taken from Robie, 2000)

```html
<TABLE>
  <TBODY>
    <TR>
      <TD>Shady Grove</TD>
      <TD>Aeolian</TD>
    </TR>
    <TR>
      <TD>Over the River, Charlie</TD>
      <TD>Dorian</TD>
    </TR>
  </TBODY>
</TABLE>
```

**Figure 5.1** HTML Document – Table Part

A graphical representation of the DOM of the example table is: (example taken from Robie, 2000)

**Figure 5.2** Graphical Representation of the DOM of the example table
As it can be seen from Figure 5.2, in the DOM, documents have a structure, which is very much like a tree. “This document object contains a tree of nodes that contain the data and structure of the information contained in the XML (or HTML) document. This tree of nodes can be accessed and modified using the DOM API” (Idris, 1999). During our implementation we will try to analyze the HTML document with the help of the DOM API. To access the HTML document we are going to use Java code by writing a text file reader that interprets the information in the HTML document. Writing a text file reader is time consuming and after finding that there are free parsers that implement Document Object Model APIs we decided to use one of them.

### 5.2 HTML Parser

An HTML parser is a Java program that converts HTML documents into some Java object model. Once the HTML document is parsed successfully, it exists in the memory of the Java Virtual Machine as a bunch of objects. The information in this document can be accessed and modified through these objects in the memory instead of manipulating the HTML document file directly. So the DOM HTML parser creates a Java document object representation of the HTML document file. In other words, the parser creates some objects that are instances of some classes that implement certain interfaces in the DOM API and these objects are instantiated when the parser reads the document. In a more simplified way, when an HTML parser loads a document, it scans the document, looks for elements, attributes, text, and so on and constructs a hierarchical tree based on those items. When the parser encounters an element in the source document, it creates a new node in the tree containing a representation of that element.

For our program we decided to use the JTidy package. JTidy is a Java port of HTML Tidy, a HTML syntax checker and pretty printer. Like its non-Java cousin, JTidy can be used as a tool for cleaning up malformed and faulty HTML. In addition, JTidy
provides a DOM interface to the document that is being processed, which effectively makes you able to use JTidy as a DOM parser for real-world HTML. (JTidy)

### 5.3 Program Overview

In this section we are going to have a closer look at the implementation of the program. It is important to clarify that after analyzing the framework and the tools that are available we decided to use a sample program that was already reading a file from the internet. This program was initially written to illustrate how to traverse a DOM tree in order to print a document that is parsed. But for our implementation purposes, the program was expanded to analyze the DOM tree and use the framework for visual complexity to return a ranking for each site.

For the model implementation, it was decided not to do an interface but focus on coding the framework. The objective was to find whether the results from the experiment could be coded in such a way to produce a reasonable and helpful result. Therefore, the above sample program was implemented to determine if such a tool can be created.

The program was reading a HTML document from a URL and parsing it using the Java Tidy to a DOM tree. Our implementation was to analyze each tree node and test what kind of element it represents. Counters were keeping track of what and how many elements were used on each web page.

There were counters for:
- Links
- Images
- Paragraphs
- Tables
- Rows
- Columns
- forms/inputs
- Lists and items within the lists
- Count of words inside lists
- Count of words that are within links
- Count of words that are not within links
- Total word count.

In addition, the program calculated ratios of:
- Words inside lists over total word count
- Words inside links over words inside lists
- Words inside links over total word count
- Word count of unlinked words over total word count
- Word count of linked words over word count of unlinked words

Following, the program, in a single class with three methods, takes in consideration the above counters and returns whether the web page is visually simple, medium or complex. The ratios were initially calculated to help on the assignment of complexity using numbers from one to ten. The program would first decide if the web page is simple, medium or complex and then take in consideration the ratios to decide the level of complexity for each category. This would happen because the ratios help on organizational issues such as to identify if links are organized or whether there are more links than text. However, when time was a big issue on the completion of the project it was decided to keep the calculations but not implement the code to return a value for visual complexity. It is important, also, to note that the current method does not keep track for the positioning part of the framework. This was decided to remain unimplemented since it was taking a lot of time as well. More on this will be discussed on the next chapter.
5.4 What the program does

To get a better idea of how the program finished up we can see what it actually returns when it reads a web page. For example, Figure 3.10 shows the Amazon web page, which was ranked as visually complex from the experiment users. The program reads the HTML document and after it analyzes it returns the following output:

```
Links: 237
Images: 44
Paragraphs: 6
Tables: 33
Rows: 36
Columns: 67
Forms: 1
Lists and Items: 320
Inside Lists word count: 417
Linked Word Count: 448
Unlinked Word Count: 696
TOTAL WORD COUNT: 1144

listWords/wordCount: 0.3648293963254593
linkedWords/listWords: 1.0743405275779376
linkedWords/wordCount: 0.39195100612423445
unlinkedWords/wordCount: 0.6089238845144357
linkedWords/unlinkedWords: 0.6436781609195402

The page is visually complex
```

Table 5.1 Sample Output – What the program returns

The program returns on a command window a list with the counting and ratio results. The most important part from the output is the categorization of the complexity of the page. It returns a sentence describing whether the page is visually simple, medium or complex. It does not return a value from one to ten. The reasons for that are going to be described in the next chapter.
6 Evaluation

This chapter will discuss the program that was implemented in Chapter 5. We will test the tool and evaluate our initial hypothesis. Then, a discussion of the problems that were faced during the implementation and suggestions for improving the framework or the tool will follow.

6.1 Testing

This section will show what the program actually does. To do that, we will take a page from each complexity category and run the code. The output will show whether it matches with the corresponding mean value of the web page that the experiment showed and explain why sometimes it might not work.

The first page that we are going to test is the Mint Research Group (Figure 3.2) (site 3). This page was ranked as visually simple from eleven out of twelve participants giving a median value complexity of three out of twenty. After parsing the web page with the program the output on Table 6.1 is produced, which shows that the complexity identification consists with the rankings from the experiment’s participants.

| Links:12   | Images: 1 |
| Paragraphs: 8 | Tables: 3 |
| Rows: 3 | Columns: 4 |
| Forms: 0 | Lists and Items: 0 0 |
| Inside Lists word count: 0 | Linked Word Count: 22 |
| Unlinked Word Count: 147 | TOTAL WORD COUNT: 169 |

listWords/wordCount: 0.0
The IMG Research Group (Figure 3.6) (site 9) was described as medium complexity that tends to be simple. The table below shows what the code describes the page to be visually medium:

### Table 6.1 Mint Group - Program Output Simple

|------------|------------|--------------|-----------|----------|-------------|----------|----------------------|-------------------------|--------------------------|------------------------|----------------------|

The page is visually medium

### Table 6.2 IMG Research Group – Program Output Medium

A web page that was described and characterized through the experiment with medium complexity that tends to be complex is the School of Computer Science web page (site 7) which is shown in Figure 3.8. When the program runs, the following output is produced (Table 6.3):
Here, the program returns that the HTML page is visually complex. This is not right or wrong. Even though that the experiment categorized the page as medium complexity, some participants mentioned that tends to be complex. Since the code does not take in consideration the ratios, can not recognize that even if the page has a lot of links are grouped with respect to the subject, or that the images are small and relative to the information that is presented.

During the experiment, four participants described the IPG Research Group, Figure 6.1, (site 2) web page as visually simple, two as medium and six as complex. Even though participants were not consistent, the results analysis showed that the web page is categorized as visually complex (median value of 14). The program supports this by producing the output shown on Table 6.4.

Table 6.3 School of Computer Science – Program Output Complex
Figure 6.1 IPG Research Group – Visually Complex

Table 6.4 IPG Research Group – Program Output Complex
The Manchester Online web page (Figure 4.1) as shows the mean and median table (Table 3.6) has the highest mean and median values with 17 and 18.5 respectively. If we run the code with this page’s address, the output consists with the participants’ rankings, by returning the page as visually complex. The output is shown below:

| Links: 136 |
| Images: 35 |
| Paragraphs: 27 |
| Tables: 3 |
| Rows: 3 |
| Columns: 6 |
| Forms: 2 |
| Lists and Items: 0 0 |
| Inside Lists word count: 0 |
| Linked Word Count: 206 |
| Unlinked Word Count: 676 |
| TOTAL WORD COUNT: 882 |

listWords/wordCount: 0.0
linkedWords/listWords: Infinity
linkedWords/wordCount: 0.23382519863791146
unlinkedWords/wordCount: 0.7673098751418842
linkedWords/unlinkedWords: 0.3047337278106509

The page is visually complex

**Table 6.5** Manchester Online – Program Output
Next are tested two web pages that were not used in the experiment. The first one is
the web page of the ISBE’s Research Group (Figure 6.2). As one can see from the
picture below, the web page can be described as visually simple if the descriptions
from Chapter 3 are taken in mind. The page has a simple and short menu on the left, a
list with logos on the right that are small and self explanatory and short text in the
middle. The code that was written consists with our first evaluation of the page. The
output it returns is shown on the table below (Table 6.6).

![ISBE Research Group – Visually Simple](image)

**Figure 6.2 ISBE Research Group – Visually Simple**
Table 6.6 ISBE Research Group – Program Output
The second page is the Times Online. As the picture shows (Figure 6.3) the specific web page is a news page and presents a variety of subjects. This is the first element for a visually complex page. It can be seen that there are a lot of small tables that contain pictures, text and links. The is a long menu on the left and the page is long as well. All the above describe a visually complex page. The program returns the same conclusion by describing the page as visually complex (Table 6.7).
6.2 Problems and Suggestions

While trying to implement the framework and model on Chapter 5 problems such as testing for the diversity or positioning part of the model were faced. These problems are going to be analyzed more here and explained how they can be implemented. It is important to note that the main reason for not implementing them was the time. We had three weeks to try to code the model and trying to find the right tools and ways to implement it took most of the time. In addition, the main aim of the project was to find out whether something can be coded. Hence, we tried to make the program to at least be able to distinguish between the visually simple, medium and complex page. Being able to do that it would mean that if the code would be implemented more, the program could be improved and return a value of complexity.

The first problem we faced was to distinguish whether an image is relative to the page or an advertisement. In order to understand the type of the image we had to analyze the link or source of the image within the HTML code. This can be actually
happen but the coding needed to do it would take more time than we had. In addition, sometimes, by analyzing the source or the link we were not able to distinguish if the image is an advertisement. In those cases, the image should be analyzed by testing what is written on the picture or even what the picture shows; something that most of the times is impossible to implement.

The next significant problem was the page elements’ positioning. By analyzing the DOM tree we were not able to distinguish the position of the images, tables, menus, lists and links. Positioning is one of the important factors for defining the visual complexity. In order to keep track of each element’s position, there should be a different program that should keep track of each space, tabs, line change, paragraph and many more. This is not impossible, but not within our time limit.

Diversity of information is another crucial factor that we did not implement. Even if long pages and large number of words and links mean that there is a lot of information, the only way to test if there are a lot of different subjects is to keep track of the various headlines that are used to group the information. This again was decided not to implement. Word and link counting was a way to recognize that the web page had various subjects to present and since the program keeps track of them we decided not to test for information diversity directly.

Background colors, font colors, font and image sizes are design characteristics that have a vital part on the visual complexity of a web page. However, nowadays designers use Cascading Style Sheets (CSS) for easy access and implementation to the style of the page. There are CSS-DOM APIs for manipulating CSS from within a program (W3C) that can help solve this problem. For our program we decided not to use them again due to time limitations.

As we can see, limited time was the reason of not implementing the entire model. Therefore, if we had time to implement all the problems that were discussed above,
the resulting program might be able to return a ranking for the complexity of the page that would help Visually Impaired people get a better idea of the web page’s structure.
7 Conclusions and Future Work

The aim of this project was to propose a model that could enable Visually Impaired web users evaluate the visual complexity of the page before going through the whole page. To do that, definitions of visual complexity of a web page were drawn with the help of the experiment.

In satisfying the project aims, we successfully used knowledge elicitation techniques to define how a visually complex page is presented, how it is designed and what the main factors of visual complexity are. Visual complexity of web pages could be defined, identifying the metrics that affect visual complexity of a page. With the definition, visually simple and complex pages could be recognized and pointed out following the appropriate classification. Moreover, a tool was designed to support Visually Impaired people distinguish a visually complex or simple HTML page from the moment their screen reader reaches the page.

The main factors that affect Visual Complexity of a web page are the amount of each element on the page, the type of elements that are presented and the way of presentation. Diversity, density and positioning of the elements, such as information, links, pictures, menus and tables or frames are what define the visual complexity of the HTML document. A visually simple page has low amount of density and diversity of the page’s elements and a visually complex pages has a large amount of density and diversity. The main difference between visually simple and visually complex pages is the diversity of information. As in Germonprez and Zigurs, the nature of information is the one that that causes information overload. The experiment showed that the more subjects are covered in the page, the more links, text, pictures and menus are used to design the page following accessibility guidelines.
It was proved throughout the project that a tool to support the Visually Impaired internet users can be implemented. If the framework that is proposed is developed in every detail the program could return an exact value of visual complexity. The program now returns the categorization of the page by assigning it to simple, medium or complex. This gives an overview to the user and helps him/her have an idea of what to expect.

Even if the tool is hard to implement up to the last detail, does not mean is impossible. If the problems, that were faced during development and described in Chapter 6, are solved, the program can be more descriptive and helpful to the users.

Visual Complexity of a web page depends on the amount of information that is presented and the way this information is organized on the screen. If a page is considered visually complex, does not mean that fails on usability and functionality. It just means that the user can find a lot of information, relative or not, usable or not, if he/she spends a lot of time on the page.
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Appendix A – Experiment List of Questions

Introduction to be read to each participant:

This experiment will try to identify the factors that affect the visual complexity of a web site. By visual complexity we mean how complicate a user believes that a site is by simply looking at it and not necessarily using it. For example, a site full of advertisements might be more visually complex than a site with just a text area.

During the experiment, you will see a set of web sites on color hard copies and follow a set of questions that the answers are going to help define visual complexity. There is no right or wrong answer – the answers are somewhat subjective.

Your participation will be anonymous and we’d like to record your session. We would like to be able to use your quotes in any write up of this work; again, this would be anonymous. Do we have your permission to do this? If you do not want to use some of your exact phrases please let me know.

Set of questions/directions that the participant must follow:

Part 1
- Take a look on all the pages and put them in order of complexity by giving them a number from 1-20, with 1 being the simplest and 20 the most complex site.

- Why did you choose to sort them like that?

- What were the main differences that made you sort them in such an order?

Part 2
- Choose the pages that are neither simple nor complex.

- Put the rest pages in two piles. One will be the “simple” pile (meaning that these sites are simple) and the other will be the “complex” pile (these sites are visually complex)

- What are the major differences between the two piles?

- What made you put each site in the simple and not in the complex pile?
Part 3
(Showing the simple pile):
- What makes these sites simple?
- What do these pages have in common?
- Why did you choose to put them in that pile?
- Sort them using 1-10, with 1 to be the less simple (most complex) site and 10 to be the simplest. You can use same numbers if you think that they have the same complexity.

(Showing the complex pile):
- What makes these sites complex?
- What do these pages have in common?
- Why did you choose to put them in that pile?
- Sort them using 1-10, with 1 to be the simplest site and 10 to be the most complex. You can use same numbers if you think that they have the same complexity.

(Showing the pile that are neither simple nor complex)
- What do these pages have in common?
- Why you can not tell if they are simple or complex?
- Do they have any differences?
- Sort them with respect to complexity.

Part 4
- Now I mix all the pages and I will randomly select three pages at a time and you are going to answer few more questions
- Select two of the three pages that you think are most similar.
- Why did you choose these two?
- What do they have in common?
- What is their difference with the third one?
- Which one is the most complex and which the most simple? Why?