ADVT Assessment

Why the Internet is not yet for everyone?

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KEYWORDS

web accessibility, visually impaired users, web difficulties for disabled people, web usability, screen readers, assistive technologies, accessibility barriers

ABSTRACT

Numerous technologies, software tools and regulatory standards have already been implemented in order to assist visually impaired people to get access to Web resources. However, there are still different barriers which prevent screen readers' users to surf on the Internet without any restrictions. The main reason of such limitations is that the majority of webpages are still not fully accessible and usable for blind people. This paper presents a review of the state of the art of the key difficulties which visually impaired users meet on the Web today and how those accessibility problems might be solved. It starts by investigating the main accessibility challenges on the Internet following by a possible solutions of the identified problem.

1 INTRODUCTION

Today the Internet has become an integral part of our lives which provides access to an enormous amount of information and networked resources, allows to make purchases online and use multiple electronic services, removes spacial barriers enabling individuals to be perpetually connected and interact with each other in a new, alternative way [1]. However, every day visually impaired people face different challenges while accessing the Web such as color and its inappropriate contrast, unreadable text sizes and its formatting styles, the lack of feedback received while navigating through a web-page, irrelevant HTML-page structure and others difficulties [2]. All beforementioned web accessibility problems prevent disabled people from effective Internet usage resulting in a lack of social competence [3] due to limited social communication and loose of effective searching tool. Numerous researchers [4]–[6] have revealed that the majority of websites have been developed without following web accessibility standards [7]. Moreover, the study conducted by B. Parmanto showed that 94% of the 159 webpages tested failed to satisfy the requirements of the minimum accessibility standard "A", and not one site met the guidelines of levels "AA" and "AAA" [4]. Thus, the vast majority of web-resources is not accessible to disabled people which results in their inability to gain benefits from using the Internet.

Accessible "Web" which places the interests of people first above other issues such as commercial benefits, gaining popularity and knocking the brand, plays crucial role in a modern world where interactive technologies are becoming an integral part of everyday life. Hence, the purpose of this literature review is to investigate the key problems which people with visual impairments have on the web, which barriers prevent them to use the Internet and how those difficulties might be solved.

The paper is composed of six themed chapters. It begins with a description of a searching strategy which will help us to have a basic understanding of the studied area and provide broad coverage of the topic in sufficient details. Then the paper discusses assistive technologies which people use to navigate through webpages. Next, the paper examines how people navigate on the web and which obstacles they face during the webpage's surfing, including one of the most significant barriers for visually impaired people – an asemantic HTML page layout and barriers due to JavaScript code (autorefresh and multimedia files such as video/audio/documents). Chapter Three analyses the problem of missing/inappropriate alternative and descriptive texts for images as well as irrelevant choice of color on webpages

which force colorblind people to loose part of information presented within a page. The next chapter evaluates the accessibility of one of the mostly used protective technique which limits the fraction of cyber attacks on a webpage – CAPTCHA and how screen readers' users struggle to complete CAPTCHA tasks. All chapters explores accessibility problems on a particular topic and then propose possible solutions for those accessibility issues. The last section of this paper summarizes identified in the main body accessibility barriers, shortly overviews the prospective alternatives which would made the Internet accessible for everyone and closes by discussing the open questions which would provide people with more knowledge about how to make the Web more accessible.

2 SEARCHING STRATEGY

In order to ensure broad coverage of the identified topic, we follow the described below search strategy. First, we will define search terms and concepts and come up with a list of their alternative phrases. For example, for a phrase "web accessibility difficulties" we have: web barriers accessibility, key difficulties on the web for disabled users, key challenges on the web for visually impaired people, accessibility problems on the web, inaccessible webpages, usability issues on the Internet, vision impairments accessibility, screen readers difficulties web and many others. By combining and using synonyms of the beforementioned phrase, we will finally come up with a list of alternative words which can be used while searching a literature. For each concept we will create a concept (mind) map which would assist us in seeking relevant information. Moreover, by scanning already found articles and their abstracts we will discover more useful phrases and key terms which would help us to enhance the search strategy. Additionally, these found articles could provide us with useful references to the relevant for us literature, i.e. citation searching, which can be also reviewed in this literature review.

Next, we will define which articles we need: for this topic we will firstly find some fundamental researches and key findings, i.e. old articles, which would provide us with the basic concepts and aid us to build up basic understanding of the topic. Then, in order to enhance the literature review with the state of the art findings, we will search for the new articles (published no later than in 2016). Thus, we will firstly form the basic comprehension of the field of the study, know what was previously done in this area and what issues are relevant today. We will use Google Scholar as a searching engine as it combines articles from different databases.

3 ASSISTIVE TECHNOLOGIES

Today a great number of everyday life activities could be performed via the Internet: we don't need to travel to a particular office to arrange the meeting with a bank accountant, pay the bills, make a purchase and so on. All these actions are now available without having to leave the house – on the Web. Despite numerous advantages this tendency have, the main drawback is that sometimes it is not available to people due to problems with their health. The research conducted by World Health Organization showed that by 2010, approximately 15% of people throughout the world have some kind of disability which equals approximately 285 million people [8]. What is more, as C. Ghaoui emphasizes, more than 6 million of people have problems with their vision [9]. To gain benefits from the Internet and take an advantage of using the Internet, they use different assistive technology devices such as "alternative keyboards and pointing devices, speech recognition, eye tracking, Braille displays, and screen readers" [10]. Prominent among them are text-to-speech synthesizers such as JAWS, NVDA, Window-Eyes and VoiceOver for the Apple Mac [11], [12]. Assistive software and devices

analyze web-resources, distinguishing images, tables, frames, lists, audio and video and enabling disabled people to “view and percept” the content of a particular HTML-page by reading the information out loud.

In spite of these advanced technologies, numerous studies showed that very often such assistive technologies present the information on a particular webpage in a wrong way which confuses a user and deprive of defeat the purpose of the information presented within the page [2], [4], [13]. As A. Stockman underlines, “the mismatch between the spatial layout of Web pages and the temporal nature of speech imply a substantially increased cognitive load for Web interactions” [12]. What is more, according to Y. Yesilada “screen readers cannot see the implicit structural and navigational knowledge encoded within the visual presentation of Web pages” [14]. In other words, while screen readers make it possible for visually impaired users to “percept” numerous webpages, very often they deprive them from understanding of webpage’s information sense . Thus, users can gain advantage from using the Internet only when it is designed in accordance to accessibility standards [15] in conjunction with assistive devices like screen readers.

4 NAVIGATION THROUGH A WEBPAGE

4.1 Webpage layout

4.1.1 Existing problem

One of the most significant difficulties which prevent people from easy interaction with Web and which result in poor usability and low level of accessibility is a webpage layout causing confusing screen reader feedback. Usually screen readers use a navigation through hotkeys allowing users to move between the webpage’s objects forward or backward. This strategy assists people in creating the mental model of a particular webpage. For this reason, the right choice of HTML-tags is crucial while building the structure of HTML-pages. As T. Stockman emphasizes “failure to use headings where they could be employed can equally make it harder to form a mental model of the page, as well as missing an opportunity to support rapid navigation” [12]. What it means that non-compliance with rules of valid semantic HTML markup leads to a wrong webpages’ structure and users’ confusion while reading the page.

A survey headed by E. Murphy, whose main objective was to elicit the most frustrating difficulties experienced by visually impaired people on the Web, revealed that if users get “lost on the Internet”, they are usually forced to shut down the computer and restart as they are not able to solve the occurred problem. As it was further established, the main reason why a user get “lost on the Internet” is the lack of feedback received due to inappropriate HTML-page layout [2].

Another study conducted by J. Lazar, which purpose was to investigate the top of blind user’s frustration on the Web, showed that inappropriate page layout was one of the most common responses among participants with 36 instances from 100 [10]. J. Lazar proposed that it could be linked to the difference in webpages’ mental model of blind and sighted people. Further, the research analyzed how blind people reads through a Web page using a screen reader and established that visually impaired people “read through the page linearly (serially), one column at a time, one line at a time, one word at a time” [10]. In contrast, sighted people percept a webpage by connecting multiple objects from different parts of the screen all together which allows them to build up an overall understanding of the information presented within a page. Another study by E. Murphy also revealed that blind people mental model of a webpage is considerably different from sighted people mental model. They

concluded that “screen reader users best described their mental models of web page information as a ‘vertical list’ of points and links” [2]. Both study demonstrated that there are significant differences in people’s mental models which have to be considered while building HTML-webpages using semantic markup approach. In other words, to make a webpage accessible this fact has to be taken into account and appropriate HTML-tags have to be used: e.g., nest headings properly, link form controls and their labels with the “label” element, include a documents title and set language of the page, use tables where appropriate with a clear caption and many others. Otherwise, the usability and accessibility of a particular webpage could be disrupted.

Research has also been done that looks at how much time screen readers’ users spent on to find a solution to a frustrating situation when they don’t receive an appropriate feedback on a poorly designed page. The study which examined 100 blind people reported that approximately 30.4% of time spent on to overcoming the challenging situation. It was also concluded that “users spend more time recovering from an incident than initially working through the incident” [10]. That is to say, asemantic HTML-webpage structure forces users to waste time while they could spent it more rationally. Overall, poor design of a webpage could lead to significant consequences for visually impaired people.

4.1.2 Possible solutions

In order to overcome the problem of an irrelevant design of a webpage layout, many improvements could be implemented. The survey conducted by E. Murphy, who asked screen readers’ users to answer what enhancements could be made to increase the accessibility of webpages, found out that a page’s customization option would significantly help people to perceive the information. Moreover, it was concluded that “an additional feedback regarding the spatial layout of a page” would increase the main understanding of the location of different HTML objects presented within it [2].

From web development side, web masters and web designers can aid screen readers to provide a summary of a webpage by creating more accessible navigational structures. Proper HTML-tags usage and semantic page making would also contribute to increased usability. Another alternative solution which was proposed in researchers [16], [17] is to use non-speech audio and haptics which could potentially assist to increase the accessibility of the Web, e.g. vibration. Additionally, multimodal Virtual Reality interface, which was proposed by [18], could help people to visualize the information presented within a webpage and build up a map of objects on it. This way of perceiving information could significantly assist people to navigate throughout a webpage.

4.2 JavaScript barriers

4.2.1 Existing problem

Another significant barrier which disabled people face while navigating through the Internet is the problem associated with JavaScript code: unpredictable webpage refresh, inaccessible files which can be downloaded via JavaScript, animation, i.e. moving objects and other JavaScript features. E. Murphy conducted a study that involved 30 visually impaired people and identified that one particular problem which confused a great number of participants was “the use of an autorefresh feature, created in JavaScript” [2]. Another research conducted by J. Lazar also revealed that the use of a webpage autorefresh can influence activity of blind people in a considerable way and prevent them from achieving their initial goals [10]. Participants reported that autorefresh forced them to repeatedly listen to the same information about a particular webpage and sometimes they were not even able to reach the end of that page. What is more, people of this study confirmed that accessing a

particular file (PDF, Word, audio/video files, flashplayers etc.) is sometimes impossible due to poor accessibility of these files or conflicts between screen readers and plugins. Both studies concluded that sometimes JavaScript may distract screen readers users from performing their initial objectives on the Web and, thus, they just waste time on solving problems connected with JavaScript features while they could spent it more wisely.

A study conducted by B. Parmanto found out that multimedia technologies such as plug-ins and add ones are a significant barrier for disabled people: users usually experienced problems while understanding the main content of such pages [4]. He concluded that interactive and dynamic behavior on the webpages that repeatedly change focus from one object to another confuse visually impaired people and limit them from understanding the information presented within a page. The findings of this study were supported by A. King who confirms it by stating, "first, it hugely increases the complexity of webpages, which now require the user to comprehend a non-standard user environment to access the content they desire; second, content may be created by the web author that is inaccessible to users who cannot use a mouse-driven visually-orientated interface" [19]. In other words, use of JavaScript, which is now becoming an integral part of every webpage, may cause additional problems for blind people which they would have to solve which results in time wasting.

4.2.2 Possible solutions

To facilize disabled people to understand webpages which are loaded with JavaScript code, numerous approaches have been proposed. First of them which would assist to increase the accessibility of multimedia pages and which was proposed by B. Parmanto is to "to accompany non-text elements with meaningful alternative text labels" so each multimedia file (video, audio, document etc.) would have its own description [4]. It would allow people with vision loss to understand what occurs on the screen. Despite the fact that this rule was even underlined in the Web Content Accessibility Guidelines (WCAG) [15], majority of webpages still loss alternative descriptive captions, transcripts for audio, video and documents which was revealed during the studies [6], [20].

Another alternative solution was proposed in the research by [21]. They developed an accessible internet browser for multimedia webpages which allows visually impaired people to use a simplified version of the webpage loaded with multimedia content. By applying external metadata to dynamic HTML-webpages, the browser transcodes the content of the page into accessible content which is described in XML. It significantly simplifies the structure of a particular webpage making it more understandable for visually impaired people.

The interesting solution has recently been proposed by M. Pantula which introduced a technique called *Narrating the scene before the act* "which means narrating the visual elements like characters in the scene, their clothing style, body language, background before the act of the scene" [22]. She developed a tool called *AuDIVA (Audio Description Inserter for Video Accessibility)* which automatically inserts short audio descriptions of the video context before the video starts playing and before every separate scene at specified intervals. According to M. Pantula, this tool will help visually impaired people to obtain a better understanding of the video content.

5 GRAPHICS ON THE WEB

5.1 Alternative and descriptive text for images

5.1.1 Existing problem

Another considerable challenge which visually impaired people meet on the Web and which forces them to have problems while completing a task is visual information. Images, GIF, charts and other graphics may represent quantitative information which provides the accurate numerical data and allows users to use it in different analysis tasks. Hence, it is very important to have an access to such graphical information and the lack of access to it prevents blind people from performing many key analysis activities. It was concluded that an image that does not have an appropriate description (ALT or LONGDESC attributes) is a barrier for visually impaired people [7].

The main issue associated with graphics is that the majority of images and charts do not have alternative texts and informative descriptions which aids visually impaired people to understand graphics. What is more, those images which have descriptions, often lack relevant information for blind users [23]. The study by H. Petrie which examined 100 homepages of major organizations revealed that only 71% of informative images had a description and only few of them had useful ones [24]. More recent research conducted by H. Alahmadi analyzed a dataset of 120 informative images which were collected on different universities websites [25]. He found that the majority of the images lack of HTML5 attributes which provide important information for screen readers' users: 92 of analyzed images did not have a LONGDESC attribute while only 15 of them had a TITLE attribute. Moreover, he also undertook a human evaluation process for each image in the dataset in order to assess the accuracy and quality of descriptive texts. According to the results of human evaluation, 88% of all images were inaccessible with only 12% of images which satisfy the requirements of accessibility standards [15].

Both studies revealed that informative images on numerous webpages lack of necessary HTML5 attributes and elements which aids to eliminate the number of accessibility errors occurring in screen readers. Additionally, a great number of those images which have descriptive attributes still do not convey the accurate meaning of a particular image.

Overall, as the results of beforementioned researches indicate, more attention should be given while developing a website, on its images in particular. Improving the quality of alternative and descriptive texts for images would result in more images on the Web become available for visually impaired people.

5.1.2 Possible solutions

Researches have also conducted various studies in order to overcome the problem of inaccessible images on the Web. For example, S. Wu designed and implemented a special tool which is built on artificial intelligence and computer vision technology and which identifies faces, objects, and themes from photos to generate photo alt-text for screen reader users on Facebook [26]. The similar solution was proposed by S. Feuz who developed a machine learning technique for automatically adding alt-text to media content on the Web: a generative machine learning model, after having been trained, generates a summary of images, video, charts found on the Internet [27]. Another interesting alternative solution was developed by researchers from Google team [28]. They implemented *A Neural Image Caption Generator* that by connecting computer vision and natural language processing generates reasonable sentences describing a particular image. The tool was trained and tested appropriately with the series of various experiments on different image's datasets that proved the robustness and efficiency of the designed tool. In summary, the use of artificial

intelligence and neural networks could be efficiently used by web developers while supplying images with alt-text and which would result in significantly decrease of usability challenges for visually impaired people.

Another alternative tool which was developed by J. Bigham, retrieves accessibility information, i.e. alt-text, from a database and while webpage is loading, it dynamically inserts alt-text into the page, instead of relying upon web authors to have added them manually [29]. This tool would decrease the likelihood of the fact that web developers have simply missed alt-texts and have not inserted them into a webpage appropriately.

While all described above solutions are focused on an appropriate generation and insertion of alt-texts, a research by J. Phlak proposed a completely different solution – he introduced a so-called *communicative images* [30]. His idea was taken as a basis for a tool which parses an SVG image, divided into regions, and allows blind people to explore those regions retrieving information about multiple image's objects and, hence, understand its meaning [31]. This tool could be used to process the images which contain quantitative information such as charts, graphics etc. This way of perceiving information would assists visually impaired people to understand images meaning easily and retrieve the data in more details.

In conclusion, all described above techniques should be used in conjunction in order to eliminate the problem of inaccessible images on the Web.

5.2 Contrast

5.2.1 Existing problem

Color deficiency influences 8% of male population and is caused by the absence of one particular type of photoreceptor in the eye [32]. This color vision problem is called *dichromacy* which forces people to loose some information presented on the screens such as TV, mobile phones, computers (there are still other color deficiency problems such as achromatism and anomalous trichromatic and they also prevent people from accessing particular information). The most significant problem associated with these type of vision impairments is an inappropriate choice of color which makes some information inaccessible for people with vision impairments. As a result, visually impaired users are unable to fully access numerous web-resources due to the fact that these webpages do not follow accessibility guidelines (W3C [7], WCAG [15]). As study conducted by Schmutz showed that about 95% of websites analysed do not satisfy accessibility requirements which means that visually impaired people, including colorblind, are still not able to access a particular web resource [33].

The study conducted by A. Frane revealed that the most common problems associated with colorblind accessibility are lightness between colors, inadequate contrast between text and background, reliance on green and red contrast, dark backgrounds with red foreground elements, unnecessarily small or thin elements (small curves and dots on charts images), inappropriate font sizes [34]. Another study, which gathered and analysed the responses of 24 colorblind users in order to understand factors related to satisfaction, pleasantness and preferences in the access of various interaction contexts, revealed the key properties a website has to have in order to satisfy color blind users requirements. These significant properties are 1) an ability to customize the interface according to suitable for users colors, 2) appropriate contrast and choice of accessible colors of images, text, layout background etc., 3) a balance "between high contrast image and aspect related to esthetics, comfort, and others subjective evaluation in interfaces" [35]. Unfortunately, colorblind accessibility is not one of web developers key goals and beforementioned websites' properties are still lacked

by webmasters while developing webpages which creates numerous barriers for visually impaired people users.

5.2.2 Possible solutions

In order to eliminate the difficulties experienced by people with wrong color perception, various strategies and tools have been proposed. As an example of such tools is "AChecker" which is a web-based instrument for checking a particular webpage conforms with accessibility standards [36]. Another similar tool is an Apache plugin which "transforms HTML on-the-fly on a server or proxy to improve accessibility and empower users" [37].

Another solution which was proposed by R. Eschbach is to use a hierarchical palette which main purpose is to optimize the color in documents and images for dichromats [38]. This framework implies that users can customize the color of a document and choose ones which suite them the most. The similar framework was implemented by K. Wakita [39]. Additionally, numerous recoloring techniques have been implemented. The most well-renowned of them are web images and web pages recoloring. The main idea of such methods is that users should provide the desired hue, saturation and brightness of the colors which they are comfortable with and, thus, a particular page/ image would have provided by a user setting and accessible color [38], [40].

6 CAPTCHA

6.1.1 Existing problem

One of the most commonly used methods to protect websites from malicious users is to use CAPTCHA (Completely Automatic Public Turing Test to Tell Computers and Humans Apart). This technique is used to distinguish humans from computers using images recognition. However, while CAPTCHA prevents various web-systems from hacker's attacks, it is still a significant barrier for visually impaired people who cannot use their vision in order to access a particular webpage.

To overcome this considerable challenge, an alternative solution has been implemented – audio or acoustic CAPTCHA where text, which has to be recognized by blind people, is synthesized and mixed in with background sounds. This way of defending web-systems is a great achievement with respect to the image-based ones. However, numerous studies proved it has some significant drawbacks and is still not an ideal alternative for images. A research conducted by J. Bigham, who analyzed the performance of the audio CAPTCHA completed by 89 blind participants, showed that successful task completion rate was only 43% with approximately 65.64 seconds spent on the task in solving 10 popular audio CAPTCHAs [41]. After it was revealed, the new design of a revised audio version of reCAPTCHA was implemented with the main difference in the text pronounced: it has now become a short phrase or sentence from radio or TV program. J. Lazar conducted a research in order to test new reCAPTCHA and compared this findings with the findings from the previous study: he found out that while the successful task completion rate was around the same (about 46%), the time spent on the reCAPTCHA completion dropped dramatically from 65.64 to 35.75 seconds [42]. He connected it with the fact that "the contextual information in spoken language is expected to make this task easier than the identification of random spoken digits" [42]. Despite the fact that the time performance improved in the second study, the task success rate is still not satisfying which means that it is still a significant obstacle for visually impaired people which prevents them from accessing numerous web resources.

Based on the findings from previous studies, J. Lazar proposed an improved method to audio-based CAPTCHAs which is called the SoundsRight CAPTCHA. The key difference from the previous techniques is that users now were "asked to identify a specific sound (for

example the sound of a bell or a piano) each time it occurs from a series of sounds that are played through the computer's audio system" [42]. Multiple tests showed that the successful task completion rate increased significantly to 90%. Moreover, visually impaired people found this method easier than digits/number based CAPTCHAs.

In spite of numerous alternative audio based CAPTCHAs have been proposed, it is still a significant barrier for blind people due to numerous reasons revealed during the study by S. Kulkarni [43]. He concluded that, firstly, a lot of audios for CAPTCHA are developed without following the WCAG regulations: they have a loud background noise, unclear speech and many other distortions. What is more, M. Noorjahan emphasized that to pass CAPTCHA test, users should have a comprehensive English vocabulary as the majority of CAPTCHAs are in English language only. Additionally, he underlined that screen readers usually talk over the audio CAPTCHAs which results in additional frustrations for visually impaired users [44].

The most recent technique, which was proposed by Google in 2014, is No CAPTCHA or reCAPTCHA v3 which uses an advanced risk analysis engine based [45]. It requires user to just click on the box to proof that they are not robots which results in higher accessibility and usability level. However, if the traffic of a particular user seems to be suspicious, this user has to complete audio/text based CAPTCHA task which, again, is a challenge for visually impaired people.

6.1.2 Possible solutions

In order to help computers to distinguish humans from robots and to enhance accessibility for screen readers' users, numerous alternative solutions have been proposed. One of them is an inclusive CAPTCHA which asks users to answer a particular question after having soothing an audio file [46]. The usability and accessibility tests showed that the task completion rate was 83% which is higher than on the 46% pass rate given in CAPTCHA and reCAPTCHA tests by J. Lazar.

An interesting solution was discussed by O. Gaggi who has observed multiple applications which use Personal Digital Assistances [47]. Such applications provide a blind person with a verified real person who can help blind people to solve a particular problem associated with disabilities – e.g. a non- accessible CAPTCHA. Such apps are already available on digital markets (one of them is "Be My Eyes" [48]).

Another alternative approach is based on a bio metric technique. When blind users meet CAPTCHA, they would be able to scan their finger print with a special device – finger print scanners . This new way of identity proof would aid visually impaired people to access numerous web resources which now are not available for them due to very confusing CAPTCHA tasks [44].

7 CONCLUSION

Despite the fact that multiple assistive technologies have already been implemented successfully in order to aid visually impaired people to surf on the Internet, there are still numerous significant accessibility barriers which prevent screen readers' users to gain full advantage of having access to different Web resources. This paper revealed the most frustrating problems encountered by blind people while navigating through webpages. Today these accessibility barriers are:

1. an inappropriately structured webpage layout which hinders the creating of an accurate user's mental model of the page resulting in slow navigation;
2. interactive and dynamic behavior on a webpage due to JavaScript code which usually starts to work unpredictably and confuses users;

3. missing/inappropriate alternative and descriptive text for images and other graphical information makes numerous images inaccessible;
4. an inappropriate choice of color which force people with vision impairments to loose some information presented on the screens;
5. use of CAPTCHA sometimes prevent screen readers' users to access a particular webpage due to the fact that they are not able to complete CAPTCHA task without the help of another person.

All identified problems influence the Web experience of disabled people in a deteriorating way preventing them from accessing a lot of important information.

Fortunately, in order to eliminate described before accessibility issues, numerous solution have been proposed with the main purpose to create a more accessible and usable digital environment. Software tools, web-based assistive technologies, mobile application and accessibility guidelines are established and developed day by day in the quest for a more usable interfaces and alternative solutions. Additionally, modern devices such as finger print scanners and applications based on crowdsourcing as a way to overcome visual barriers would aid visually impaired people to obtain access to any web resource they require.

However, there is a still lack of accessible websites and web designers should pay more attention to accessibility guidelines such as W3C/WCAG ([7],[15]) in order to limit the number of poorly structured and, thus, inaccessible webpages. Further research is needed to help visually impaired people access the Internet and answers to the below questions would contribute to more knowledge becomes available:

- What facilities visually impaired people the most while surfing on the Internet?
- What are the most frustrating things on the Web for screen readers users?
- How accessibility guidelines can be complemented ?
- What information blind users do expect to meet on webpages ?
- How should the information appear on webpages in order to satisfy the expectations of screen readers users?
- How web developers could enhance the accessibility of webpages without detrimental effects for sighted people?
- What is the most suitable way of presenting inaccessible information (e.g. JavaScript objects, dynamic behavior and others) on webpages for screen readers' users: special web browsers, redirecting to accessible pages with the similar information etc.?
- What is the best way of presenting visual information: by descriptive text, by communicative regions of images etc.?

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