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Algorithm for Validating Financial and Economic Web Pages in Terms of Web Content Accessibility Guidelines

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Abstract:

Purpose: *The purpose of the research is to present the algorithm for the validation of economic and financial websites, allowing to check the degree of accessibility of these websites in terms of WCAG standards with particular attention to people with disabilities and the elderly. The developed method is automatic and allows to obtain both a general score for the analyzed page and a detailed list of analyzed aspects.*
Design/methodology/Approach: *A two-step needs analysis process was conducted to develop the algorithm. In the first phase, the literature was analyzed for selected aspects of accessibility particularly relevant to people with disabilities and the elderly.*
Findings: *The results made it possible to determine the general directions of the algorithm, which are particularly important for the mentioned users. The next stage was the analysis of selected aspects of the websites in the context of their relation to the groups of recipients and the possibilities of analysis by the algorithm. The result of this stage is a set of 9 aspects, within which the individual elements checked by the algorithm were dissected.*
Practical Implications: *The results obtained indicate that the evaluation made by the algorithm coincides with the evaluation of the accessibility of the pages made by the experts. The algorithm allows us to quickly analyze web pages for accessibility and to detect general trends that characterize a given theme of pages. It allows to make general recommendations for improvements and good practices for building accessible pages according to WCAG recommendations.*
Originality value: *The algorithm created is a proprietary project that allows the automatic evaluation of websites. It is based on 9 aspects that make up websites, with the possibility of expanding to more. It can be used to supplement expert knowledge or be used as a general tool to inform about the state of accessibility for a given page.*

Keywords: *WCAG, algorithm, website validating, financial website, economic website*

Paper type: *Research paper*

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1. Introduction

WCAG standards are designed to increase accessibility. This is the most important task to allow users to access different web pages regardless of specific difficulties. Accessibility is a phenomenon that means full access to information and services. It means that an accessible website is one that can be viewed by any person. In the age of digitization and globalization, web accessibility is of particular importance (Park and Kim, 2013). Increasingly, they are not just an add-on, but the main channel of communication.

This phenomenon accelerated and deepened during the Covid-19 pandemic, which forced an increased emphasis on resolving issues, including official or medical ones, using remote communication techniques, including the Internet (Park *et al.,* 2008). The increased emphasis on being able to do many things over the Internet using Web sites, however, presents accessibility challenges. Often, the sites developed were intended to serve only a secondary role as one of many available channels of communication (Duarte *et al.,* 2018). Today, this priority has shifted and they have become one of the most important methods. Therefore, website accessibility, achieved by meeting WCAG standards, is an extremely important element in the development of modern websites (Parmanto and Zeng, 2005).

2. Literature Review

2.1 Accessibility and Disability

To enable accessibility for a wide range of audiences it must be considered in the context of disability. Accessibility, which is understood as independent, convenient and efficient access to web services, in a safe and easy way (Halees and Weng, 2004). It is these features, combined with specific requirements resulting from the specific needs of people struggling with disabilities, that allow for the creation of truly accessible websites. It seems important to emphasize that there is no single type of disability, and thus no single proven recipe for accessibility (Song *et al.,* 2018). To achieve an accessible site, the diverse needs of different groups must be taken into account. Among the most common types of disabilities considered in the context of web design are (Yu *et al.,* 2020; Zhang *et al.,* 2015; Alsaeedi, 2020):

1. Blind people - as part of increased accessibility, various tools are offered for them to help them navigate the Internet, such as Braille rulers and screenreaders.
2. Visually impaired people - it should be noted that very often these are also elderly people, and it is also one of the types of difficulties that may be temporary. For visually impaired people we offer solutions that allow magnification of the presented content, screen readers, the possibility to invert or change the color, as well as increase the contrast.
3. Deaf persons - to increase accessibility in this group tools are used to facilitate video and written contact.

4. Persons with mobility impairments - to increase accessibility within this group, not only the solutions found within the software, but also specialized keyboards and controls, the ability to control voice, breathing and eye movement.

5. Dyslexic individuals - accessibility for this group should take into account errors made by these individuals while navigating the Web, not only in written form, but also in other forms.

6. Poorly educated people - improving accessibility also means using language that is understandable to the widest possible range of people. The use of difficult technical phrases is a barrier that reduces the accessibility of this particular group to materials present on the web.

Attention should also be paid to the phenomenon of aging (Sanchez-Gordon and Lujan-Mora, 2013). Due to the aging nature of the population, the percentage of people in the post-working age is increasing in medium and high developed countries. Also due to cultural and social conditions, these people use modern technical solutions to a greater extent (Huber and Vitouch, 2008). This is caused, for example, by the globalization of societies and the necessary mediated contact.

However, aging as a natural process of the body brings many aspects that should be taken into account in the process of web development. In the aging process, there is a loss of hearing, which means that sounds may be difficult to distinguish, sounds with higher tones may be missed (Ilyas, 2012). There is also a deterioration of vision manifested by a decreased ability to focus on objects close by, but also a change in color perception and sensitivity or a decreased sensitivity to contrast. Physical problems associated with aging can result in a decline in motor skills, difficulty using a mouse or keyboard, difficulty clicking on small areas, or the development of deformities resulting from non-ergonomic postures (Yang and Chen, 2015). One of the next elements is a decline in cognitive function. There may be problems with short-term memory, difficulty concentrating, distraction from movement or irrelevant material, and difficulty coping with information overload. However, regardless of the challenges that are posed due to different types of impairments resulting from disability or from natural processes in people's bodies, increasing accessibility offers many positive effects for both individual users and society as a whole (Saldano *et al.*, 2013).

2.2 Positive Aspects of Increasing Accessibility

The possibility of increased web accessibility, by developing and adapting sites to defined user problems and difficulties, allows for increased social interaction and communication. People who are lonely due to increased mobility, COVID-19 pandemic or mobility difficulties have the opportunity to have daily conversations with both family and friends using the Internet. This also means increased access to information, individuals have the opportunity to read more data, opportunities for growth or support opportunities (Campoverde-Molina *et al.*, 2020). Another positive aspect is access to government services and civic participation. This means that

regardless of disability or handicap, users are able to access materials or activities that interest them. Another element is training and learning opportunities. Upgrading qualifications and self-development are an important point in everyone's life. They have a positive impact on the general level of self-satisfaction and mental health. The last element is employability (Chiang *et al.*, 2005). Due to the globalizing progress of civilization, nowadays people's work is becoming disconnected from their place of residence. This results in people with disabilities or other difficulties not having to be confined to a specific location, but being able to perform their jobs remotely, from anywhere in the world (Federici *et al.*, 2005).

2.3 The Need for Automated Accessibility Checks

Due to the explosive growth of websites and browser-based applications, manual accessibility checking has become not so much a lengthy task as an unpaid one (Bakhsh and Mehmood, 2012). Additionally, the need to quickly adjust many sites forced by the COVID-19 pandemic has made it necessary to develop a tool that will provide clear guidelines and a clear message regarding the accessibility of a selected site. Automating the tool by implementing an algorithm also allows for easy maintenance and updating, which is an extremely important element in the context of changing WCAG requirements (Cooper *et al.*, 2012). Additionally, automation of the tool allows for its further development. Many tools offered on the market offer checking only a selected feature of a given functionality, while they do not refer to a complex check of the whole website in many aspects. The proposed algorithm is designed to meet those features and is an attempt to present a comprehensive solution for quick and efficient evaluation of a selected website (Adamand Kreps, 2006; Sirithumgul *et al.*, 2009).

3. Methodology

3.1 Selected Aspects of WCAG Implemented in the Algorithm

Within the proposed solution, selected aspects of accessibility were implemented. Among them was the aspect of color. The algorithm offers to check if any textual or non-textual elements on the page indicate any content by specifying it in color only. It also allows you to check the contrast in all text elements, non-text elements and menu options. It also checks the indication of elements on the page by color and the contrast of elements present on the page with respect to the page background.

Another aspect is the forms phenomenon. The algorithm allows for validation whether an error in the data entered in the form is simultaneously identified, available and understandable for all users. It checks if the format and nature of the mandatory information to be given in the form is unambiguous and understandable for all, validates the location of form field labels, checks the fields of similar meaning and their grouping. It checks that all the fields used in the form are correctly identified. The next aspect is the presence of graphics.

The algorithm checks if all graphics in the site have a correctly formatted attribute, all non-text elements in the site have a correctly formatted attribute, all decorative graphics have an empty attribute, elements that require it have a correctly created and extended description and if there is a solution reducing accessibility, e.g., CAPTCHA. The next element checked by the proposed solution is the multimedia aspect. The algorithm checks if all significant animated or sound elements have proper description explaining what they present and what they are about, if all multimedia elements have the possibility to be run without eyesight with correctly formulated autodescription, if all multimedia elements having defined soundtrack have correctly formulated subtitles for the deaf, if there are no elements on the page causing rapid changes of brightness, fast flashes in red color.

The algorithm also checks whether all scripted or otherwise programmable elements are fully accessible for assistive devices, whether they have live subtitles. The absence of flashing or moving elements that cannot be stopped is also checked, as well as whether all multimedia elements carrying content are available without the use of a mouse or have an alternative available. Another category checked is the navigation aspect. The algorithm checks if there are warnings before opening a new window or tab, if all active elements on the site are accessible via keyboard, if there is no keyboard trap, if there is no mechanism automatically refreshing the page, if there is no mechanism automatically redirecting the page to another address. The ability to easily understand the purpose and function of links is checked, as well as the consistency of links throughout the site. It is validated if there are empty links, if the current map on the site is up to date, if there is a consistency of layout and operation of menu bars and other navigation elements on the site.

Another aspect analysed by the algorithm are scripts. Within the scripts, it is checked whether if the script changes the non-text content on the page, the alternative content is also changed. If mouse event management attributes are used in the page code, do they have an equivalent for keyboard and vice versa. Whether the content dynamically generated by the script appears immediately after the element causing it to appear, whether element roles are used correctly or whether all elements dynamically generated by the script are accessible. Another aspect is standards, which allow to check if DTD declaration is correctly formulated in page code, if there are no errors or outdated html elements, if proper, correct page titles are present, if correct language declarations are present on each page, if correct language declarations are present for foreign language elements in page content. The next aspect is the structure of the pages.

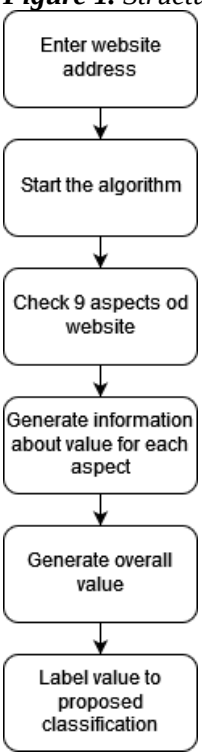
Within the structure it is checked if there is at least one h1 header on each page, if the headers on the page are assigned to the right elements in the right order, if there are no lists of elements that are not reflected in the page code, if there is correct structure of definition lists and correct signaling of citations, if the documents available for download also meet these rules. The last aspect to be checked is the presence of tables. The algorithm allows to validate that all tables have correctly

defined headers linked to data, that tables that do not present data do not have table elements presenting data, that there are no tables visually presenting data, that there are no tables with missing titles and descriptions and that tables serving as the backbone of the page have a clearly defined role. research.

3.2 Structure of the Algorithm

The algorithm is built on the basis of the previously mentioned aspects with the possibility of further expansion. For each aspect three types of information can be generated: no warnings and errors, warning and error. The number of generated warnings and errors is defined by the number of sub-aspects checked by each element. Each aspect can be given a value between 0 and 1. The navigation aspect has a double weight in the algorithm, which means that the value of the obtained points is multiplied by 2. Values close to zero indicate a low number of warnings and errors, values close to 1 indicate a high number of errors and warnings in the given aspect. For each page, a total score is generated that ranges from 0 to 10, where 0 means no warnings and errors and 10 means maximum number of warnings and errors. Diagram 1 presents the graphical structure of the algorithm.

Figure 1. *Structure of an algorithm*



Source: *Authors' algorithm.*

4. Research Results and Discussion

4.1 Algorithm Performance Analysis and Scoring Ranges

In order to test the effectiveness of the algorithm, an analysis of 300 web pages connected to finance and economics was conducted. The websites were divided into the following categories:

-Bank websites;
-Websites for investing;
-Financial and economic portals;
-Portals containing financial and fundamental analysis;
-Websites generally related to finance and economics.

This division yielded 60 sites for each category. The listed sites were subjected to an accessibility analysis for the selected 9 aspects conducted by 10 independent competent judges. Each person was informed about the purpose of the study and then trained on the aspects to be checked for the sites. Each person rated the site on the aspects listed and also assigned an overall score. The concordance of the competent judges' scores was checked by W-Kendall's test and was 0.87 for $p<0.001$, which indicates high concordance of the scores. The listed set of pages was then analyzed by the algorithm, resulting in two sets of ratings for each category: those generated by the expert judges and those generated by the algorithm.

Due to possible biases in the ratings, each page was checked ten times by the algorithm so that the result obtained was the average value. The values of the competent judges' ratings and the values of the algorithm's ratings were then compared to each other using a test of significance of differences between groups. If there are statistically significant differences, it would mean that the expert judges' opinions are significantly different from the data generated by the algorithm. If there are no statistically significant differences, it means that the obtained responses from both the experts and the algorithm are statistically consistent with each other. The obtained results are shown in Table 1.

Table 1. *Comparison of page ratings by expert judges to algorithm results - significance of differences test*

	Expert Mean Value	**Expert Standard Deviation**	**Algorithm Mean Value**	**Algorithm Standard Deviation**	**Statistical level of importance***
Colors	6.4	1.2	6.0	1.0	p=0.41
Formulas	5.2	0.8	5.8	0.9	p=0.13
Graphic	7.3	0.7	7.4	0.6	p=0.74
Multimedia	4.1	1.0	3.5	0.9	p=0.17
Navigation	5.5	0.9	5.1	0.8	p=0.31
Scripts	5.3	0.9	5.4	0.7	p=0.78
Standards	6.8	1.0	6.9	0.9	p=0.82

Structures	7.9	0.5	7.7	0.4	p=0.34
Tables	5.6	0.4	5.2	0.5	p=0.06
All	6.0	0.8	5.9	0.7	p=0.77

Source: *Author's analysis, *n=10 for experts and for runs of algorithm.*

Based on the results, it can be seen that the algorithm assigned convergent scores to those obtained from the expert site evaluators. None of the analyzed categories were statistically significant which means that there are no statistically significant differences. This is information indicating that the effectiveness of the algorithm is similar to the manual evaluation of experts for selected aspects. Based on the results obtained for the defined aspects and the total score, the following classification is suggested:

Overall value for page 0-3 - green color - high degree of accessibility;
Overall value for page 4-7 - yellow color - medium accessibility degree;
Overall value for page 8-10 - red color - low degree of accessibility.

5. Conclusions, Proposals, and Recommendations

The purpose of this paper was to present the basic problems and assumptions related to web accessibility and WCAG standards. Due to the rapid development of web pages, an automatic solution based on a proprietary algorithm for detecting warnings and errors was proposed. The solution was implemented for 9 general categories, within which sets of subcategories necessary for checking were distinguished. Then, the developed algorithm was tested for effectiveness on a sample of 300 pages, showing no statistically significant differences from the experts' evaluations.

Based on the results obtained, it is concluded that the effectiveness of the algorithm is satisfactory. The ongoing work has produced data that has allowed the development of three general categories of accessibility, high, medium and low. Further work on the algorithm will involve expanding both the already developed subcategories within aspects, adding more aspects, as well as further effectiveness tests on larger groups of websites.

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