Accessibility of Bulgarian Regional Museums Websites

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Abstract—**Web accessibility is an inclusive practise that ensures everyone including people with disabilities can successfully work and interact with websites and use all their functionality. The research in the paper investigates the problem of web accessibility of Regional museums in Bulgaria and the compliance of their websites with the recommendations of Web Content Accessibility Guidelines 2.1 (WCAG 2.1), published by World Wide Web Consortium (W3C). The study presents the results of the user experience of people with disabilities regarding the accessibility of museums and exhibits in them. A methodology for automated testing of web accessibility with several software tools is described in the paper. Results from these tests are analysed and visualized with graphical tools. Some important conclusions about most common accessibility problems are given.**

Keywords—Accessibility; museums; web accessibility; visual disability; disabled person; testing; automatic validation tools; WCAG criteria

I. INTRODUCTION

In present days Internet brings information to the user in a quick and easy way by just one mouse click. But this is not the case regarding people with different types of disabilities. According to the World Health Organization (WHO) a disabled person is anyone who has "a problem in body function or structure, an activity limitation, has a difficulty in executing a task or action; with a participation restriction". In 2021 WHO reports [2] state that people identified as disabled are over 1 billion. The COVID pandemic dramatically increases the importance of the special needs of people and addressing the accessibility problem. One of the most important issues that all digital resources and site makers on the Internet should consider and work on is the accessibility for people with visual impairments. According to WHO 253 million people are affected by some form of blindness and visual impairment. This represents 3.2% of the world's population, the second largest group of people with a certain type of disabilities. People with disabilities often have difficulty accessing the content of websites. Web accessibility includes good practices for removing these limitations through appropriate content design and organization. There is no clear correspondence between the good functionality of a website and its accessibility. In practice, designers and developers need to make additional efforts to understand the needs of people with disabilities and to adapt the developed web accessibility standards to their digital resources [3], [4].

World Wide Web Consortium (W3C) [8] presents Web Accessibility Initiative (WAI) [9] as guidelines and recommendations for web accessibility. WAI initiated the development of the Web Content Accessibility Guidelines (WCAG), which are now at version 2.1. The guidelines were built on four principles [8]:

- Perceivable - information and user interface components must be presentable to users in ways they can perceive;

- Operable - User interface components and navigation must be operable. The interface cannot require interaction that a user cannot perform;

- Understandable - users must be able to understand the information as well as the operation of the user interface;

- Robust - content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

There are three compliance levels within WCAG 2.1 [5], [7]:

- Level A: Minimal compliance - prohibit elements that would make the website inaccessible;

- Level AA: Acceptable compliance - all the success criteria categorized as A and AA are satisfied. Used in most accessibility rules and regulations around the world;

- Level AAA: Optimal compliance - all the success criteria categorized as A, AA and AAA are satisfied.

The WAI Accessible Rich Internet Applications Suite (ARIA) [9] defines a way to make web content and web applications more accessible for dynamic content and advanced user interface controls developed with Ajax, HTML, JavaScript, and related technologies [6].

Aside from ethical and business justifications, there are legal reasons for applying Web Content Accessibility Guidelines in various nations and jurisdictions. In January 2017, the US Access Board approved a final rule to update Section 508 of the Rehabilitation Act of 1973. The new rule adopts seventeen WCAG 2.0 success criteria, but 22 of the 38

existing A-level and AA-level criteria were already covered by existing Section 508 guidelines. In EU Directive 2016/2102 requires websites and mobile applications of public sector bodies to conform with WCAG 2.1 Level AA. The European Parliament has approved the directive in October 2016, the European Commission updated the WCAG reference from 2.0 to 2.1 in December 2018 [22].

This paper presents results from an automated testing of accessibility of the websites of the Regional museums in Bulgaria. Some of the results are also discussed in relation to the user experience gathered by a group of volunteers with visual impairments. Sections 2 shows an overview of other accessibility research articles related to museums. In Section 3 authors present the methodology of the conducted experiment. The results of the testing experiment are presented and discussed in Section 4.

II. ACCESSIBILITY AND BULGARIAN MUSEUMS

Digital museums are important part of today's digital world. The accessibility of their websites is even more important in last two years of world pandemic. There are a lot of research articles related to museum accessibility. In [12] is discussed how changes caused by the COVID-19 pandemic potentially pose a threat to the experience of disabled people, in particular blind and partially sighted visitors. Research [13] investigates the perspectives of 72 blind and partially sighted individuals on enhancing their visiting experience in museums. In [14] and [18] some case studies are presented, and the results and conclusions reveal that museums websites in Bulgaria and in other countries are still far from being considered accessible, and improvements in several areas are required.

The accessibility of museums includes not only visually impaired people being able to visit the museums, but also the content and objects in them being perceivable and understandable to them. Some of the possible and often used worldwide solutions to improve accessibility for the blind and visually impaired people in museums are to place Braille signs on all doors, secure stairs with handrail, tactile guide paths, audio information, Braille language plaques.

Unfortunately, this is not always enough for visually impaired people, who may not be able to find the appropriate Braille inscriptions. Even if they do find them, they often do not offer complete information about the objects like the full information that can be obtained by a person with normal vision in the museum or cultural site.

Increasing attention is being paid also to audio guides - cultural routes with audio sounds, voice guidance and digitally accessible content, libraries and archives.

Some common accessibility barriers for blind and visually impaired people and possible solutions include:

1) Getting main information about location, physical access points, work time, available cultural and historical exhibitions, collections, objects and information in the museum.

2) Finding, reading and understanding available information online and offline on sight.

3) Booking a visit for a person/ group with special needs, organizing companion or assistant help if needed.

4) Providing online directions with text or audio

5) An online map of site content with hyperlinks is greatly useful for those with disabilities.

6) Searching information or objects - a site needs to have an easy-to-find and operate search module/ tool on the first page. Usually, it is located in the top headline section, with an option to search with one or a few keywords in pages of the site or an available database and library with cultural and historical knowledge and object. In order to be found the data should be properly organized, categorized, described, meta tagged, etc. [20].

7) Digital accessibility of sites: Website need to be accessible for all types of users and devices from everywhere and it should not take too much time to load and open a page or find the most important information. More about site accessibility and criteria can be found in [11] and [19]. More about web accessibility of sites is also described in the next pages with research results.

Bulgaria has many natural wonders, historical and cultural relics and heritage. There are more than 180 museums in the country that preserve and expose unique samples of Bulgarian and world cultural heritage [10]. Most of them have sites with digital materials and information, virtual tours and expositions on the websites.

Bulgarian Ministry of Culture published a list with 50 cultural museums in 2020 that offer online services and tours, during the epidemic measures situation. Many of those sites and the ones reviewed by the authors in previous research papers [1] and [11] have short video tours, images and text digitized materials, but only a few of the sites show rich data repositories with large collections, annotated objects with captions, metatags and detailed categorized descriptions and search functionality. Some sites have simple education materials with basic games, images for printing and quizzes for kids; other museums use videos online in sites and social networks with people presenting exhibitions or objects, as more interactive digital storytelling [1].

Unfortunately, previous research of cultural sites shows that the accessibility of digital content and the websites of many of these museums in general is not at a high enough level. The survey conducted with volunteers with visual impairments found that over 80% of museums digital sites are not accessible to people with visual impairments, i.e., don't have an audio or text alternative. The results are similar in the negative aspect of the question "Is there access to museum-related materials in Braille, enlarged font and audio?" [11].

There are 30 Regional museums in Bulgaria with websites with information and digitized materials. In the next sections authors investigate the accessibility of these sites. Table I presents a list of Regional museums with their name, website URL and unique ID used for reference in the results section.

TABLE I.   LIST OF MUSEUMS

ID	Name	URL
1	Regional Museum - Veliko Tarnovo	https://museumvt.com/bg/
2	Regional Museum - Gabrovo	https://h-museum-gabrovo.bg/
3	Regional Archaeological Museum - Plovdiv	https://www.archaeologicalmuseumplovdiv.org/
4	Regional Ethnographic Museum - Plovdiv	https://www.ethnograph.info/front/index.php
5	Regional Museum of Natural History – Plovdiv	https://rnhm.org/bg/home
6	Regional Museum - Plovdiv	https://historymuseumplovdiv.org/
7	Regional Museum - Burgas	https://www.burgasmuseums.bg/
8	Regional Museum - Ruse	https://www.museumruse.com/
9	Regional Museum - Varna	http://www.museumvarna.com/
10	Regional Museum - Pleven	https://rim-pleven.com/
11	Regional military museum - Pleven	http://panorama-pleven.com/
12	Regional Museum - Lovech	https://lovech-museum.bg/
13	History Museum - Sofia	https://www.sofiahistorymuseum.bg/index.php?lang=bg
14	Regional Museum - Yambol	http://yambolmuseum.eu/
15	Regional Museum - Vidin	http://museum-vidin.domino.bg/index2.htm
16	Regional Museum - Vratza	https://vratsamuseum.com/
17	Regional Museum - Silistra	https://www.museumsilistra.com/bg/
18	Regional Museum - Pernik	https://www.museumpernik.com/
19	Regional Museum - Smolyan	https://museumsmolyan.eu/
20	Regional Museum - Pazardzhik	https://museum-pz.com/wp/
21	Regional Museum - Sliven	http://museum.sliven.net/
22	Regional Museum - Razgrad	https://abritus.bg/
23	Regional Museum - Shumen	https://museum-shumen.eu/
24	Regional Museum - Montana	https://montana-museum.weebly.com/
25	Regional Museum - Kyustendil	http://www.kyustendilmuseum.primasoft.bg/bg/index.php
26	Regional Museum - Stara Zagora	https://www.rimstz.eu/
27	Regional Museum - Kardzhali	https://www.rim-kardzhali.bg/
28	Regional Museum - Haskovo	http://haskovomuseum.com/
29	Regional Museum - Dobrich	https://www.dobrichmuseum.bg/
30	Regional Museum - Blagoevgrad	https://museumbld.com/

III. METHODOLOGY

Automated evaluation software testing tools often called validators check the web site accessibility according to the guidelines defined by WCAG. They try to identify some errors and potential problems and give some recommendations about improvements of the web site accessibility. These automated tools are not panacea. They give an initial impression about the accessibility level of a web resource and can help developers about fixing general accessibility problems. For more detailed and complete accessibility test an additional manual testing should be conducted. Similar research and results on the topic can be found in [21]. During this manual testing all potential problems from automatic testing tools should be also addressed. It is not a rare case when automated testing tools give a false positive result indicating that the site is 100% accessible. Examples of such cases are presented in the next section. That is why additional manual testing is mandatory. However automated testing results can give a good overall impression about the web accessibility of a site. There are more than 150 automated testing tools in the Web Accessibility Evaluation Tools List from W3C. Three of them are selected to perform the tests of the website's accessibility of Bulgarian Regional museums.

1) TAW [15]: TAW is an automated tool for web site analysis based on WSAG recommendations. It is developed by the Spanish Foundation Centre for the Development of Information and Communication Technologies. It is available either as a browser extension or as a web service. It summarizes results in three categories "Problem" (should be fixed), "Warnings" (developer review is needed), "Not reviewed" (manual check is required). In the experiments performed are used options for Level AA accessibility checking with HTML, CSS, JS options enabled.

2) WAVE [16]: WAVE is another web accessibility test automation tool that also can be used either as a browser extension or as a web service. The report contains five categories that indicate and errors and features that should be addressed to improve accessibility.

3) Lighthouse [17]: It is an open source automated tool for quality improvement of the web site. It can be used as a web browser extension. The report gives scores and recommendations about different indicators. Only one of them is accessibility.

IV. RESULTS

Table II presents scores for all the museum sites with the three testing tools that were used in the research.

Result for each museum is shown on a separate row and assigned ID from first column corresponds to the ID from Table I. Same ID is used as a reference label on the other graphical results that follows next in this section.

TABLE II. ACCESSIBILITY TESTING SCORES OF MUSEUM SITES

| | TAW | | | | | | | | | | | | | | | | | Lighthouse | | | | | WAVE | | | | | |
| | Problem | | | | | Warning | | | | | Not reviewed | | | | | | | | | | | | | | | | | |
	P	O	U	R	T	P	O	U	R	T	P	O	U	R	T		P	A	B	S		E	C	A	F	St	AR
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		47	92	83	64		0	0	0	0	0	0
2	6	7	1	14	28	98	50	6	0	154	3	9	6	1	19		62	88	67	78		7	24	27	29	46	46
3	7	0	1	37	45	14	12	6	0	32	4	8	5	1	18		90	72	67	69		3	15	24	9	14	0
4	3	0	1	10	14	3	2	0	0	5	4	8	5	1	18		93	68	58	67		3	0	27	2	1	0
5	37	12	10	21	80	89	82	0	4	175	3	5	5	0	13		97	68	60	78		25	41	24	19	43	0
6	17	0	1	2	20	13	14	0	0	27	4	7	5	1	17		74	67	93	92		14	4	15	1	0	0
7	4	19	2	1	26	48	30	6	0	84	4	8	5	0	17		45	88	80	81		29	20	5	9	29	14
8	9	6	2	51	68	57	18	6	16	97	4	8	5	0	17		30	94	93	92		3	4	23	6	32	48
9	11	1	1	21	34	42	18	0	4	64	4	7	5	1	17		97	65	73	54		5	1	8	10	8	0
10	15	20	0	48	83	18	18	0	0	36	4	8	6	1	19		26	88	93	98		8	38	31	16	37	14
11	8	2	1	35	46	39	10	0	0	49	4	7	5	1	17		96	69	67	69		7	1	45	3	6	0
12	20	12	4	12	48	75	39	12	20	146	3	7	6	0	16		31	87	87	74		13	33	54	18	47	7
13	14	20	2	23	59	83	59	6	0	148	4	6	5	0	15		18	74	67	79		22	23	36	18	62	5
14	18	84	3	97	202	157	115	6	166	444	4	7	6	0	17		12	91	67	84		51	113	56	52	129	15
15	1	0	1	5	7	0	2	0	0	2	4	8	5	0	17		0	33	80	64		1	0	2	0	0	0
16	82	0	1	53	136	145	2	0	0	147	4	8	5	1	18		68	61	73	69		30	1	16	3	0	0
17	23	7	4	11	45	562	51	6	16	635	4	7	5	0	16		17	86	80	100		7	5	37	39	38	77
18	15	8	1	33	57	21	13	0	0	34	4	7	5	1	17		31	60	73	58		16	0	15	7	7	0
19	4	5	1	6	16	16	15	0	0	31	4	8	6	0	18		56	80	100	89		7	0	1	4	6	4
20	10	5	2	12	29	80	33	6	6	125	4	7	6	0	17		13	82	67	77		17	5	42	21	72	28
21	30	3	1	7	41	6	60	6	0	72	4	8	6	0	18		57	65	73	87		9	12	43	3	47	0
22	15	16	4	33	68	49	45	24	15	133	4	7	5	0	16		6	80	80	90		21	31	15	25	63	13
23	19	16	1	13	49	105	43	0	11	159	4	7	6	0	17		3	90	67	70		23	29	86	44	18	70
24	25	23	0	119	167	56	23	0	0	79	4	7	5	1	17		50	77	80	92		22	2	5	2	24	2
25	43	11	6	136	196	97	3	12	10	122	3	7	5	0	15		98	76	67	75		6	0	30	28	0	0
26	9	17	1	33	60	29	11	0	0	40	4	8	5	1	18		95	84	60	83		11	11	34	9	6	0
27	2	0	1	83	86	17	19	0	4	40	4	7	5	1	17		79	85	80	67		1	3	17	10	9	0
28	10	12	1	2	25	24	39	6	53	122	4	6	6	0	16		21	86	87	85		15	28	27	11	29	2
29	37	64	4	5	110	84	87	12	20	203	4	7	6	0	17		52	96	80	91		30	11	84	17	71	14
30	7	4	1	8	20	16	37	6	8	67	4	6	5	0	15		23	92	73	86		11	5	29	3	39	24

Lighthouse presents results for web site quality in five categories. In Table II, they are denoted as P (Performance), A (Accessibility), B (Best Practices), S (SEO). A special web application was created for automatic usage of Lighthouse API to test all the sites. The application performs three consecutive tests for each site and average the results.

Fig. 1 presents the results for the main criterion that considered – accessibility. Good results are those that are over 90. These are only 6 museums and only one of them is with score over 95. This is the Regional Museum of Dobrich (29). Regional Museum of Vidin (15) has the lowest score. Its site is with a very old-fashioned design even visually and also with bad technical implementation.

Considering data displayed on Fig. 2, the conclusion is that most of the museums (57%) are below the average Lighthouse score of 79 for all tested sites. Also, 80% of them are with a score below the acceptable value of 90. This means according to Lighthouse measurement Bulgarian regional museums websites are with low accessibility level.

Fig. 3 presents the other scores that Lighthouse uses to measure the quality of a web site. As a general conclusion it can be stated that websites with low accessibility level in most cases have low values on the other measurements too.

In the experiment is performed a manual testing for accessibility to the site of Regional Museum of Dobrich (29) which has the highest Lighthouse score. A group of volunteers with visual impairments found some additional problems that were not detected by the automation testing. For example, the main menu is totally inaccessible since it does not contain the necessary attributes for screen readers to find that there are dropdown options. Also, the dropdown list opens on mouse hover and not on Enter key click, which makes it totally inaccessible.

TAW testing tool displays potential problems and warnings according to the four accessibility principles: Perceivable (P), Operable (O), Understandable (U) and Robust (R). These results are presented on Table II for each site. The total number of potential accessibility errors are presented in the column marked with T on its header section. Results marked with red are from the sites where TAW was not able to perform the test because of some automation restrictions incorporated in the site.

On Fig. 4 are presented results for issues marked as "Problems" by TAW tests.

Fig. 1.   Lighthouse Accessibility Scores of Tested Museum Sites.
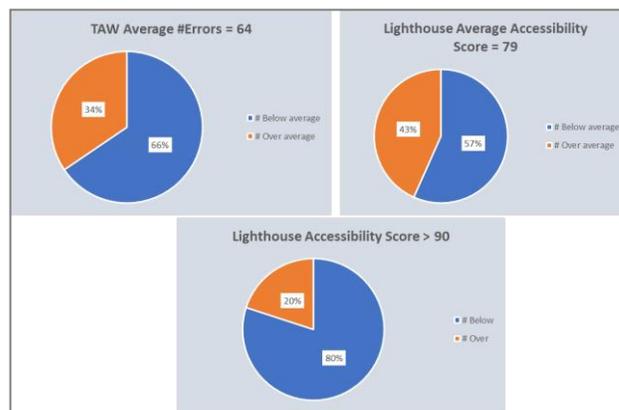

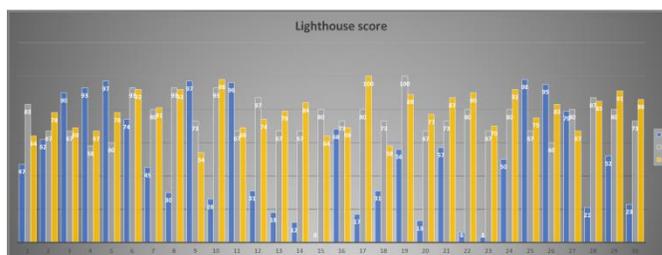Fig. 2.   Average Scores for Accessibility.
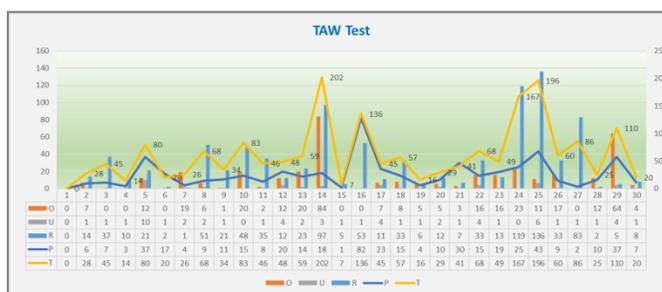

Fig. 3.   Lighthouse other Scores.

Fig. 4.   TAW Scores.

A total number of potential problems detected on the site is indicated with yellow line.

The results of Regional Museum – Gabrovo (Number 2 in Table I), Regional Museum – Haskovo (28), Regional Museum – Blagoevgrad (30) and several other similar scores can be distinguished as museum sites with lowest number of accessibility problems. On the other side are Regional Museum – Yambol (14), Regional Museum – Montana (24) and Regional Museum – Kyustendil (25) with total number problems close to 200.

It's interesting to notice some controversial result for the same websites between the Lighthouse scores and those generated by TAW. For example, Regional Museum – Yambol (14) has accessibility score of 91 by Lighthouse but on the other hand TAW notices a total number of 202 problems. In fact, the TAW results are more adequate in this case, and this is confirmed by performed manual testing of the site by the group of volunteers. Most of the errors detected by TAW are related to bad menu navigation and not well-formed link tags. Also, there are a lot of problems connected to parsing – HTML not

well formed or not used according to specs. These problems are confirmed in manual testing but omitted in Lighthouse. Also, there are cases where Lighthouse evaluation is more precise than TAW. It has been already discussed the badly designed and totally inaccessible site of Regional Museum – Vidin (15) but TAW does not manage to find all the problems in this simple functionality and generates only 7 problems. On the other hand, Lighthouse correctly produces low score of only 33.

Reconsidering the results from Fig. 2 about the average number of TAW errors, it can be noticed that about 66% percent of the sites has below this average number of 64 errors. This could be considered as generally good result for overall accessibility.

WAVE produce a web accessibility report for a web site in five categories: Errors (E), Contrast Errors (C), Alerts (A), Features (F), Structural Elements (St), HTML5 and ARIA (AR).

The results for each category and for each of the tested sites are presented on Fig. 5.

Again, the site of the Regional Museum - Veliko Tarnovo (1) is not successfully tested due to access restrictions.

From other sites with the lowest levels of Errors and Contrast errors Regional Museum – Ruse (8) and Regional Museum – Kardzhali can be distinguished. Again, there are some false negative results like Regional Museum – Vidin (15). According to WAVE it has only 1 error and 2 alerts, but manual check proves that the accessibility problems in this case are much more.

An interesting and unique part of web site analysis with WAVE is that the developer receives a direct visual remark about the accessibility problematic elements on the page. Fig. 6 presents one such visual report about the problems related to the site of Regional Museum – Ruse (8).
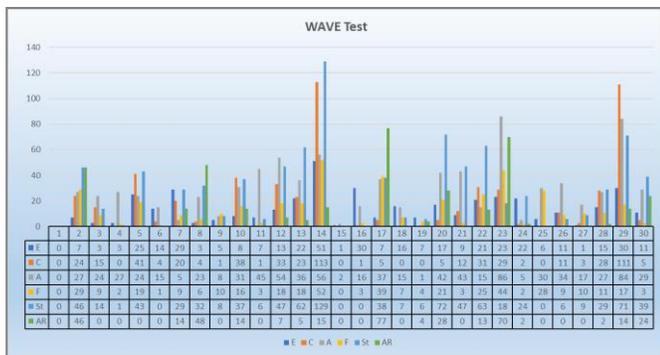

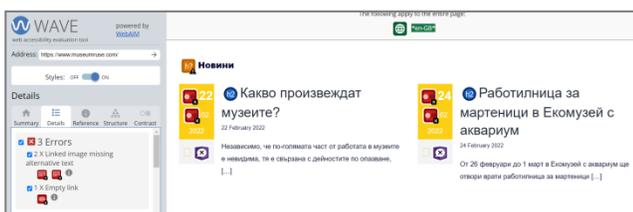Fig. 5.   WAVE Software Test Scores of the Experiment.

Fig. 6.   WAVE Software Visual Report Screen from the Research.

V.   Conclusion

The research in the paper investigated the important problem of web accessibility on museum sites. The research uses automatic web site testing tools and a group of volunteers – blind and with visual impairments for manual testing of 30 websites of Regional Museums in Bulgaria.

In general, the conclusion is that most of the web sites present below average and not a satisfactory level of digital accessibility. Most common accessibility problems found on the researched websites of museums are summarized as follows:

1) Heading elements are not in a sequentially descending order – tags from <h1> to <h6> are missing or are not used in proper way.

WCAG criteria:

- 1.3.1 Info and Relationships (Level A).
- 2.4.6 Headings and Labels (Level AA).

2) <html> element does not have a [lang] attribute - a screen reader assumes that the page is in the default language and might not announce the page's text correctly.

WCAG criteria:

- 3.1.1: Language of Page (Level A).

3) Links do not have a discernible name – if present they improve the navigation experience for screen reader users.

WCAG criteria:

- Success Criterion 2.4.4: Link Purpose (Level A).

4) Image elements do not have [alt] attributes - informative elements should aim for short, descriptive alternate text.

WCAG criteria:

- Success Criterion 1.1.1 (Non-text Content) (Level A).

5) Background and foreground colours do not have a sufficient contrast ratio - low-contrast text is difficult or impossible for many users to read.

WCAG criteria:

- Success Criterion 1.4.3: Contrast (Minimum) (Level AA).
- Understanding Success Criterion 1.4.6: Contrast (Enhanced) (Level AAA).

The volunteers with visual impairments in the experiment stated, during the research, that the automatic software results are useful for orientation and defining main points of sites they need to improve in order to comply with Web Content Accessibility Guidelines, but further real-time testing with visually impaired people is also needed, as the software cannot detect all important issues on sites concerning accessibility, functionality and usability of sites for visually impaired and blind people. This is a matter of further research and scientific papers.

Nevertheless, the existing web accessibility testing software for sites is very useful for web developers and site makers, as well as for institutions and museum representatives. They enable a vast number of sites and databases to be checked automatically in a very short time. Such automated software solutions are necessary in modern times with immense volumes of generated and uploaded online information and sites.

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