Towards developing a framework for automated accessibility evaluation of web content from expert perspectives

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***Abstract*—The current set of web accessibility evaluation tools requires a certain specification of information that requires user or expert perspectives. To improve the correctness and effectiveness of the evaluated result, expert perspectives can lead to great success, especially for the information that requires great effort, knowledge, and broadening research to set their determinator. Also, from the literature, not much effort is being observed to develop solutions for web accessibility evaluation addressing expert perspectives. Besides, the correctness of the evaluation report also depends on the used methods and technologies. Thus, consideration of advanced techniques might improve the performance of the assessment report. Therefore, in this paper, we aim to propose a framework to evaluate the accessibility of web content considering several evaluation criteria from expert perspectives considering several advanced techniques specifically Artificial Intelligence (AI) techniques. The proposed framework includes fifteen criteria that we obtained from consulting web experts and researchers that have a great effect on assessing the accessibility from the user's point of view. The proposed methodology evaluates accessibility following three phases: (a) identification of evaluation criteria from expert perspectives, (b) execution of the web accessibility evaluation process involving different evaluation algorithms incorporating different AI techniques, and (c) validate the framework through experimental and user-centric study to follow-up its computational ability. The proposed method is dynamic in nature and can be applied to different platforms to evaluate multiple web pages.**

***Index Terms*—Web accessibility evaluation, algorithmic evaluation, automated evaluation, user-centric design, social inclusion.**

I. INTRODUCTION

With the rapid growth of digital opportunities, interconnecting and processing information from web platforms (e.g., webpages) is becoming a common aspect of our daily activities. However, WebAIM reported that in 2023, across the world, 96.3% of webpages do not ensure full accessibility as it is quite difficult to offer a completely accessible platform that requires great effort and careful observation [1]. With this in mind, many studies addressed the importance of accessibility needs that should be focused on in the development stage for providing complete support of accessibility criteria [2].

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From this perspective, they suggested incorporating the Web Content Accessibility Guideline (WCAG) as it has a great role in facilitating the evaluation process of web content. Besides, it is a valuable resource to identify many aspects of the web that are relatively impossible to detect without having proper guidelines for the end users. However, along with numerous potentialities of WCAG, studies reported that WCAG does not cover every aspect that may cause accessibility issues [3]. This is might happen as the web are dynamic platform and it's continuously changing, also developers are injecting several advanced prototypes into the web. Therefore, after a long-term debate, ongoing research, and enormous effort, many web researchers concluded that consideration of additional criteria along with WCAG might be a wise decision to improve and make the web content accessibility evaluation result reliable and effective, similar to an approach proposed by Josefin Carlbring [4].

Focusing on this particular aspect, we evaluated several recent studies from the state-of-the-art literature (can be found in section 2) and concluded that none of the recent existing studies consider additional criteria from user or expert perspectives to evaluate the accessibility of web platforms. Most of them focus only on usability and accessibility criteria from various platforms such as multiple guidelines or standards including aesthetic design, cognitive load, etc. but do not really focus on the user or expert perspective. User or expert perspectives play a vital role in identifying some additional criteria from their personal experience that could be helpful for accessibility evaluation [5,6]. Besides, to implement the selected criteria in real-life applications, an advanced and improved web accessibility testing tool is an emerging need as successfully implementing these criteria requires advanced and updated techniques. In the previous literature, several approaches have already implemented different methods and techniques to evaluate several accessibility criteria such as ontology modeling [7], agile methods [8], variable magnitude approach [9], etc. However, in some cases, these techniques are not efficient enough to improve the performance of the developed tool. Some recent studies addressed this issue and enhanced the importance of incorporating several Artificial Intelligence (AI) techniques in implementing and evaluating the accessibility criteria that could bring some great and significant outcomes to contribute

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to the accessibility domain of web platforms [10-12]. Addressing this manner, in this paper, we have considered expert opinion or perspectives as an important factor, and selected 15 major attributes for evaluating webpage accessibility through our proposed framework where the proposed framework is developed considering several AI techniques, specifically NLP methods and some auxiliary functions.

The main aim of this paper is to contribute to the accessibility perspective of digital platforms by proposing an automated web accessibility evaluation framework incorporating AI techniques to determine webpage accessibility according to the additional evaluation criteria from expert perspectives. The proposed system is dynamic in nature, it can be integrated or implemented for any webpage evaluation considering the webpage URL as input to process and generate the result. The prime contributions of this research work are listed as follows:

- In our proposed framework, fifteen key attributes are considered that are beyond web content accessibility guidelines related to the web page's arbitrary information and content information.
- To validate the proposed framework, an experimental evaluation has been performed considering 15 healthcare webpages from Hungary.
- Along with this, we have conducted a questionnaire-based evaluation to evaluate their accessibility considering the selected 15 attributes for the same webpages that we used to evaluate through our proposed framework.
- Finally, we conclude the accessibility status of the evaluated webpages with identified issues that require additional consideration in the future to improve the accessibility of the tested webpages.

This paper is organized as follows. Section 2 provides a brief review of related studies that contributed recently to this field. Section 3 discusses the methodology of the proposed framework by demonstrating the system architecture, design, development, implementation, and validation strategies in detail. Section 4 provides a detailed discussion. Finally, Section 5 concludes the paper with some recommendations and future directions.

II. RELATED STUDIES

Web Content Accessibility Guideline (WCAG) was initiated for the advancement of public and private sector practitioners to direct them about some extensive criteria related to the design and development of web platforms in order to motivate designers and developers to implement such criteria to ensure complete access opportunities for the people with disabilities [13,14]. However, mainly, the focus of WCAG is on the technical artifact of the web, but not on users' and experts' perspectives. This means that the conformance of WCAG is technical-oriented rather than evaluating user experience, more particularly, the needs of people with specific needs. Therefore, we argue that this could be a contributing factor to reducing accessibility opportunities from real-life facts.

Recently, there have been several studies conducted by considering accessibility as the prime resource to assess issues with web navigation. For example, Bigham et al. [15] concluded several crowdsourced methods that contribute to web accessing barriers. Unfortunately, they concluded that though these methods have effectiveness in accessibility issues evaluation, most of them were a particular guideline-specific approach. Abhirup Sinha [16] evaluated several Indian web pages regarding web content accessibility guidelines incorporating several automated accessibility testing tools. They concluded their findings by highlighting the importance of accessibility improvements. In another study, a similar approach was also conducted by Parmanto and Zeng [17] by proposing their custom accessibility evaluation metrics (called WAB score). Also, Miranda and Araujo [18] proposed a framework to support in analysis, development, and validation of accessibility requirements following the agile routine. Their prime objective is to improve the specification and demonstrate accessibility requirements through a goal-oriented model according to the WCAG. In another study, Alzahrani, and Al-Aama [19] proposed a framework, namely, the social media accessibility framework (SMAF), to evaluate the accessibility of social media platforms specifically for people with hearing and visual disabilities. Their evaluation showed that the ratio of accessibility was noticeable when the guidelines were followed during the development. Besides, few studies focused on guidelines from the Americans with Disabilities Act (ADA). Fichtner and Strader [20] stated that to make a website accessible according to ADA compliance, developers need to incorporate advanced tools and at the same time, they need adequate training to design accessible websites effectively.

However, considering user requirements or expert perspectives, a limited number of studies have been noticed in the literature. In one of the studies, Koutsabasis et al. [21] proposed a web accessibility evaluation framework considering user requirements related to colors, style sheets, and images. Another study conducted by Akgül et al. [22] evaluated web platforms considering the user requirements related to accessibility, usability, readability, and security issues.

These user-centric approaches have a limited number of user criteria in consideration as issues with accessibility tend to evaluate every aspect of web objects including arbitrary information, structural objects, and visual aspects. Besides, along with user criteria, regarding the technological aspects, most of the related works developed their framework considering some traditional methods and techniques such as ontological model, heuristic model, agile techniques, etc. which is also a crucial issue that needs to be focused to improve the performance of the developed model or generated reports.

Addressing all of these issues, first, we have conducted an extensive study involving experts to identify the additional criteria that are beyond WCAG criteria and crucial to improving the accessibility of the web platform. Later, we validated webpages using the selected criteria through our

proposed framework where we considered several AI techniques that have a great contribution to identifying the accessibility status of the tested webpages in terms of the selected criteria and improving the performance of the evaluation method.

III. Material and Methods

This section is structured by demonstrating the selected evaluation criteria, and the proposed framework with clarifying its design and development process. Also, the proposed framework has been validated through an experimental process where we experimented and evaluated a bunch of samples of webpages.

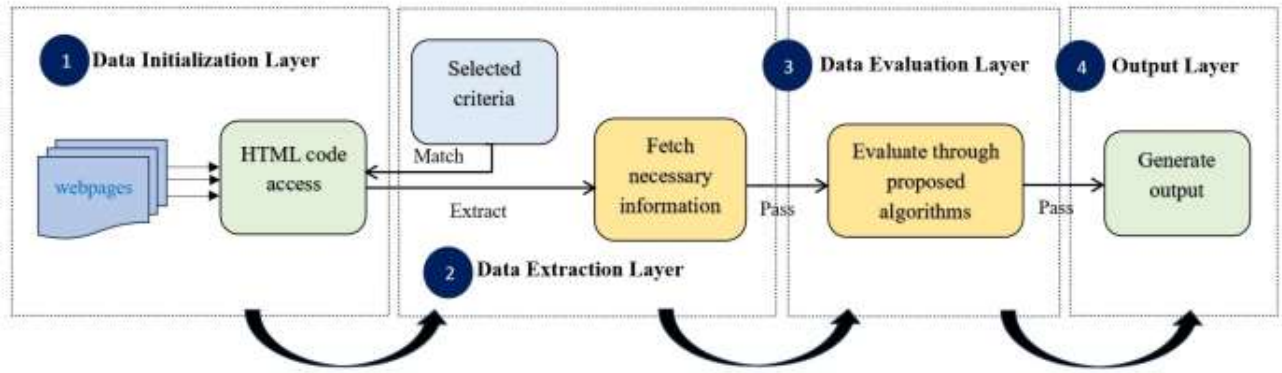

Fig. 1: The System Architecture of the proposed model

A. Evaluation Criteria Selection

As literature supported that web content accessibility guidelines could not support every aspect related to accessibility, thus our prime focus in this work is to identify what are the additional criteria that could be effective in facilitating the evaluation process along with WCAG. Addressing this issue, we conducted an expert study where we interviewed five experts and asked their suggestions about the possible potential additional criteria that weren't mentioned in the WCAG and might be valuable to incorporate into the evaluation process. All of the experts were from the Department of Electrical Engineering and Information Systems, University of Pannonia, Veszprem, Hungary. Three experts have more than 20 years of experience in the accessibility of digital platforms and others have more than 5 years of experience in this field. Based on their feedback, we identified 15 criteria that could be used as additional criteria and might be effective for facilitating the website accessibility evaluation. The selected 15 criteria are related to two distinctive aspects such as arbitrary information {sever status; webpage loading time; and webpage length}, and the content information {paragraph length; the ratio of Hyperlinks; webpage default language; user information; CAPTCHA; multiple language options; image ratio; text font family; text font size; text pattern; content type; audio/video content ratio}. All of these aspects have been analyzed through several criteria using three separate algorithms. The whole automated evaluation process has been described in detail in the following sections.

B. System Architecture, Design, and Development

The proposed framework has four distinctive layers as shown in Figure 1. The first layer is responsible for data initialization, the second layer is responsible for data extraction, the third layer is for extracted data evaluation through algorithmic observation and the final layer is responsible for output representation. All of these layers are described in detail in the following subsections:

a) Data Initialization Layer: The data initialization layer performs the tasks of accessing the HTML code of the tested webpage via the URL of the page. We used sublime text editor as a development framework and Python programming language to write the script. For HTML code access, we used an HTML parser which parses the HTML code and facilitates the data extraction process. We used an HTML parser as HTML source code represents objects referring to several tags, elements, and attributes which are considered as unstructured or semi-structured elements or information. Considering this large number of unstructured information, it is quite difficult to perform the evaluation process effectively. Thus, to make this unstructured information into a structured format, we used an HTML parser which extracts information from HTML source code in a tree view format with a structural manner. As an HTML parser, we used [1]Beautiful Soup which is a Python package that allows us to access any HTML or XML documents. After initializing the data, it redirects its output into the data extraction layer.

[1] https://en.wikipedia.org/wiki/Beautiful_Soup_(HTML_parser)

b) Data Extraction Layer: The data extraction layer performs the extracting process of all the necessary data or information from the HTML tree view or HTML source code of the tested website. We extracted information according to our selected criteria that have been selected according to the expert opinion. Under the selected criteria, 15 key attributes have been decided to be included in this study. To determine the selected criteria in the HTML code and extract the related information, we perform a simple matching function that matches all the criteria in terms of tags, elements, and attributes in a hierarchical manner. Upon matching the criteria, we extracted or fetched their corresponding information and passed the information to the next layer to evaluate through an algorithmic observation.

c) Data Evaluation Layer: In general, the data evaluation layer is responsible for conducting the algorithmic evaluation process incorporating several auxiliary methods to determine the accessibility issues of the tested webpage. The whole evaluation process is performed using three different algorithms stated in Algorithms 1–3 where algorithm 1 is for evaluating webpage arbitrary information, algorithm 2 is for evaluating webpage content information, and algorithm 3 is for overall score computation and accessibility status specification.

Algorithm 1: Algorithm for webpage arbitrary information.

Input: Webpage URL
Output: **A**rbitrary information score

1. counter = 0;
2. initialize the webpage through URL;
3. load the webpage through urllib.request.urlopen (URL);
4. parse the HTML code using BeautifulSoup parser

//validating webpage activation status

5. read the responses through requests.get(URL) function;
6. if (response.status_code == 200),
7. *webpage_activation_score*=counter++;

//calculate the webpage loading time

8. calculate the start time = time.time ();
9. read the responses through requests.get (URL) function;
10. calculate the end time = time.time ();
11. calculate the loading time = end time – start time;
12. if (loading time <=0.3 sec),
13. *webpage_loadingTime_score*=counter++;

//calculate page length

14. calculate page length in byte using (len(urllib.request.urlopen (URL).read())) function;
15. convert page length into byte to KB by dividing 1024;
16. if (page length <=14 kb),
17. *webpage_length_score*=counter++;
18. calculate *score_of_arbitrary_information* = {*webpage_activation_score* + *webpage_loadingTime_score* + *webpage_length_score*}

Algorithm 1 evaluates arbitrary information on the tested webpage by calculating the webpage's active status, loading time, and webpage length. Initially, it performs by loading the webpage and extracting the HTML code of a given URL using the BeautifulSoup python library (lines: 1-4). Upon accessing the webpage resources, it evaluates the arbitrary information. To evaluate the active status of the tested webpage, we tracked the responses of the loaded webpage and according to the response status code, we determined their activation/deactivation status (lines: 5-7). To evaluate webpage loading time, we calculated loading time by tracking the start and end times. After tracking the start time, it continues to read all the responses that are redirected from the page, as well as the end time, and uses it to calculate the overall loading time (lines: 8-13). The loading time is calculated using the difference between the start and end times. Finally, we calculated the page length into bytes and then converted it into kilobytes to evaluate their preferable length (lines: 14-17). Finally, it calculates the score of arbitrary information using the arbitrary information score calculation formula in line 18.

Algorithm 2: Algorithm for webpage content information.

Input: Webpage URL
Output: Content information score

1. counter = 0;
2. initialize the webpage through URL;
3. load the webpage by sending request through urllib.request.urlopen (URL);
4. parse the HTML code using BeautifulSoup parser

//validating webpage text length

5. calculate the length of the textual content by words;
6. if word count <=1500,
7. *webpage_textLenght_score*=counter++;

//validating webpage hyperlinks ratio

8. count all the hyperlinks;
9. if hyperlinks count <=50,
10. *webpage_hyperlinks_score*=counter++;

//validating webpage default language

11. identify the default language;
12. if language is ("en" or "en-US" or "en-GB"),
13. *webpage_language_score*=counter++;

//validating webpage required user information

14. check the required login information;
15. if no ('Username' and 'Password') is required,
16. *webpage_userInformation_score*=counter++;

//validating webpage CAPTCHA

17. identify the 'captchaBlock' in div element;
18. if (‘id’! = 'captchaBlock'),
19. *webpage_CAPTCHA_score*= counter++;

//validating webpage language changing option

20. check language option through (‘nav’, ‘ul’, ‘li’, ‘a’) elements;
21. if ('onclick' is active),
22. *webpage_languageOption_score*=counter++;

//validating webpage image ratio

23. count all the images;
24. if (image count >10),
25. *webpage_image_score*=counter++;

//validating webpage audio/video ratio

26. count all the audio and video content;
27. if (audio/video count is between >=1 to <=2),

28. *webpage_audioVideo_score*=counter++;
//validating webpage font type
29. check the font family using style element,
30. if font family is (Tahoma/Calibri/Helvetica/Arial/Verdana/Times New Roman),
31. *webpage_fontType_score*=counter++;
//validating webpage font size
32. check the font size in pixel using style element;
33. if font size is (16px/17px/18px/19px/20px),
34. *webpage_fontSize_score*=counter++;
//validating webpage text pattern
35. check the text pattern;
36. if (b, strong, i, em, mark, sub, sup) pattern is not in text,
37. *webpage_textPattern_score*=counter++;
//validating webpage content type
38. check the content type;
39. if (text/image/video) content is identified,
40. *webpage_contentType_score*=counter++;
41. calculate *score_of_content_information* = {*webpage_textLenght_score* + *webpage_hyperlinks_score* + *webpage_language_score*+ *webpage_userInformation_score* +*webpage_CAPTCHA_score*+*webpage_languageOption_score*+*webpage_image_score*+*webpage_audioVideo_score*+*webpage_fontType_score*+*webpage_fontSize_score*+*webpage_textPattern_score*+*webpage_contentType_score*}

Algorithm 2 demonstrates the evaluation of webpage content information where we considered twelve attributes such as texts, hyperlinks, language, required user information, CAPTCHA, language option, images, audio/video, font style, font size, text pattern, and content type. Similar to algorithm 1, at first it loads the webpage through the given URL to parse the HTML code through BeautifulSoup python Library (lines: 1-4). Upon accessing the HTML code, the algorithm checks each selected attribute and evaluates them according to the determined criteria to validate their status in terms of accessibility considering several auxiliary functions and Natural Language Processing (NLP) techniques. In lines: 5-7, the webpage text length is evaluated by counting words and if the counted number is under the determined condition, the accessibility status is marked as successful, and increase the counter number. Also, a similar approach has been used for other selected attributes to evaluate their accessibility status (lines: 8-40). Finally, it calculates the accessibility score of content information by summing the score of each evaluated attribute, in line 41.

Algorithm 3: Algorithm for accessibility score computation.

Input: Webpage URL
Output: Overall accessibility score

1. retrieve the 15 types of attributes selected for accessibility evaluation;
2. calculate score of each attribute;
3. calculate accessibility score (*score_arbitrary_informan*+*score_content_information)/N*;

Algorithm 3 calculates the accessibility score of the given webpage URL. First, it considers 15 types of attributes and calculates the score of each attribute incorporating Algorithm 1 and Algorithm 2 (lines 1-2). After calculating all the attributes scores, the accessibility score per webpage is calculated by summing their score using the accessibility score calculation formula, in line 3.

d) Output Layer: The output layer provides the analysis results considering each attribute with their evaluation status (Passed, Failed, Not Tested, and Not Detected), identified issues, and future improvement suggestions. Besides it provides the computed overall accessibility score and overall accessibility status based on the overall accessibility score where we consider several ranges such as if accessibility score is >=90 then Completely Accessible; if accessibility score is <90 to >=75 then Comparatively Accessible; if accessibility score is <75 to >=55 then Partially Accessible; and if accessibility score is <55 then Slightly Accessible.

C. Implementation and Validation

In this section, we presented our implementation by experimenting with 15 selected web pages and validated the evaluation result performing a questionnaire-based user study to represent the effectiveness of the proposed framework for accessibility evaluation of web contents.

TABLE I
TESTED WEBPAGES WITH THEIR EVALUATED SCORE AND ACCESSIBILITY STATUS

Web ID	Webpage URLs	Accessibility score	Accessibility status
Web1	https://klinikaikozpont.unideb.hu/en/node	53.33 %	Slightly Accessible
Web2	https://szkt.hu/en/	40.0%	Slightly Accessible
Web3	https://eegeszsegugy.gov.hu/web/eeszt-information-portal/home	33.33%	Slightly Accessible
Web4	https://www.bazmkorhaz.hu/	41.52%	Slightly Accessible
Web5	http://www.sopronkorhaz.hu/	35.33%	Slightly Accessible
Web6	https://petz.gyor.hu/	40.08%	Slightly Accessible
Web7	https://csfk.hu/	30.02%	Slightly Accessible
Web8	https://www.mfkh.hu/	43.08%	Slightly Accessible
Web9	https://onkol.hu/	46.66%	Slightly Accessible
Web10	https://www.uzsoki.hu/	39.05%	Slightly Accessible
Web11	https://bhc.hu/en/kedvezmenyek	33.33%	Slightly Accessible
Web12	https://wmc.hu/en/	35.59%	Slightly Accessible
Web13	http://heimpalkorhaz.hu/	49.66%	Slightly Accessible
Web14	https://delpestikorhaz.hu/	30.36%	Slightly Accessible
Web15	https://kk.pte.hu/klinikak-intezetek	32.71%	Slightly Accessible

a) Proposed framework implementation: To implement the proposed framework, we experimented by validating fifteen healthcare webpages (hospital and medical point) from Hungary that are listed in Table 1. Also, in Table 1, we presented the evaluation result in terms of their computed accessibility score (by applying three algorithms described in section B) with their accessibility status that has been classified according to the statistics described earlier (subsection *B (d)*).

Table 1 depicts that none of the tested web pages was found accessible in terms of the selected evaluation criteria. All the tested webpages found as slightly accessible that indicate none of the webpages followed all the selected criteria and, in this regard, all of the pages have serious issues with accessibility. Additionally, we found some issues that were frequently observed in the majority of the tested webpages such as issues with 'webpage loading time', 'hyperlink ratio', 'webpage length', 'webpage default language', 'language changing option', 'font type', 'font-size', and 'webpage content type' that need to be considered in future to improve accessibility.

b) Proposed framework validation: To validate the proposed framework, we incorporated end users to evaluate webpages and provide their feedback in terms of our asked questions where the questions asked were related to our identified 15 criteria. To perform the user study, we invited participants to attend online participation via Zoom meeting. All the participants were university bachelor's and master's students from the Electrical Engineering and Information Systems Department of the University of Pannonia, Hungary. The total number of participants was 20, including 8 female and 12 male students aged between 21 and 25. All of them have sufficient knowledge about 'web programming', and 'User Interface Design'. To make the evaluation process effective, first, we briefly explained the aim, and testing process and described each question to the participants which took around 10 minutes. All the questions were designed in such a way as to understand the user perspective properly. After explaining everything to the participants, we shared the resources with users including the Google questionnaire link, and the website information in a shared file that needs to be evaluated. On average, the experiment took 20 to 30 minutes. The questionnaire used for the user feedback is shown in the following.

Q1: Does the webpage's loading time satisfactory? (Yes/No), please clarify your answer.

Q2: Is the paragraph or textual content length of the webpage satisfactory? (Yes/No), please clarify your answer.

Q3: Is the webpage's ratio of hyperlinks satisfactory? (Yes/No), please clarify your answer.

Q4: Is there a default English version of the webpage? (Yes/No), if yes/no, do you think it's useful? (Yes/No), clarify your answer.

Q5: Is the length of the webpage satisfactory? (Yes/No), please clarify your answer.

Q6: Is the server of the webpage active? (Yes/No), if yes/no, do you think it's useful? (Yes/No), clarify your answer.

Q7: Does webpage require user information to access? (Yes/No), if yes/no, do you think it's useful? (Yes/No), clarify your answer.

Q8: Does webpage use CAPTCHA? (Yes/No), if yes/no, do you think it's useful? (Yes/No), clarify your answer.

Q9: Does webpage have a multiple-language option? (Yes/No), if yes/no, do you think it's useful? (Yes/No), clarify your answer.

Q10: Is the ratio of image content satisfactory? (Yes/No), please clarify your answer.

Q11: Is the font used on webpages understandable? (Yes/No); if not, please clarify your answer.

Q12: Is the font size on webpage satisfactory? (Yes/No); if not, please clarify your answer.

Q13: Does webpage use multiple text patterns? (Yes/No), if yes/no, do you think it's useful? (Yes/No), clarify your answer.

Q14: Does webpage contain multiple content types (e.g., audio/video/text/images)? (Yes/No), if yes/no, do you think it's useful? (Yes/No), clarify your answer.

Q15: Is the ratio of audio/video content on the webpage satisfactory? (Yes/No), please clarify your answer.

Each participant's responses to the asked questions are listed in Table 2. This table shows that from the overall feedback for each of the questions, the majority of the user answers were very poor in terms of positive responses. It depicts that the majority of the users were not satisfied while they navigated the web pages to respond to the asked questions. It directs the emerging need to consider the addressed criteria in this paper in the web accessibility evaluation process as these criteria have a great impact on improving accessibility.

TABLE II
ASSESSMENT QUESTIONNAIRE WITH PARTICIPANT'S RESPONSES

Questionnaire	Yes (%)	No (%)
Q1: Does the webpage's loading time satisfactory?	51.38	48.62
Is the paragraph or textual content length of the webpage satisfactory?	30.32	69.68
Q3: Is the webpage's ratio of hyperlinks satisfactory?	20.0	80.0
Q4: Is there a default English version of the webpage?	8.7	91.30
Q5: Is the length of the webpage satisfactory?	60.05	39.95
Q6: Is the server of the webpage active?	92.15	7.85
Q7: Does webpage require user information to access?	9.48	90.52
Q8: Does webpage use CAPTCHA?	5.0	95.0
Q9: Does webpage have a multiple-language option?	9.53	90.47
Q10: Is the ratio of image content satisfactory?	64.71	35.29
Q11: Is the font used on webpages understandable?	31.58	68.42

Q12: Is the font size on webpage satisfactory?	42.11	57.89
Q13: Does webpage use multiple text patterns?	20.3	79.7
Q14: Does webpage contain multiple content types (e.g., audio/video/text/images)?	10.65	89.35
Q15: Is the ratio of audio/video content on the webpage satisfactory?	76.17	23.83

However, the work presented in this paper is a part of our detailed research regarding web accessibility. From the analysis, we can conclude that there is a huge scope to improve the accessibility of web platforms. As the web platform act is an important medium to access a wide array of information, thus this platform should be well designed along with future improvements, considering improving webpage loading time, properly maintaining hyperlink ratio, reducing webpage length, providing webpage default language, and language changing option, and ensuring proper font type, font size, and webpage content type. We believe that this study might help website designers, developers, and future researchers to enhance their contribution to their developed sites to a large extent. Also, we believe more future studies regarding this context could bring some new perspectives and motivate the practitioners to put their attention broadly.

IV. Discussion

In general, web content accessibility guidelines, for example, Web Content Accessibility Guideline (WCAG) is one of the widely accepted standards but few special objects are not included in this standard that could raise accessibility issues associated with people with disabilities. For example, almost every webpage has no manual text size or color adjustment option which raises issues for people with vision disability or color disabilities in navigating the content. Sometimes webpages require user information for accessing web content, and few webpages ask to pass through CAPTCHA testing which is considered a difficult task for people with special needs. Some other issues related to the excessive number of internal/external links, images, and video and audio content also hinder access opportunities for people with cognitive disability. Unfortunately, the most advanced and standard guidelines normally do not consider these aspects during their guideline specification. Therefore, according to the expert's opinion, considering these aspects as additional criteria along with any standard guideline might facilitate the webpage accessibility evaluation process to reveal the true insights of webpage accessibility. Besides, the proposed approach is an AI-driven approach that facilitates the evaluation process in terms of time, semantic improvements, and matching the web feature with specific guidelines compared to other solutions such as ontological modeling, agile modeling, or goal-oriented modeling.

With this aim, this work presents an automated web content accessibility evaluation framework that performs the evaluation considering different algorithmic evaluation considering AI techniques. According to the expert suggestion, in our proposed framework, we considered fifteen criteria that are crucial to incorporate into the webpage accessibility evaluation. To evaluate the web content regarding the selected criteria, we conducted an algorithmic evaluation which directed that the majority of the tested webpage has serious accessibility issues regarding the selected aspects. Also, from the user-centric study, the same scenario is reflected similarly to the evaluated result. Also, during the user study, we encouraged the participants to share their additional suggestions that might help to understand the most frequent issues they have experienced in the tested webpages. After analyzing all the shared opinions or suggestions, we categorized their responses under six factors. Therefore, according to the respondents' opinions, the tested webpages should have adequate focus on the following factors:

- hyperlink ratio
- webpage length
- webpage default language
- language changing option
- font type
- font-size
- webpage content type

Figure 2, the pie chart depicts that 20% of suggestions were related to the issues with font type and font size adjustment option; 17% of responders reported issues related to the webpage's default language and demand for specifying the English language as a default language to improve the accessibility of webpage; 15% responder suggested to add manual language changing option; 11% responder suggestion was related to issue with hyperlink ratio; and 9% and 8% responder were concerned about webpage length and webpage content type, respectively.

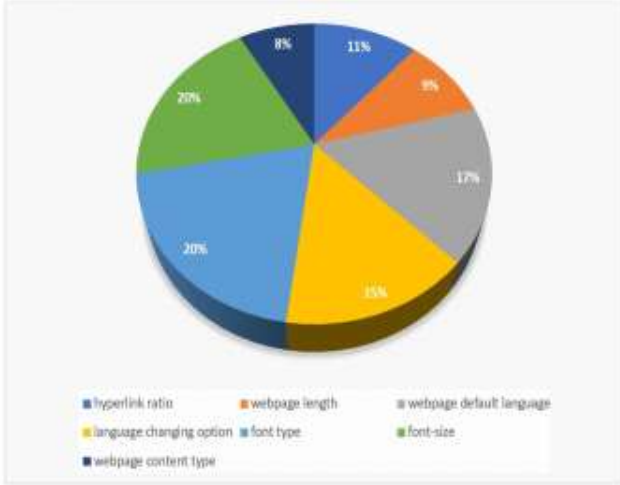

Fig. 2: Responders suggestion for evaluated criteria

V. Conclusion and Future Research

This paper presents an extensive study on the development of an accessibility evaluation framework to evaluate accessibility of the web content. As the ratio of the inaccessible web has increased dramatically, thus an updated and dynamic web evaluation tool is an emerging need.

Besides, to improve the performance of the evaluation tool, the importance of focusing on advanced techniques is significantly important. To address this concern, we proposed a framework that incorporates several AI techniques that make the development dynamic in nature and able to evaluate any webpage in terms of our selected 15 attributes. Our main challenge was implementing AI techniques to make it dynamic as different HTML structures have been used in different web page development. This proposed framework can act as a tool that can evaluate accessibility issues and generate accessibility scores for the tested webpage. Along with this, an experimental evaluation and questionnaire-based user validation have been performed which reveals that the proposed framework has significance in generating satisfactory results which also indicates the significance of AI-based web accessibility evaluation tools. However, our future work aligns with performing another extensive study involving the user to validate the outcome of this proposed approach and identify suitable criteria that need to be focused on in the web accessibility evaluation process further.

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