WAccess - A Web Accessibility Tool based on the latest WCAG 2.2 guidelines

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The vision of providing access to all web content equally for all users makes web accessibility a fundamental goal of today's internet. Web accessibility is the practice of removing barriers from websites that could hinder functionality for users with various disabilities. Web accessibility is measured against the accessibility guidelines such as WCAG, GIGW and so on. WCAG 2.2 is the latest set of guidelines for web accessibility that helps in making websites accessible. The web accessibility tools available in the World Wide Web Consortium (W3C), only conform up to WCAG 2.1 guidelines. No tools exist for the latest set of guidelines. Despite the availability of several tools to check conformity of websites with WCAG 2.1 guidelines, there is scarcity of tools that are both open source and scalable. To support automated accessibility evaluation of numerous websites against WCAG 2.2 and 2.1, we present here a tool, *WAccess*. *WAccess* highlights violations of 9 guidelines from WCAG 2.1 and 7 guidelines from WCAG 2.2 of a specific web page on the web console and suggests the fix for violations while specifying violating code snippet simultaneously. We evaluated *WAccess* against 2246 government websites of India, and observed a total of about 2 million violations.

CCS Concepts: • **Information systems** → **World Wide Web**; **Web mining**; • **Human-centered computing** → **Accessibility systems and tools**.

Additional Key Words and Phrases: Web, Accessibility, Tools, Guidelines, Government Websites

1 INTRODUCTION

Usability and accessibility are the commonly used terms in the context of enhancing the user experience for users of the world wide web. While there is no universally accepted view or definition for usability, a commonly accepted definition presented in ISO 9241-11 standard explains that a product is considered to be useful if the specified users can accomplish specified tasks effectively, efficiently, and with satisfaction [18]. Currently, most public and private activities heavily rely on web-based services, making it critical for the web to be usable by any individual, irrespective of any physical or mental barriers [23]. Usability of websites is strongly influenced by the level of accessibility of websites [6]. Web accessibility has attracted significant attention from researchers and governments across the globe since its inception to provide better access to the websites [21]. Researchers have emphasized the need for web developers to abide by accessibility guidelines of websites to support broader usability of web [14].

Despite the massive digitization, a significant amount of web content and e-services are not accessible to a large section of users today. When it comes to utilizing the web, a diverse range of users exists, including visually impaired or disabled groups and older adults, who might find it difficult to read through a page [4]. Providing content in a similar fashion to all types of user groups as presented to user groups without disabilities makes the web inaccessible to the rest of these groups [1]. Several attempts are being made to address this challenge of web accessibility [2, 5, 15]. In order to overcome these challenges, standard guidelines such as WCAG have been proposed to support website developers and designers to ensure website accessibility. The latest revised WCAG guidelines are WCAG 2.2[1] proposed in the year 2021. Several tools such as Achecker [5] and CAC [13] have been developed to evaluate websites against different

[1] https://www.w3.org/TR/WCAG22/

versions of guidelines such as WCAG 1.0[2], WCAG 2.0[3] guidelines, Stanca Act[4] (Italian accessibility guidelines), and so on. Most of the existing tools focus on highlighting errors based on WCAG 2.0 guidelines, while fewer tools exist for evaluating websites based on WCAG 2.1 guidelines [13], and no tools exist to evaluate websites based on WCAG 2.2 guidelines. World wide web consortium (W3C) lists 132 web accessibility evaluation tools for WCAG 2.0, 67 evaluation tools for WCAG 2.1, while none are listed for WCAG 2.2.[5]

Of the 67 tools, only 15 are available as open-source to evaluate websites against WCAG 2.1 guidelines. Tools supporting command-line interfaces help verify the accessibility of a large number of websites automatically [3]. In contrast, tools designed as browser plugins help in an easy and quick understanding of the accessibility of the website. However, based on the above criteria, *QualWeb*[6] is the only tool listed to support both command-line and browser plugin facility. We observe that *QualWeb* is not available as a browser extension yet. It also requires the further installation of other packages such as npm and revised chromium-browser to use the command line interface version, making it difficult to use the tool. Even after installing the required dependencies, many errors occurred, preventing the functioning of the tool[7]. This indicates the need for better tools and approaches that could evaluate the accessibility of websites against WCAG 2.1 guidelines and consequently be used in web development.

Hence, in this paper, we propose *WAccess*[8], a tool to assess web accessibility of websites against WCAG 2.2 guidelines, along with WCAG 2.1 guidelines. *WAccess* displays a *list of errors* with respect to *accessibility guidelines*, the *code snippet* that causes the *error* and a *suggested fix*. Since a large number of users are intending to use the government's e-services, the massive volume of government information is incorporated onto the web [7]. This aspect resulted in the growth of research on evaluating the accessibility of government websites [8, 10, 16, 21]. However, these evaluations are performed on a smaller number of websites ranging from 10 to 302 website evaluations, as the existing tools for evaluating web accessibility are complex in nature for performing guideline automated analysis. Also, these evaluations are based on WCAG 2.0 and WCAG 1.0, which were proposed prior to WCAG 2.1, in 2010. While Narasimhan et al. have evaluated accessibility of a larger number of GoI websites (7800), this evaluation was also confined only to WCAG 2.0 guidelines [17]. Indian Government websites contain vast information and are critical for good governance in the country [20].

As an attempt towards analyzing accessibility of multiple government websites against WCAG 2.2 and 2.1 guidelines, and simultaneously towards evaluating the usefulness of *WAccess*, we performed a study on the accessibility of 2246 Indian government websites using *WAccess*. Through this study, *WAccess* could detect 2000556 violations across 2246 websites, with respect WCAG 2.2 and 2.1 guidelines. The results of the study are presented here[9].

2 RELATED WORK

Web Accessibility is considered as an important issue in the current digital world, leading to the emergence of several approaches and guidelines to improve accessibility [2, 5, 15]. Moreno et al. have emphasized the need for standardizing the web accessibility standards across the world, and suggested the use of WCAG guidelines [15].

There are several tools and techniques in the literature to evaluate websites' accessibility against WCAG guidelines [5, 13, 24]. Takata et al. [24] proposed a tool to verify the accessibility and syntactic correctness of a website. The tool

[2] https://www.w3.org/TR/WAI-WEBCONTENT/
[3] https://www.w3.org/TR/WCAG20/
[4] https://www.levelaccess.com/accessibility-regulations/italy/
[5] https://www.w3.org/WAI/ER/tools/
[6] http://qualweb.di.fc.ul.pt/evaluator/about
[7] Snapshots of the errors occurred are presented in this document - https://osf.io/k9v8a/?view_only=9b7799ccf554412f9cdaafa61da4bf52
[8] https://sites.google.com/iittp.ac.in/waccess
[9] https://osf.io/fnx4t/?view_only=1769872b5dd447fbbb30fe47ecf88ece

supports verification of any XML document, by separating out the guidelines to facilitate easy modification of the guidelines [24]. *Achecker* [5] is a standalone open-source tool to analyze the extent to which a website adheres to a set of accessibility guidelines. It facilitates users to choose the desired accessibility guidelines, which are to be evaluated for a website from a pre-loaded list [5]. *WAVE* tool has been proposed to identify accessibility errors with respect to WCAG guidelines, to support web developers in developing web pages that are accessible to all, irrespective of individuals with disabilities[10]. *CAC* evaluates a website against WCAG 2.0 guidelines for accessibility issues [13]. *CAC* also reports issues to the users by highlighting them on the webpage and proposes possible solutions to resolve the issues [13]. Crespo et al. also suggest a novel approach to support the rectification of a few accessibility issues in websites, based on evaluating adherence to a set of accessibility guidelines [2].

Web usability evaluation of government websites has been performed by several countries such as China [21], Tanzania [16], Kyrgyz Republic [9], India [11] and researchers have observed that most of the websites fail to meet the minimal accessibility standards. Recently, Spina has analyzed WCAG 2.1 guidelines for libraries and found that it is important to update the existing tools to support WCAG 2.1 [22].

There is scarce research on web accessibility in the Indian context. Researchers have evaluated web accessibility of banking websites [12], educational institutions [8] among other websites. An expert manual study of 28 Government of India (GoI) websites found that most of the websites are either down or have accessibility issues in the year 2011 [11]. A study performed by the Center for Internet and Society on 7800 websites of GoI using existing web accessibility evaluation tools based on WCAG 2.0 found an average of 63 errors per home page, with a few pages crossing 1000 errors [17]. In a study conducted to assess the accessibility of 15 GoI portals concerning WCAG 2.0 (2008) and GIGW Guidelines, Patra et al. have listed specific aspects that are to be considered to improve accessibility websites [19]. Recently, Paul et al. studied the accessibility and usability of 65 Indian government websites against WCAG 2.0 and WCAG 1.0 using automated tools specified for these guidelines [20]. The results revealed that the considered websites do not prioritize accessibility aspect, eventually leading to the low quality of government websites in India [20].

As mentioned above, majority of the existing approaches and tools for WCAG 2.1 are proprietary. Only 13 tools are open-source, out of which only *QualWeb* works both as a browser plugin and a command line interface. However, *QualWeb* did not work when attempted to run and also has the overhead of installing other packages as pre-requisites to run. Furthermore, no tools exist for the latest WCAG 2.2 guidelines. Hence, we propose *WAccess*, as a Google Chrome plugin that aims to verify the accessibility of websites based on WCAG 2.1 and 2.2 guidelines. We further evaluate *WAccess* with 2246 Indian government websites to understand the usefulness of *WAccess* and to analyze the accessibility of these websites.

3 DESIGN AND DEVELOPMENT OF *WACCESS*

3.1 WEB ACCESSIBILITY GUIDELINES

The Web Accessibility Initiative (WAI) of the W3C has proposed several standards with the goal of "access to the Web by everyone," with each of the standards having a layered set of principles, guidelines, success criteria, and sufficient and advisory techniques.

WCAG 1.0 is one of the initial web accessibility guidelines that appeared in 1999 with a revised version of WCAG 2.0, 2.1 in 2008 and 2018 respectively and the recent standard version, WCAG 2.2, in 2021.

[10] http://wave.webaim.org/

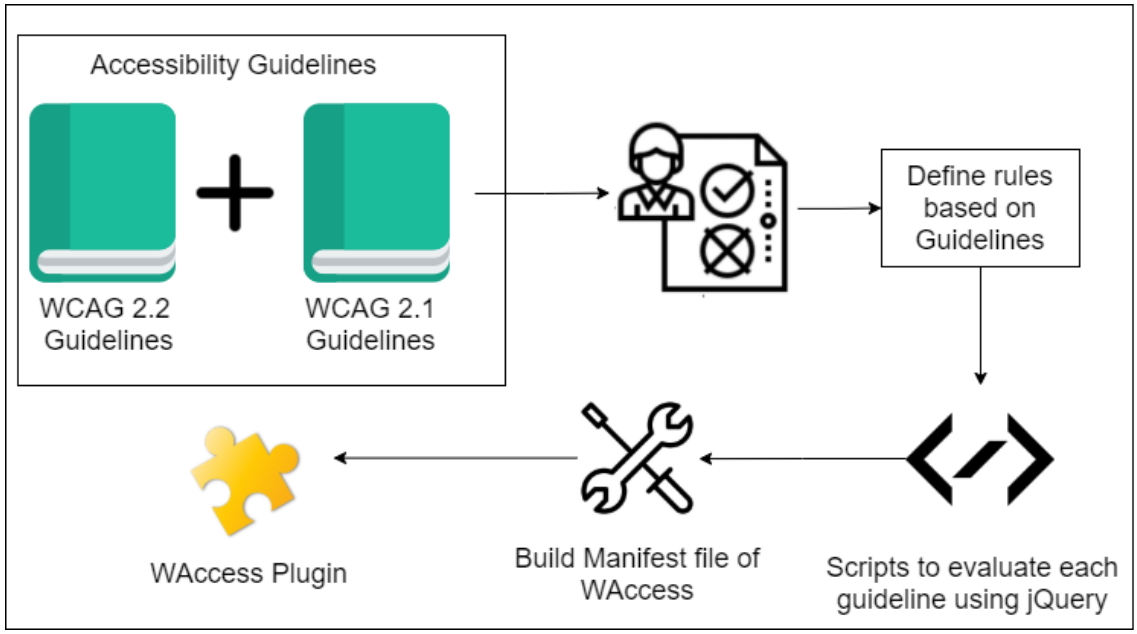

Fig. 1. Design Methodology of *WAccess*

Each of these standards is backward compatible with each other. Since the start of WCAG 2.0, three conformance levels of accessibility denoted as A (basic accessibility), AA (desirable accessibility), AAA (full accessibility) are introduced that could be customized as per specific needs of the web content and web content providers. In addition to WCAG, two more standards - Authoring Tool Accessibility Guidelines (ATAG) 2.0 and User Agent Accessibility Guidelines (UAAG) 2.0, are proposed to assist web developers and users with disabilities by enhancing user agents in the websites, such as text-to-speech support.

3.2 DESIGN METHODOLOGY

WAccess plugin has been designed based on the approach shown in Fig 1, explained below.

WAccess was developed to help determine if web content meets accessibility standards with WCAG 2.2 and 2.1 in consideration.

We focus on WCAG 2.1 and 2.2 which are based on four core principles and 21 guidelines with each guideline having multiple success criteria. The four core principles are as follows:

- **Perceivable:** Users must be able to perceive all relevant information in your content.
- **Operable:** Users must be able to operate the interface successfully.
- **Understandable:** Users must be able to understand the information and operation of the interface.
- **Robust:** Content must be accessible to all users and should be easily interpreted by wider range of user agents.

WAccess considers 7 WCAG 2.2 guidelines, 9 WCAG 2.1 guidelines, which do not require human intervention, as shown in Table 1, to evaluate the accessibility of a website. We integrate the WCAG 2.1 guidelines into 4 classes - (i) *aria-related*, (ii) *color-contrast related*, (iii) *HTML-check related* and (iv) *interaction-related*. These guidelines are reviewed

Guidelines	ID	Description	Level
WCAG 2.2	3.3.7	Accessible Authentication	A
	2.5.7	Dragging Movements	AA
	2.4.11	Focus Appearance (Minimum)	AA
	2.4.12	Focus Appearance (Enhanced)	AAA
	2.4.13	Page Break Navigation	A
	2.5.8	Target Size (Minimum)	AA
	3.2.7	Visible Controls	A
WCAG 2.1	1.3.5	Identify Input Purpose	AA
	1.3.6	Identify Purpose	AAA
	1.4.11	Non-Text Contrast	AA
	1.4.13	Content on Hover or Focus	AA
	2.1.4	Character Key Shortcuts	A
	2.3.3	Animation from Interactions	AAA
	2.5.3	Label in Name	A
	2.5.5	Target Size	AAA
	4.1.3	Status Messages	AA

Table 1. Accessibility Guidelines considered for developing *WAccess*

Guideline	Violations	Number of websites
1.3.5	10009	1471
1.3.6	4574	1060
1.4.11	49591	1799
2.5.3	76378	2053
2.5.5	67054	2100
2.4.11	746137	1882
2.4.12	670884	1723
2.5.7	365519	1791
3.3.7	10410	1404

Table 2. Violations per guideline with number of websites violating each guideline

to identify and sort the best practices required to meet the criteria of all guidelines. Based on the best practices observed, rules are defined to evaluate a web page against the specified criteria. Scripts to check the accessibility of a website based on the rules defined are written using JQuery. Each of these scripts are designed to address one accessibility guideline. A manifest.json file is built to run the all these guideline specific java script files.

4 EVALUATION

WAccess performs accessibility check pointing automatically, we chose all the websites from GOI web directory and performed the analysis. On each website in the evaluation list, *WAccess* evaluates the code violations in HTML markup loaded on the website and sends the violations to a database, that can be exported to various formats such as .json, .csv for further analysis. With *WAccess* we find number of violations conforming to 7 of WCAG 2.2 and 9 of WCAG 2.1 guidelines, and each violation is described with the code snippet causing violation and a possible correction to avoid the violation. *WAccess* is evaluated on 2246 government websites, and a graph highlighting the distribution violations across different guideline is shown in Fig. 4.

Fig. 2. Snapshots depicting results of *WAccess*. [A] depicts the UIDAI website which is evaluated by *WAccess*. [B] highlights the option to be selected to trigger *WAccess*- Accessibility evaluation. [C] shows a list of errors identified by *WAccess* based on the guidelines. [D], [E], [F], [G], [H] and [I] likewise represent violations with respect to different guidelines

Guidelines	1.3.5	1.3.6	1.4.11	2.5.3	2.5.5	2.5.7	3.3.7	2.4.11	2.4.12	Total Violations
Number of Violations	1	15	48	77	118	745	1	2372	1726	5103

Table 3. Violations observed for Commerce Website

Guidelines	1.3.5	1.3.6	1.4.11	2.5.3	2.5.5	2.5.7	3.3.7	2.4.11	2.4.12	Total Violations
Number of Violations	5	22	5	138	58	393	6	2384	2431	5442

Table 4. Violations observed for UIDAI Aadhaar Website

4.1 Guidelines and Violations

In this section, we describe the violations resulted from the study on the chosen government websites. Violations observed for each guideline and number of websites violating each guideline is tabulated in Table 2. We base our observations from the results obtained in Fig. 4, and Table 2. **Guideline 1.3.5** , that is aimed to identify the input

Fig. 3. Snapshots depicting results of *WAccess*. [A] depicts the Commerce website which is evaluated by *WAccess*. [B] highlights the option to be selected to trigger *WAccess*- Accessibility evaluation. [C] shows a list of errors identified by *WAccess* based on the guidelines. [D], [E], [F], [G], [H] and [I] likewise represent violations with respect to different guidelines

purpose, has been violated at least once by 1471 among the 2246 websites chosen, with maximum number of violations observed for a website[11] at 407. **Guideline 1.3.6:** Success criterion of this guideline ensures identifying purpose of user interface components. 1186 websites have not violated this guideline, while it has been violated for a maximum of 55 times among the websites chosen. **Guideline 1.4.11:** The guideline non-text contrast (1.4.11), was violated at least once by 1799 websites, with a maximum at 1224 by any website. Less than 30 violations per website make 73% of the non-zero violations. **Guideline 2.5.3:** More than 90% of the websites failed to meet this guideline. One among the 2246 websites chosen, violated this guideline for a maximum of 1478 times. Maximum number of websites violating this guideline fell in the violation range 10-30. **Guideline 2.5.5:** This guideline requires the controls be large enough to see and touch. Only 6.5% of the websites do not violate this guideline. Maximum of 891 violations were observed for this guideline. **Guideline 2.5.7:** Success criterion of this guideline ensures dragging elements to not limit to single pointer access, almost all the websites (99.3%) found to be violating this guideline. Maximum number of violations

[11] https://www.kdmc.gov.in/RtsPortal/CitizenHome.html

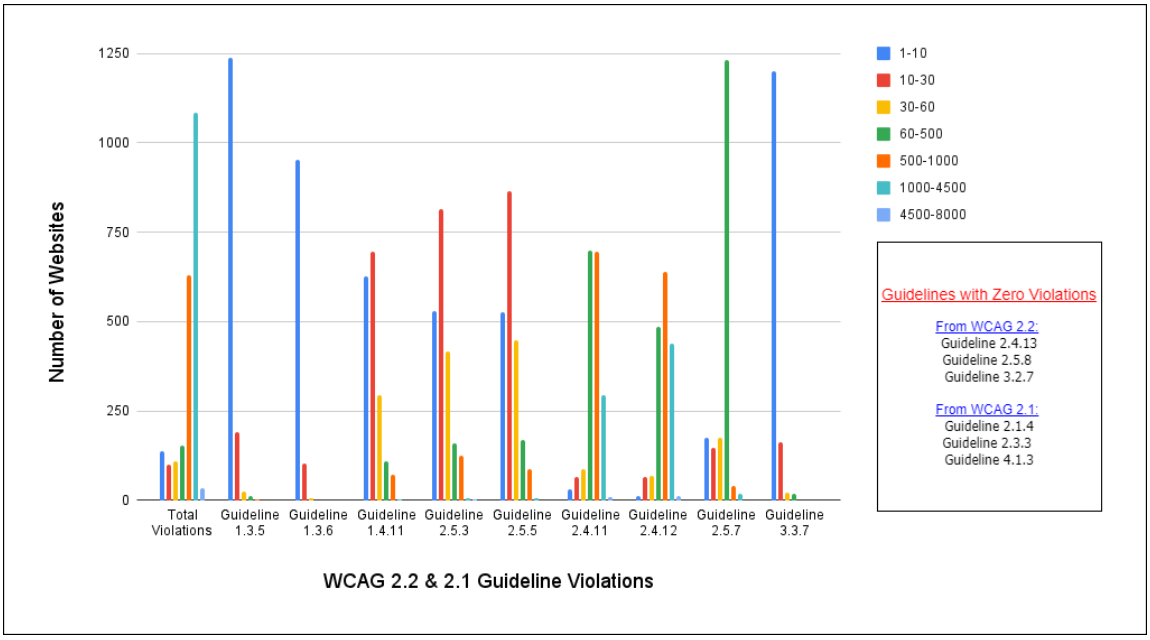

Fig. 4. Results of study of 2246 Indian Government Websites using *WAccess* for 9 WCAG 2.1 guidelines, and 7 WCAG 2.2 guidelines

referring to this guideline were ranged from 100-500, with a maximum violated by any website at 2361. **Guideline 3.3.7:** Nearly, 32% of the websites, found meeting the requirements referring to this guideline. Majority of the websites violated this guideline less than 10 times, with maximum number of violations at 408 for any website. **Guideline 2.4.11:** This guideline focuses on appearance of elements on focus. Almost 83% of the websites violated this guideline at least once. Majority of the websites violated this guideline at least 60 times and at most 500 times. **Guideline 2.4.12:** This guideline also focuses on appearance of elements on focus, however calling for higher level of conformance. Nearly 24% of the websites passed the success criterion for this guideline.

4.2 A brief case study

We demonstrate the usage of *WAccess* by navigating to two Indian government websites, UIDAI (Fig. 2[A]), and Commerce website (Fig. 3[A]). The UIDAI website contains unique identification details of all citizens in the country and is used by billions of Indian population, and the Commerce website contains services and merchandise with respect to latest trade, foreign trade and public sector. To check the accessibility of the plugin, we selected the "Accessibility Test" option from the drop-down menu, as shown in Fig. 2[B] and Fig. 3 [B] , obtained by right-clicking the mouse. Fig. 2[C] and Fig. 3 [C] displays a list of deviations from the accessibility guidelines as errors identified by *WAccess* with respect to the defined guidelines, the code snippet that caused the deviation, and a suggested fix. These errors are presented in different colors as represented in Fig. 2[D], Fig. 2[F] and Fig. 2[H], to differentiate error types among the four classes. We observed that *WAccess* could list out guidelines that are not being followed by a website from 9 WCAG 2.1 and 7 WCAG 2.2 guidelines considered in its design.

4.2.1 UIDAI website. Through *WAccess,* we found 5442 guideline violations on this website. Nearly 88% of the violations attribute to the guidelines 2.4.11 and 2.4.12. About 7.2% of the violations failed to meet the 2.5.7 guideline requirements. Less than 10 violations were observed for the guidelines 1.3.5, 1.4.11 and 3.3.7. With respect to accessibility standards guidelines 2.5.3 and 3.3.7 conform to level A, guidelines 1.3.5, 1.4.11, 2.4.11 and 2.5.7 to level AA, and guidelines 1.3.6, 2.5.5, and 2.4.12 conform to level AAA. Guidelines conforming to conformance level AA, took a significant share in the number of violations (about 51%), while for A, the number of violations were observed to be lesser (only around 2.6%). Guidelines referring to minimum conformance level AAA, formed 46% of the total violations.

4.2.2 Commerce website. Demonstration of using *WAccess* for the commerce website is depicted in Fig. 3. Through *WAccess,* we found 5103 guideline violations on this website. Violations referring to guidelines 2.4.11 and 2.4.12 constitute a share of 75% of the total violations. About 14.5% of the violations failed to meet the 2.5.7 guideline requirements. Only one violation was observed for the guidelines 1.3.5 and 3.3.7. Guidelines conforming to conformance level AA, took a significant share in the number of violations (about 62%), while for the conformance level A, the number of violations were observed to be the least (only around 1.5%). Guidelines referring to minimum conformance level A, formed 36% of the total violations.

5 DISCUSSION

In this paper, we presented *WAccess*, a tool for checking web accessibility, based on WCAG 2.1 and WCAG 2.2 guidelines. *WAccess* evaluates accessibility with respect to 9 WCAG 2.1 and 7 WCAG 2.2 guidelines. Though WCAG 2.1 and WCAG 2.2 comprise more number of guidelines, some of them require human intervention, restricting the scope for automated evaluation of the websites. Hence, only those guidelines which do not require human intervention have been considered in the development of *WAccess*. We have evaluated the usefulness of *WAccess* through a study of 2246 Indian government websites, where accessibility of these websites has been evaluated by *WAccess*. The results of the study indicated 635 websites found to be satisfying all the guidelines. However, this result is based only on the 9 considered guidelines of WCAG 2.1 and 7 of WCAG 2.2. These results might not be valid if all the WCAG 2.1 and WCAG 2.2 guidelines are considered for evaluating the websites.

6 CONCLUSION AND FUTURE WORK

In this paper, we presented *WAccess*, as an open source tool to assess the web accessibility of websites based on WCAG 2.1 and WCAG 2.2 guidelines. Though there are multiple tools available to evaluate websites against WCAG 2.1 guidelines, these tools do not support automated evaluation of large number of websites, and are not open source. Further, there do not exist any tools to check the conformance of a website against WCAG 2.2 guidelines.

WAccess is a browser extension based on a total of 16 WCAG guidelines, 9 from WCAG 2.1 and 7 from WCAG 2.2, and supports large scale accessibility evaluation. We used *WAccess* to automatically detect accessibility violations in 2246 Government of India websites. The results of the evaluation showed the deviations of each website with respect to the 9 WCAG 2.1 and 7 WCAG 2.2 guidelines being considered. These deviations are displayed as errors in each web page's browser-console, along with the code snippet that caused the deviation and a possible fix to rectify the deviation.

WAccess can further be explored to include a broader scope of guidelines by avoiding human intervention through the implementation of advanced techniques in Artificial Intelligence and Machine Learning domains. We also plan to enhance the existing version of *WAccess* by improving the user interface of the tool and by employing better technologies for the development of the tool. *WAccess* currently suggests fixes to the webpage based on the violations against WCAG

2.1 and WCAG 2.2 guidelines. It can be further improved to support automated or semi-automated refactoring of the websites during website development, thus, consequently helping web developers in abiding by the accessibility guidelines, towards making the websites accessible to everyone. Other forms of *WAccess* tool, such as open API, webpage, and so on, can also be developed to support a broader range of audience, and a wider range of studies, aimed to analyze the accessibility of websites. *WAccess* can also be extended to support other domain-specific accessibility guidelines, such as GIGW, a set of guidelines for government websites in the Indian context.

ACKNOWLEDGMENTS

We thank our under graduate students, Krishnendu Sudheesh and Nikhil for helping us with a part of the development of *WAccess*

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