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Accessibility of Indian universities' homepages: An exploratory study

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Abstract Websites have evolved into an excellent medium of information dissemination and visibility. Hence governments and organizations around the world have websites as primary medium for information communication. The universal accessibility of this web medium remains a major challenge for both web developers and accessibility researchers. Conformance of WCAG 2.0 guidelines by web pages is a significant factor in measuring universal accessibility. This paper presents an exploratory study about the accessibility of Indian university website homepages. We have analyzed the homepages of 302 Indian universities under different conformance levels of WCAG 2.0 recommendation using automatic accessibility evaluation tools to find accessibility report of websites and then classified them comparatively into three groups namely low accessible websites called Tier-III, medium accessible websites called Tier-II and high accessible websites called Tier-I. Statistical classification and accessibility report of websites shows that an array of further improvements have to be made in order to make them more accessible and usable in terms of WCAG 2.0. Based on the results of the analysis, this paper proposes the necessary steps which shall be taken to further enhance the accessibility of the websites.

1. Introduction

In the last 15 years (2000–2015), internet user base has undergone a phenomenal increase from 361 million users in the year 2000 to the present value which is greater than 3270 million.[1] In 2015, Asia's internet users are 47.8% and rest of world is 52.2%. As the web has become the primary information access resource, the web accessibility has evolved into a critical issue in the present scenario. Web accessibility is the measure of ease and comfort with which, a person with disability would be able to access the web resources similar to the manner a typical user would access. In addition to persons with disabilities, the special needs of elderly persons while accessing the information is also under the purview of web accessibility. The accessibility can be measured in three layers according to levels of conformance of *WCAG 2.0 (Web Content Accessibility Guidelines)* as fully accessible, partially accessible, and inaccessible one. When the contents are easily accessible to users regardless of disability then website is said to be accessible.

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[1] Internetworldstats [WWW Document], 2015. URL http://www.internetworldstats.com.

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Access by everyone is an essential aspect and the power of web is in its universality.[2] According to W3C, the designers should take into consideration all different types of disabilities like Visual disabilities, Audio Disabilities, Speech, Cognitive and Learning disabilities, etc. when designing and building websites.[3] Also, according to W3C, *the web is fundamentally designed to work for all people, whatever their hardware, software, language, culture, location or physical or mental ability* and the element which is critical for the World Wide Web is Accessibility.[4]

The main motive of e-Accessibility Toolkit for Policy Makers is to measure the accessibility of product or service which are used by persons with disabilities as effectively as used by persons without those disabilities. People with different disabilities have different needs for accessing a technology so accessibility guidelines or standards have been formulated for different technologies to ensure the product or service is accessible to all persons in one or other.

The WCAG 2.0 standard formulated by the World Wide Web Consortium (W3C) is the universally adopted standard for designing or making websites that are fully accessible (Olalere and Lazar, 2011). Hence Governments (Patr et al., 2014) around the World have formulated their customized accessibility policies on this standard. The fundamental accessibility principles – POUR of WCAG 2.0 are as given below:

- **Principle 1:** All content, including text information, multimedia, video and audio must be presented to users in a way they can perceive easily *(Perceivable)*.
- **Principle 2:** The components of user interface and navigation must be operable *(Operable)*.
- **Principle 3:** User interface information and operation must be understandable *(Understandable)*.
- **Principle 4:** Enable contents which are to be interpreted reliably by a wide variety of user agents including assistive technologies, must be robust*(Robustness)*.

The conformance levels which are used by WAI Guidelines for assigning priority based mechanism for measurement of website are given below:

- **Priority 1:** Conformance to this priority level is described as *A* level conformance. In this priority, the guidelines of WCAG 2.0 must be satisfied by web developers, otherwise it will be impossible for one or more groups to access the web content easily.
- **Priority 2:** Conformance to this priority level is described as *AA* level conformance. In this priority, the guidelines of WCAG 2.0 should be satisfied by web developers, otherwise some groups will find it difficult to access the web content.
- **Priority 3:** Conformance to this priority level is described as *AAA* level conformance. In this priority, the guidelines of WCAG 2.0 may be satisfied by web developers in order to make it easier for specialized groups to access the web content.

The accessibility of web pages is one of the important criteria for disseminating information to a wider group of audience. This paper focuses on measuring the accessibility of *Homepages of Indian Universities*. The university web sites serve as the primary information source for both the aspiring candidates who want to join or the existing students to better harness the resources hosted in the University web page. With the phenomenal increase in adaptability of digital medium for information delivery in countries like India, measuring of accessibility is mandatory, as it provides key insights for improving it further.

Another key aspect of performing the accessibility study is that a number of people who get benefited by such an effort is very significant. According to the United Nations report, there are around 1 Billion persons with disabilities which is 15% of the world population. In order to create an inclusive ambience, the requirements of these persons in accessing information resources on the digital ecosystem needs to be given higher priority. This study is a step towards achieving such a goal.

2. Motivations

The products and environments which are designed for all categories of people should be usable and accessible is the main aim of Universal Design. When we use universal design strategies to web interfaces, most of the persons with disabilities who already use web feel better and easier in accessing the contents of web than before (Laux, 1998). So, for achieving better accessibility of web pages we have to follow universal design standards completely. Web accessibility means that *anyone using any kind of web browsing technology must be able to visit any site and get a full and complete understanding of the information as well as have the full and complete ability to interact with the site if that is necessary* (Chisholm et al., 2001). Keeping track of the accessibility level of pages and the need of accurate methods and tools for measurement of accessibility is the main aim of International accessibility observatories like *European Internet Accessibility Observatory (EIAO)*, *Vamola project in Italy*.

Various studies have been conducted on analyzing specific group of websites across a spectrum. When analyzed, state level websites of Maryland by Lazar et al. (2013), it was found that there was tremendous a need for longitudinal studies of state level website accessibility and then the role of the web page template which was introduced in Maryland state government web pages and the template has been performed background check for accessibility and the result showed an improvement in accessibility and often a tremendous one (Lazar et al., 2013). An exploratory study on accessibility of Chinese local government websites were examined to find how much they are accessible in terms of WCAG 2.0 and it has identified many accessibility issues for persons with disabilities. Recommendations were also provided to improve the accessibility levels (Shi, 2007).

The Spanish University websites were analyzed and evaluated to check the validity of websites in terms of web

[2] W3C, http://www.w3.org W3C Home Page News Archive, 1997. [Online]. Available: http://www.w3.org W3C Home Page News Archive.

[3] W3C, W3C, 2008.Web Content Accessibility Guidelines (WCAG) 2.0. Retrieved June 13, 2012,from. http://www.w3.org/TR/WCAG, 2008.

[4] W3C, W3C, 2010. Accessibility W3C. Retrieved June 12, 2012, from. http://www.w3.org/standards/webdesign/accessibility, 2010. [Online]. Available: W3C, 2010. Accessibility W3C. Retrieved June 12,http://www.w3.org/standards/webdesign/accessibility.

assessment index which focused on four categories: Accessibility, speed, navigability and content. The results of this analysis of Spanish University sites have demonstrated the high flexibility of the WAI and detected the main weaknesses of the sites assessed (Buenadicha Mateos et al., 2001). Several evaluation techniques and methods are used in Alabama and federal government websites to improve their accessibility to a significant level and to establish a baseline for monitoring the progress of websites of Alabama on online accessibility (Potter, 2002).

Many universities also lacked public accessibility policies (Bohman, 2003) and also unclear features and incomplete policies. Several other researchers (Hackett et al., 2004; Yu and Parmanto, 2011; Hanson and Richards, 2013) have found that government websites perform better web accessibility than many commercial websites which means that despite the growing complexity of websites, accessibility has been improved in government websites in overall score than others. Still it is found that the web accessibility remains an issue in Alabama state websites and the presence of a standard does not correlate with compliance and web accessibility may not have been improved since Potter's analysis (West, 2008). Researchers (Harper and DeWaters, 2008) have also worked in measuring accessibility of e-government websites and their complexities and have reported improvements in accessibility dimension. The study conducted by Harper and DeWaters (2008), also raised awareness about issues of access in higher education using exemplary model to evaluate the accessibility of their institution's website homepage and to achieve greater website accessibility for all constituents by emulating this exemplary model to evaluate the overall accessibility of their university homepages.

Website accessibility is the major problem in the corporate sector web pages as well. A study on state webpages of Albama and Federal Government sites (Youngblood and Mackiewicz, 2012) reveals that substantial problems with municipal websites of Alabama, usability including accessibility and there is no correlation between government websites of Alabama and corporate sites, and state Albama and Federal Government sites often outperform commercial sites when it comes to accessibility (Youngblood, 2014).

Multi-method analysis of the homepages of top 100 international universities was used for analyzing the accessibility standards and its conformance levels, image accessibility, alternative languages and text-only content, quality of web accessibility statements (Kane et al., 2007). Also, the results showed that many top universities continue to have accessibility problems and also found that many sites lack clear web accessibility statements and documentation (Kane et al., 2007).

An evaluation of the accessibility of top ranking university websites in terms of accessibility rates from 2005 to 2015 was evaluated using the AChecker – accessibility evaluation tool. This recent study was conducted by researchers from Princess Nora and Griffith University respectively (Tahani and Steve, 2016).

Web accessibility of 20 public university websites in Malaysia using *AChecker and WAVE* accessibility tools based on WCAG 2.0 and Section 508 guidelines was carried out and the result showed some improvements in terms of accessibility than the previous study. Although there are some improvements, certain measures must be considered to ensure better compliance to the web accessibility standards and guidelines by the public universities of Malaysia (Ahmi and Mohamad, 2015).

Improvements in academic library website accessibility for persons with disabilities of Edith Cowan University, aiming for Web content accessibility guidelines 2.0 (WCAG 2.0) level AA were also carried out by researchers (Billingham, 2014).

Evaluation report of university websites of Turkey in terms of their usability test for visually impaired users was also performed and it was found that final examination dates on the academic calendar posed major difficulties and accessing the course schedule webpage required most time and it was concluded that the need for a search engine on each page, text version for all pages, rearrangement of web link sequences with tabs and also provide more information about visuals and the suggestions of visually improved students offered (Menzi-Çetin et al., 2015). Also, the study worked on the top USA Universities to check their website usability and content accessibility of websites using two automatic evaluation tools *Bobby and LIFT* and the result showed that a low compliance with WCAG standard and a low usability rating for most of the university websites (Zaphiris and Ellis, 2001). Kaur and Dani (2014) has conducted studies in Accessibility under WCAG 2.0 to find some common errors among websites.

To enhance interaction between Government and people, and to improve the quality of services through electronic media, the guidelines for web accessibility is formulated by National Informatics Centre (NIC), India.[5] Dynamic content, heavy graphical user interfaces, complicated navigation structures are the major hurdles in making the web more accessible. Due to different considerations and to overcome existing barriers, we have to rethink of accessibility more as a philosophical change than a technological contribution (Ballesteros et al., 2015).

It is found that the accessibility and usability are highly related and the respondents also think that accessibility is applicable to everyone and not just people with disabilities. More than just inspecting the source code for accessibility evaluation, it is important that accessibility must be grounded on User-centered practices, so these perceptions are important for usability, developers of evaluation tools, UX professionals and website evaluation practitioners. The progress and position of a country in terms of accessibility is also explored by research studies and its importance is highlighted (Yesilada et al., 2015).

This paper focuses on the accessibility evaluation of Indian University homepages. In a fast growing country like India with its focus on digital technologies, accessibility gets furthermore importance to achieve inclusive service delivery. This study has focused on University websites which function as sources of important information delivery and whose accessibility needs to be considered with paramount importance.

3. Research questions

Evaluation of Indian university websites for persons with disabilities in terms of their accessibility is the main objective of this study. This study is based on the fundamental principle that if you want to improve certain things, first it has to be

[5] "Accessibility of Government Websites in India: A Report," 2012. http://cis-india.org/accessibility/accessibility-of-govt-websites.pdf.

measured. The measurement of web accessibility of Indian university websites has been presented in this paper. The overall research objectives of this study are as listed below:

- To find the current status of university homepages in terms of their web accessibility under different accessibility evaluation tools.
- To classify these university homepages into three categories based on levels of conformance of accessibility checkpoints.
- To find the common web accessibility problems among university websites.
- To provide alternate solutions to solve these accessibility problems.
- To provide feedback regarding how to make websites more accessible in terms of WCAG 2.0.

4. Methods used for collection of data and its analysis

For the purpose of this study, the URLs of university web pages were collected from *University Grants Commission (UGC)* web site. For the purpose of extracting the URLs from the aforementioned web page, a web scrapping tool named *import.io* was used. The urls were classified as per the state in which they were located. The website home pages were analyzed with various evaluation tools such as AChecker,[6] webpage Analyzer[7] and WAVE.[8]

The accessibility of an individual web page shall be measured simply by supplying the url of the concerned web page in any of the aforementioned evaluation tools. A screenshot of accessibility evaluation using *AChecker* is as shown in Fig. 1.

The initial evaluation of websites shall be carried out with automatic evaluation tools followed by manual assessment. The AChecker is an open source web accessibility evaluation tool which provides us many options of international accessibility guidelines to check and provide accessibility report of websites.[9] The different options for accessibility report of webpages in AChecker were available but the current work about accessibility was based on WCAG 2.0 under all conformance levels and was conducted during the time period from *October 2015 to February 2016*. We found various problems such as *potential problems, known problems, likely problems* in the websites of Indian universities under different levels of conformance.

Another web accessibility evaluation tool called *WAVE*[10] was used for central universities of India to check different types of errors like *Simple Errors, Alerts, Features, Structural Elements, HTML 5 and ARIA errors and Contrast Errors*. Some problems were not identified by automated tools, so manual evaluation testing was needed to solve them that is, to make decisions on some potential problems human intervention would be required. For example, human decision was required to determine whether linked text describes the purpose of a link or textual description of an image correctly or not. In addition to these tools, many pages were needed to be navigated with a keyboard or with special assistive technologies like a screen reader.

To evaluate the websites two datasets have been built. The first dataset comprised of the errors identified by the accessibility evaluation tool *AChecker* and the second dataset is the evaluation data from *WAVE* tool. The analysis of both these results were presented in this paper. We visited 302 Indian university websites and their overall report under different levels of Conformance WCAG 2.0 is provided in Table 1. Each level of conformance has three different problems and their report are in Table 2. Overall summary and Average value of these 302 Indian university websites are given in Tables 3 and 4 respectively. Also, we provide the classification of these universities in terms of web accessibility report by *AChecker* into three groups based on computation of average value as shown in (1):

$$\sigma = \frac{\sum_{i=1}^{N} |\alpha(P_i)|}{N} \tag{1}$$

In (1), $|\alpha(P_i)|$ indicates the number of barriers exposed by page N and indicates the total number of universities analyzed. Using the computed value of σ, a median range is derived as shown in (2).

$$\rho = \sigma \pm \lambda \tag{2}$$

In (2), λ indicates the offset value used to derive the median range ρ. The value for λ is computed as shown in (3).

$$\lambda = 0.25 \times \sigma \tag{3}$$

With respect to our experiments, the respective values for average σ, median range ρ and offset value λ are computed by substituting observed values in the aforementioned equations. The value of σ is computed as shown in (4).

$$\sigma = \frac{\sum_{i=1}^{N} |\alpha(P_i)|}{N} \tag{4}$$

here, value of $\sum_{i=1}^{N} |\alpha(P_i)| = 375989$ and $N = 302$

Therefore, Value of $\sigma = 375989 \div 302 = 1244.996$

The offset value is computed as shown in (5).

$$\lambda = 0.25 \times \sigma \tag{5}$$

$$\lambda = 0.25 \times 1244.996 = 311.249$$

The median range ρ is derived with values of σ and λ, as shown in (6).

$$\rho = \sigma \pm \lambda \tag{6}$$

$$\rho = 1244.996 \pm 311.249 = \langle 933.74 \ldots 1556.24 \rangle$$

On the basis of aforementioned parameters, the classification of university websites was made into three different Tiers as shown in Table 7 and their graphical representation in terms of percentage ratio of accessibility is shown in Fig. 8. Also, the web page accessibility evaluation report of central university websites was performed by *WAVE* tool is shown in Fig. 9.

5. Results

Using the aforementioned evaluation techniques, the accessibility data from the homepages of 302 Universities (Central

[6] AChecker, http://achecker.ca/, 2015. [Online]. Available: http://achecker.ca/. [Accessed: 14-Feb-2016].
[7] websiteAnalyzer, web page analyzer, 2015. [Online]. Available: http://www.websiteoptimization.com/.
[8] WAVE, Web evalaution tool, 2016. [Online]. Available: http://wave.webaim.org/. [Accessed: 01-jan-2016].
[9] AChecker, http://achecker.ca/, 2015. [Online]. Available: http://achecker.ca/. [Accessed: 14-Feb-2016].
[10] WAVE, Web evaluation tool, 2016. [Online]. Available: http://wave.webaim.org/. [Accessed: 01-jan-2016]

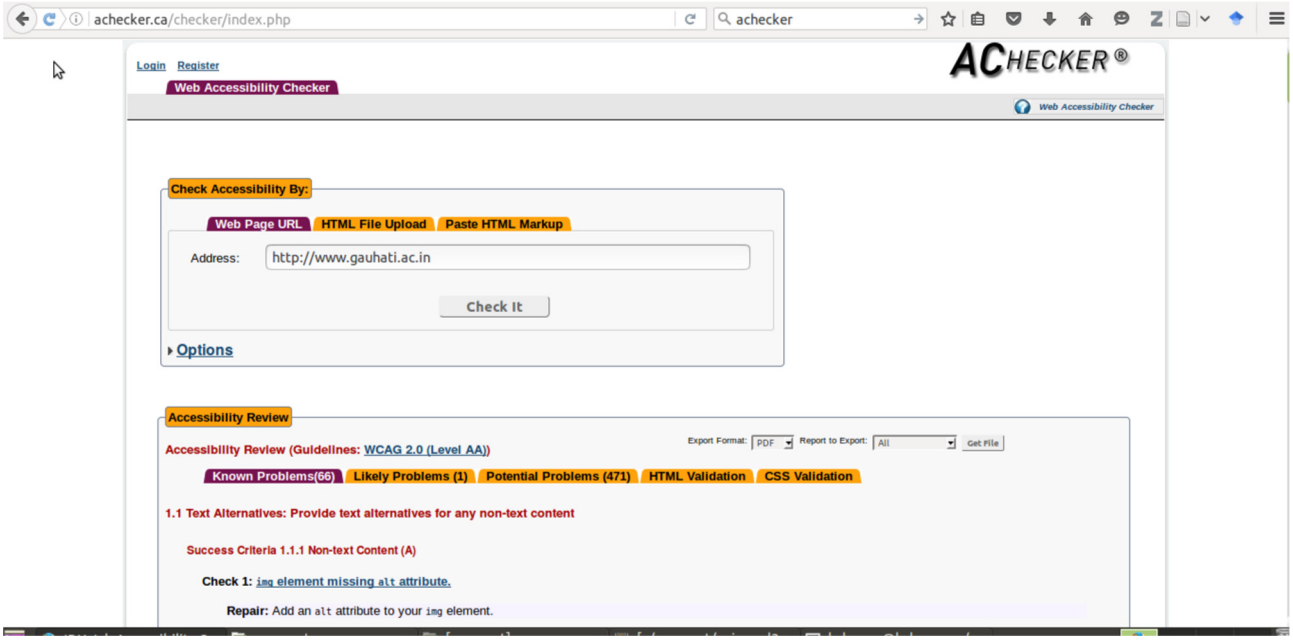

Fig. 1 Screenshot of AChecker.

Table 1 Number of problems under different levels of conformance by AChecker.

Number of websites visited	Level 'A' problems	Level 'AA' problems	Level 'AAA' problems
302 (central & state universities)	111277	131338	133374

Table 2 Level wise problems of WCAG 2.0 by AChecker.

WCAG 2.0. Levels	Known problems (1)	Likely problems (2)	Potential problems (3)
Level A	11314	688	99275
Level AA	26101	688	104549
Level AAA	23289	351	109734

Table 3 Universities total problems and their classification by AChecker.

No. of websites	Total No. of problems	Known problems	Likely problems	Potential problems
302	375989	60704	1727	313558

as well as State universities) of India were collected October 2015 to February 2016. These university homepages were analyzed under different techniques of Accessibility to check their problems and generate report according to WCAG 2.0 standard and classified them into three groups according to their performance report.

Overall report about accessibility problems of Indian university websites under different levels of conformance of WCAG 2.0 are shown in Table 1.

The AChecker report of different problems under different levels of WCAG 2.0 are as given under Table 2.

Overall summary of Indian university homepage errors in terms of web accessibility by AChecker are as given under Table 3.

Average Accessibility problem report of Indian University Websites under WCAG 2.0 by AChecker as shown in Table 4. The comparison of Known, Likely and Potential errors across three levels of conformance Level A, Level AA and Level AAA of WCAG 2.0 are as shown in Figs. 2–4 respectively.

Overall Graphical representation of Accessibility report of Indian University homepages by AChecker under all levels of Conformance of WCAG 2.0 as shown in Fig. 5. This Fig. 5 also indicates a statistical comparison among all levels of WCAG 2.0 and by their type of problems fall in each level of conformance.

The average report of errors or problems of all levels of WCAG 2.0 by *AChecker* evaluation tool for 302 state as well as central Government university website homepages under each level type of problem is shown in Fig. 6.

The summary of web Accessibility problems which were collected from October 2015 to February 2016 using web accessibility evaluation tools under all Levels Of Conformance of WCAG 2.0 of 302 Indian state and central government university homepages is represented by a Parallel Coordinate chart as shown in Fig. 7.

Some common errors found in university websites under different checkpoints and priority levels of WCAG standard are shown in Table 5. The Table 5 shows the major errors in university webpages which should be reduced or minimized so that we can achieve the goal of accessibility for all.

The descriptive Statistics of Central Universities of India in terms of their accessibility checkpoint errors under level AA of WCAG 2.0 with principles as shown in Table 6.

The classification of three groups of university websites was based on calculated average value of problems identified by

Table 4 Average error report of conformance levels under their types by AChecker.

WCAG 2.0 levels	Level 'A'			Level 'AA'			Level 'AAA'		
Types of problems	Known (1)	Likely (2)	Potential (3)	Known (4)	Likely (5)	Potential (6)	Known (7)	Likely (8)	Potential (9)
Average	37.464	2.278	328.73	86.427	2.278	346.19	77.116	1.162	363.36

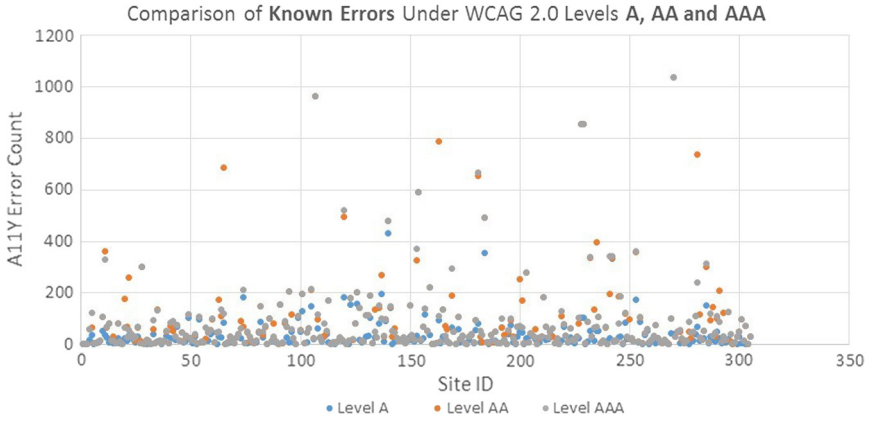

Fig. 2 Comparison of Known Errors.

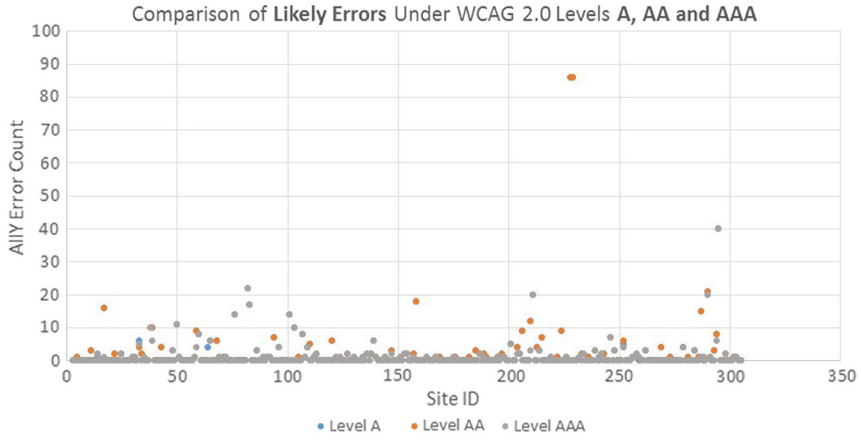

Fig. 3 Comparison of Likely Errors.

AChecker as Tier-I, Tier-II and Tier-III. The Tier-I group sites fall below the median range which means they are comparatively high accessible websites than other two group websites. Tier-II group sites fall in the median range which means they are comparatively less accessible websites than Tier-I websites and comparatively high accessible websites than third group websites. Tier-III group sites fall above the median range which means they are comparatively less accessible websites than Tier-I and Tier-II websites. This classification was purely on a relative measure for easier comprehension and analysis. So, the classification or grouping of University websites is shown in Table 7 and their percentage ratio of accessibility in terms of comparison between them is shown in Fig. 8.

The web accessibility evaluation tool (called WAVE) report of central universities of India showed how much the central university homepages were accessible and also provides the report of different types of errors which occurred among the websites because of violation of WCAG standard rules. The overall summary report of WAVE tool is shown in Fig. 9.

5.1. Readability analysis

Readability is also an important component in evaluating accessibility of a web page. The readability shall be measured using various metrics. The metrics which has been adopted to measure the *readability score* of Indian University Homepages in our experiments is *Gunning Fog Index* (Gunning, 1969). The Gunning Fog index estimates the total number of years of education required to understand the text.

The Gunning Fog index was computed with a Python script which extracted text from web page and derived the readability score. For the dataset considered in this paper, the mean *Gunning Fog* score was computed as 13.22 which in the original scale refers to *College freshman* by grade. As the dataset consisted of University homepages, the target users are mostly

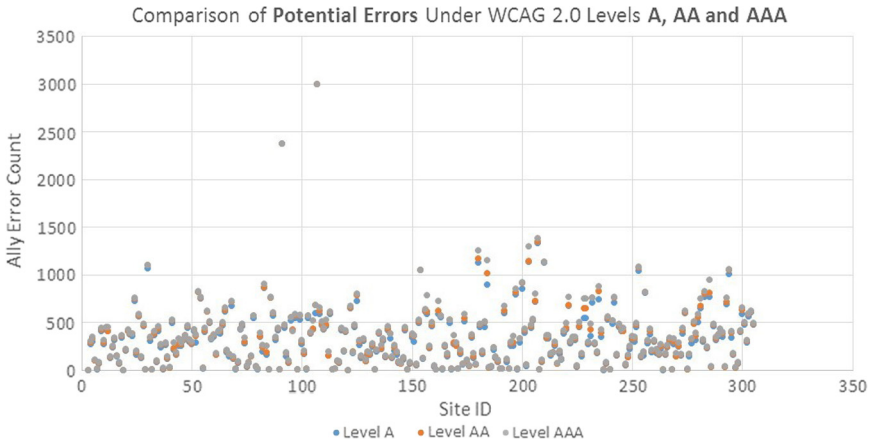

Fig. 4 Comparison of Potential Errors.

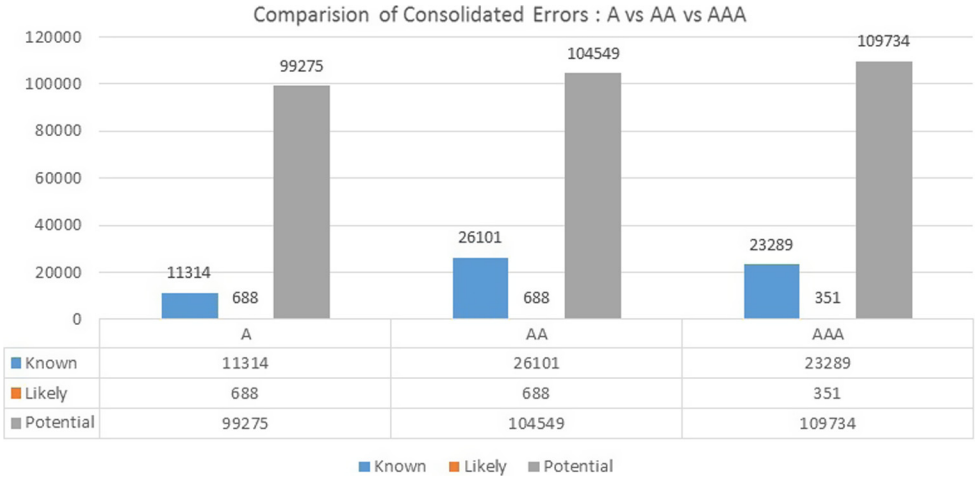

Fig. 5 Consolidated Error comparisons under each level of Conformance of WCAG 2.0.

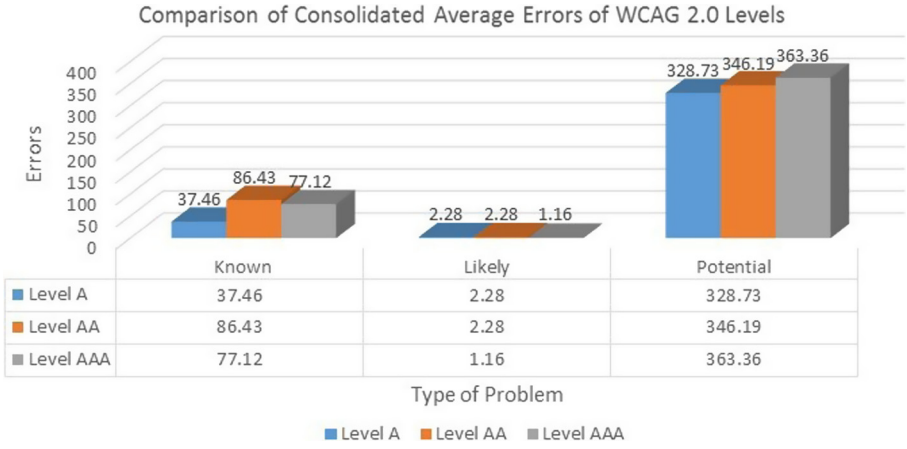

Fig. 6 WCAG 2.0 Consolidated Average Error comparison representation of web accessibility problems of university homepages.

the pass outs of undergraduate programs and hence the readability shall be treated as *acceptable*. However, it shall also be noted that, if efforts are made to reduce this score further then the contents shall be understood by a broader group of users.

6. Comparative analysis

Analysis of website accessibility is an active field of research. Studies have been conducted across the globe over the years

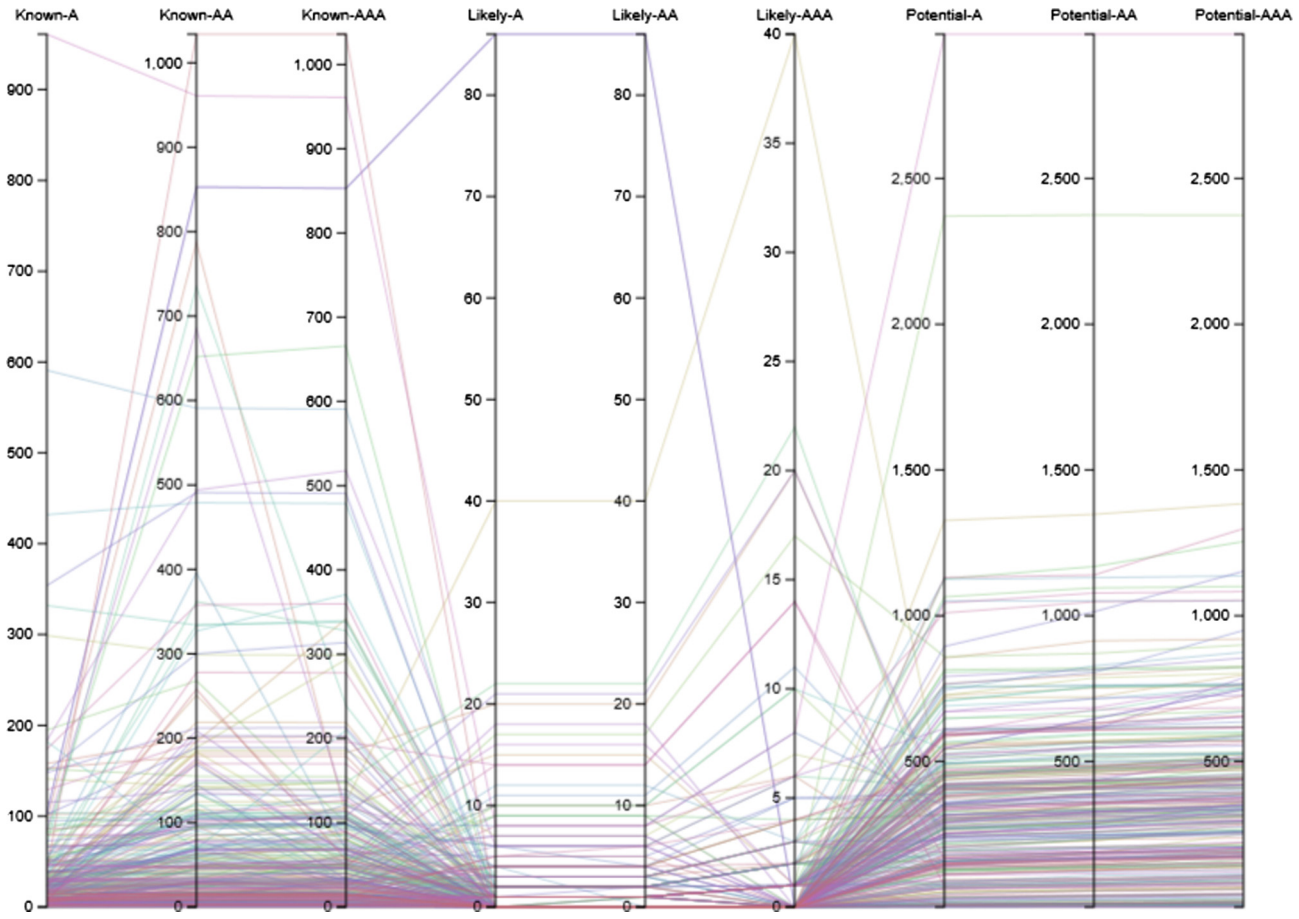

Fig. 7 Parallel Coordinate chart – summary report of accessibility problems of Indian University Homepages Under WCAG 2.0 guidelines.

Table 5 Some checkpoints of WCAG 2.0 and their common errors in homepages of university websites.

Checkpoints	Errors
1.1	Provide a text equivalent for every non-text element
1.1.1	Non text content (P)
1.3.1	Info and relationship, (P)
1.3.3	Sensory characteristics
1.4.1	Use of color
2.2	Provide users enough time to read and use content
2.3.1	Three flashes or below threshold
2.4.1	Bypass blocks
2.4.4	Link purpose in context (O)
3.1.1	Language of a page (U)
3.2.1	On focus
3.2.3	Consistent navigation
3.3.2	Labels or instructions
3.4	Use relative rather than absolute units in mark-up language attribute values and style sheet property values
3.5	Use header elements to convey documents structure and use them according to specification
4.1.1	Parsing (R)
4.1.2	Name, role, value (R)
4.3	Identify the primary natural language of a document

for measuring accessibility of online content to persons with disabilities.

In this section, a comparative analysis is performed with three of the existing note-worthy studies that are listed as follows:

- A study conducted to measure accessibility of Top 100 global University web pages (Kane et al., 2007).
- A study that performed the accessibility analysis of 20 Malaysian Universities (Ahmi and Mohamad, 2015).
- A recent longitudinal study which has analyzed the accessibility of a global set of universities (Tahani and Steve, 2016).

These three studies are chosen for comparison as their objective is in alignment with the study presented in this paper. The comparative analysis is presented in Table 8 which compares the results of these studies, using ten different factors.

The dataset for Indian University home page accessibility study incorporates 302 state and 42 central universities. The longitudinal study on global universities analyzed 180 pages of 60 universities (Tahani and Steve, 2016). The Malaysian university analysis study involved 20 universities (Ahmi and Mohamad, 2015) and the study by Kane et al., covered Top 100 global universities (Kane et al., 2007).

Table 6 Descriptive statistics of WCAG 2.0. level AA of central university homepages.

Level AA error type	Total errors	Percentage	Minimum	Maximum	Mean	Std. deviation
Known	1332	9.691	0	186	42.97	6.555
Likely	62	0.451	0	17	2	1.414
Potential	12350	89.857	7	1020	398.387	19.960
Perceivable (P)	4139	30.115	0	213	133.516	11.555
Operable (O)	9179	66.786	0	903	296.097	17.207
Understandable (U)	414	3.012	0	33	13.355	3.654
Robust (R)	12	0.087	0	1	0.387	0.622

Table 7 Three Tier classification of university websites based on average problems found in their homepages by AChecker in terms of WCAG 2.0 guidelines.

Tier-I websites (below median range)	Tier-II websites (median range)	Tier-III websites (above median range)
124 websites (41.059%)	98 websites (32.450%)	80 websites (26.490%)

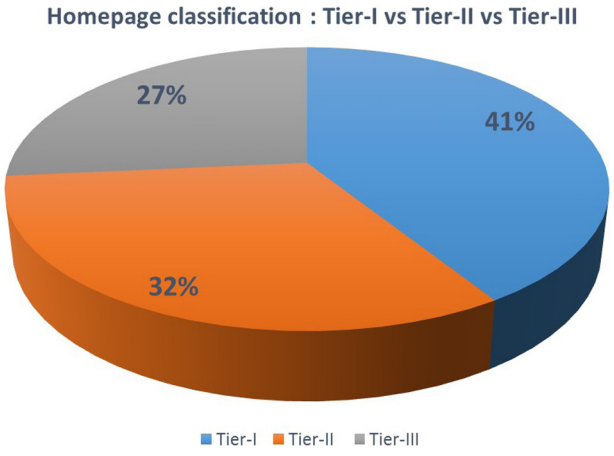

Fig. 8 Percentage ratio of three tier classification of Indian university websites (Central and State) in terms of web accessibility report.

All the four studies have adopted WCAG standards in their analysis. *AChecker* was observed to be a major tool used by many accessibility studies. With respect to the number of accessibility errors, the Indian university home pages have shown comparatively a large number of errors. This serves as a critical indicator for taking necessary actions without further delay to make these pages more inclusive. In Top 100 University study and Malaysian University study, two web sites were observed with zero accessibility errors, at the time when the studies were conducted. With the results of the present study, we were unable to identify any website with zero accessibility error. Making the sites to reach this goal shall be set as a priority task, to make these pages barrier free for persons with disabilities.

Our study included language readability measure in the accessibility evaluation process. We were not able to locate any readability analysis in the other three studies. The Gunning Fog index for the pages in our study was observed as *13.22*. Though this value shall be treated as *acceptable*, measures need to be taken to increase the readability score (reduce the Gunning Fog index value) so that the contents shall be easily understandable by a broader group of audience.

7. Discussions

Based on our study and findings the following recommendations are made with respect to the design of university homepages. These recommendations are inline with the repeated errors that were observed during the accessibility analysis.

1. Text alternatives should be provided for all non-text web content.
2. Headers to be included for each page, section and table.
3. There should be a supported mechanism for controlling color contrast and all keyboard functionalities.
4. All the forms must be well structured and interactive.
5. Adjustment of contrast and brightness should be granted to users.
6. Allow the users to adjust all speech characteristics provided by the speech synthesizer.
7. Resizing and repositioning of media in videos should be allowed by media players.

Developers and designers should focus on key points to achieve web accessibility in a better way and also update the evaluation tools to more advanced to overcome the current problems which we face during analysis of data. That is, some websites showed timeout problems and some gave zero error report sometimes. Due to these types of problems we were not able to collect data from such homepages. So for further research we have to find the solution and causes for these known and unknown problems and then optimize these evaluation tools.

Also, this study can help the web administrators of these sites in enhancing the accessibility of their sites to persons with disabilities. To measure the accessibility of websites using an automatic website evaluation accessibility tools and techniques is easy and convenient way, Chen et al. (2013) but the error severity among the same checkpoints cannot be differentiated by these automatic tools. Also, all the guidelines of WCAG 2.0 were not checked by these tools and some need human judgement also. The webpages or websites analyzed may be changeable also should be taken into consideration. Thus, the results between October 2015 and February 2016 carried out in this study reflect the status of the websites of central and state university homepages projects the outcome of automatic evaluation carried out during the specified period.

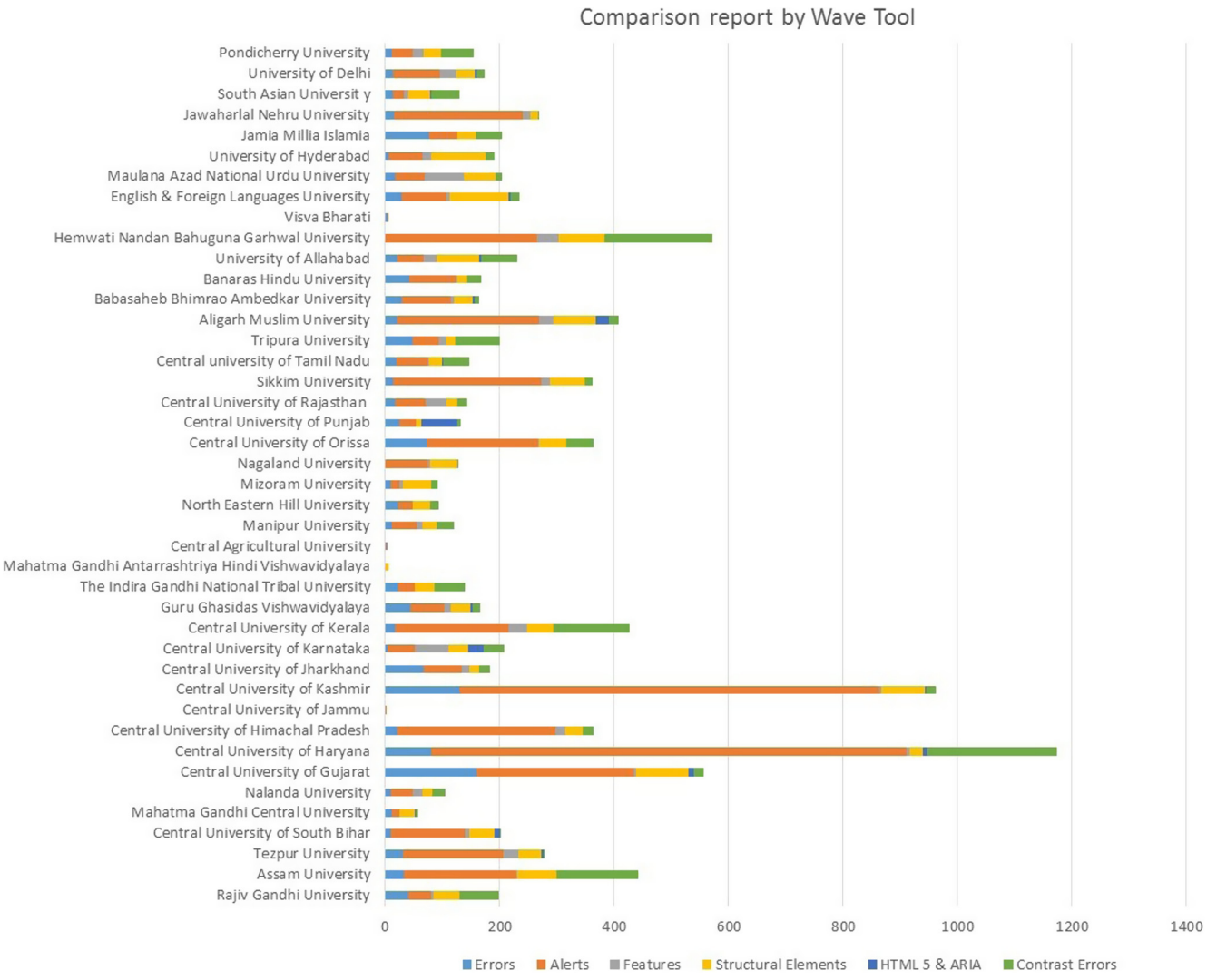

Fig. 9 Comparison report about central university homepages using WAVE tool.

Table 8 Comparative analysis.

Features/study	Kane et al.	Ahmi and Mohamad	Tahani and Steve	This study
Data Set	Top 100 Univ	Malaysian Univ	Global Univ	Indian Univ
Count	100	20	60 Univ (180 Pages)	State: 302; Central: 42
Standards applied	WCAG 1.0	WCAG 2.0	WCAG 2.0	WCAG 2.0
Evaluation tool	Bobby and Cynthia says	AChecker, WAVE	AChecker	AChecker, WAVE
Total error count	937	14935	82685	375989
Known errors	NA	351	1169	60704
Likely errors	NA	19	42	1727
Potential errors	NA	1465	7033	313558
Univ with zero errors	2	2	0	0
Readability test	No	No	No	Gunning Fog: 13.22

8. Conclusions and future directions

With the results of the study, it was observed 73% of the homepages falls either under Tier I or Tier II category which indicates greater scope for improvements. The inferred findings indicate that each website has its own strengths and weaknesses that can be capitalized on for conforming with guidelines for better design of websites. The result of this study provide administrators, summarized results in terms of problems and then decide how much their websites are

accessible. With the identification of frequently reoccurring accessibility errors, alternate solutions shall be derived to solve them easily.

The future directions for the research includes the following:

- Incorporation of sub directory level pages would provide a detailed view regarding the specific accessibility issues posed by those pages.
- Strengthening of accessibility report shall be carried out by including manual assessments as well for specific accessibility checkpoints. This would incorporate the specific accessibility components such as language understanding.
- Application of machine learning techniques shall be explored in classification of web pages in terms of accessibility barriers.

Awareness program about accessibility standards and their implementations should be performed among developers and designers to train them how to develop, maintain and update websites in terms of accessibility principles.

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