Enhancing the Accessibility of Images on the Web: A Holistic View and New Perspectives

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Abstract— None of the available web specifications consider images as purely visual elements. However, their online accessibility remains challenging. This issue has taken on an entirely new dimension with the evolution of mobile technology. Nowadays, most Internet users use mobile phones equipped with an increasing number of cameras. Obviously, this has helped democratize access to the web. However, it has made images the major medium of communication, and thus it has increased the challenge of image accessibility for people with disabilities. In light of the above, we present a holistic view of the accessibility of images for use on the internet. Precisely, we seek to provide an overview of the various accessibility strategies while highlighting an implementation gap that research has attempted to address. In addition, we discuss new research perspectives that can lead to the design of a new alternative to the image. Soon, it may be possible to supplement the ALT text with non-speech sound alternatives or even tactile alternatives.

Keywords— Web accessibility, image accessibility, people with disabilities, user experience (UX).

I. INTRODUCTION

Nomadic technologies have evolved considerably in recent years. They all contain built-in image acquisition devices. Nearly no laptop is designed these days without a built-in webcam. Most tablets have two cameras, and smartphones on the market have up to four camera modules. With the increasingly widespread use of these connected communication devices, the use of images as a medium for disseminating information has gained increasing popularity. Soon, more and more images with limited accessibility will be shared in cyberspace, where this poses challenges. Moreover, most users are unaware of the attendant problems. An image that provides sighted users with useful information can be a hindrance for visually impaired people when accessing information online. Similarly, people with certain cognitive disabilities [15], [24] or those with autism spectrum disorders may find it difficult to understand the content of an image. These populations seem to be in the most dire need of adapted interactions. In this context, Barreto and Hollier (2019) presented an in-depth examination of visual disabilities as well as strategies to promote web accessibility [4].

Web specifications have never considered the image to be a purely visual element, even before the appearance of the first guideline for web accessibility. There was an early awareness of the lack of accessibility to the visual representation of the image not only for the visually impaired, but also for everyone else owing to technical constraints, such as low Internet speed that can hinder the uploading of images. The HTML specifications associated with an image stipulate that an alternative text is rendered if the given image is unavailable. Unfortunately, screen readers in the market cannot understand the image, and translate it into text; they can only get the replacement text of the image if it exists. Worse still, desktop and mobile websites as well as web apps are limited in terms of compliance with accessibility recommendations, despite the fact that the right to access information is protected by law.

Certainly, there are numerous automated tools for evaluating website accessibility. There are also many European research projects on web accessibility. For instance, WAI-Tools [13], WAI-CooP [12], and EIII [27]. Despite significant research on making images accessible, recent studies confirm that images on the web still lack accessibility. Alahmadi and Drew (2018) claimed that relying just on automatic tools to assess the relevance of an alternative text is insufficient and that an accessibility expert's evaluation is also required [2]. Calvo et al. (2016) [8] claimed that many desktop and mobile websites are not yet accessible. The audit carried out by experts on accessibility highlighted seven issues that are not covered by WCAG 2.0 AA, and can cause problems for users with disabilities. One of these issues is insufficient icon contrast for colorblind users or for outdoor use. The study provided recommendations for improving web accessibility. Yan et al. (2019) [33] found that more than 94% of android applications violate accessibility. Moreover, the IBM Mobile Accessibility Checker (MAC) tool that they used for their assessment covered only 67% of the relevant issues on average. They proposed two new parameters: the percentage of inaccessible items, and the percentage of issues with a given item compared with the maximum number of issues. They also suggested that app stores use automatic tools to require a minimum level of compliance from developers. They highlighted that ImageView and ImageButton are among the five widgets that lead to the main violation. Over 53% of potential violations are caused by ImageView. The used tool (MAC) reported potential violations because it could not determine whether the given images were decorative or

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https://doi.org/10.17758/EIRAI18.DiR0523101

contained information. Regarding the ImageButton widget, MAC reports violations as warnings.

This study tries to provide a holistic view of image accessibility. Section 2 discusses means of realizing advanced accessibility to images. Section 3 suggests new alternatives that can complement the textual alternative. The conclusion is given in the section 4.

II. Implementing Advanced Accessibility

The requirements in terms of accessibility have evolved considerably over time [31]. Access to services offered by the web (e-commerce, e-learning, e-health, e-transport, etc.) is no longer a luxury, but rather a necessity. Consequently, new accessibility measures must be put in place in order to be able to keep up with the technological development that has continued to assign an increasingly important role to images.

A. The efficiency of Textual Descriptions

For years, image accessibility has been a daunting challenge. Clark addressed it explicitly in his chapter “The image problem” [10], where he proposed bottom-line accessibility advice that defines the three levels of accessibility described in Table I.

TABLE I
THE THREE LEVELS OF ACCESSIBILITY ACCORDING TO CLARK

Level of accessibility	Description
1. Basic	Use alt texts on absolutely all images without exception.
2. Intermediate	Add titles to images in increments no smaller than a page: Either all graphics on a page contain titles or none does.
3. Advanced	Write long descriptions for more intricate images.

In 2002, this advice on accessibility was revolutionary. In fact, most current websites date back to Web 1.0 (1990–2000), and still use HTML 3.2. This version offers the ALT attribute but not the TITLE and LONGDESC attributes, which were introduced in HTML 4.

However, achieving advanced accessibility does not rely only on web designers. At least, it is also shared between authoring tool developers and web browser designers. Indeed, the W3C offered Web Content Accessibility Guidelines (WCAG), Authoring Tool Accessibility Guidelines (ATAG), and User Agent Accessibility Guidelines (UAAG). Human-computer interaction (HCI), particularly interaction design, user experience (UX), and cognitive computing sciences, should also be considered. Enhancing accessibility also requires a holistic view and a deep understanding of the issues.

The quick addition of the two attributes TITLE and LONGDESC shows that the ALT attribute alone is not sufficient to achieve advanced accessibility for all users. Indeed, the information provided by the ALT attribute is available only in the absence of the image. It is an accessibility process primarily intended for assistive technologies, and thus does nothing for users with graphical browsers—the most common navigation scenario. Therefore, the TITLE attribute has come to enrich the image owing to the additional information available to all users of graphical browsers. Moreover, the LONGDESC attribute allows for a longer text description to be attached to the image. In contrast to ALT, which does not allow more than 1k characters, LONGDESC does not have any restriction on the length of the text. This can allow authors of web content to provide a detailed description of the image that is sufficient to understand its content and purpose. Today, the inadequacy of LONGDESC for achieving advanced accessibility has become clear to the point that the first HTML 5 specification made the LONGDESC attribute obsolete, and suggested providing a regular A element to link to the description instead [30]. The reasoning behind this decision makes sense. As this text description is provided only for assistive technologies, it is usually omitted by authors (who do not see what they have implemented), and is ignored even by browsers (which do not try to implement what will not be used). Although LONGDESC did not achieve the advanced accessibility expected of it, it was added to the HTML 5 specification (after some discussion), and most current browsers have implemented it. The W3C cannot abandon any accessibility process even if it is not efficient. This reminds us of the ACCESSKEY attribute, the use of which has been generalized even with images despite its limited effectiveness [20].

Undoubtedly, using textual descriptions is essential, not only for the blind but for everyone. It offers a basic layer of accessibility, without which the image becomes an obstacle to accessing information, and users risk failing to accomplish their online tasks. However, the efficiency of available implementation of textual description remained limited. Therefore, research has tried to bridge the gap.

B. Bridging the Accessibility Gap

Although using the ALT text is mandatory, a large number of images on the web are either poorly designed or have no textual alternative. These images remain inaccessible in particular to blind people or users of screen readers [4]. Scariot et al. (2021) [23] have argued that the design of most images on the web is inadequate for the visually impaired (poor design and lack of criteria for accessibility). They proposed a model to create accessible charts based on information visualization theory and the relevant literature. This model was judged to be relevant according to an evaluation carried out by three experts in the field.

In addition, there are several publications on alternative text testing and generation. Sanchez-Gordon et al. (2016) proposed for e-learning platforms an editor for embedding accessible images [21]. Morris (2021) [16] discussed the opportunities offered by vision-to-language technologies to help make such images accessible. She claimed that the key challenges of these technologies are ways to select the relevant details and maintain an error rate acceptable to the user. She developed a smart prototype while sharing end-user preferences that guided her design. Wu et al. (2017) [32] proposed a system to automatically generate text alternatives from Facebook photos and thus make them more accessible to users of screen readers. Low et al. (2019) proposed a browser extension that adds alt text to Twitter images [14]. Likewise, Pereira et al. (2021) provided tools to improve the accessibility of user-generated content on Twitter and Facebook by suggesting text alternatives for images [19]. Labeling visual elements with comprehensive descriptions enables a wide range of accessibility applications. Indeed, Zhong et al. (2015) provided blind users with an accessible touchscreen interface, helping them through audio guidance to explore complex images describing the spatial layout of the workplace [35].

C. Toward a Cognitive Accessibility

Research on human cognition is interested in studying how the human brain thinks not only to propose theoretical models, but also to develop computer processing capable of simulating human thought. Cognitive disabilities such as attention deficit hyperactivity disorder (ADHD), autism, dementia, and dyslexia can hander access to the Web. Indeed, the W3C has published a draft for a review of WCAG 2.2 [28] that adds nine new accessibility requirements to WCAG 2.1. The new criteria for success address the needs of people with cognitive or learning disabilities, and users of mobile devices and e-books. In this context, Seeman and Lewis (2019) tackled the accessibility barrier for people with cognitive disabilities. They discussed advances in supporting cognitive accessibility through adapting the information, its presentation, and the offered interaction modalities [24]. The W3C has specified native HTML tags and attributes to enhance the semantics of web interface elements, including images. In addition, it has also suggested WAI-ARIA attributes [29]. Their goal is to aid authors in creating accessible, rich Internet applications for people with disabilities. Precisely, they allow them to extend or complement the HTML element features with roles and properties that assistive technology can use to make the interface's semantics more accessible to users.

Most research on the cognitive accessibility of the web has focused on automatic text processing to make it more accessible. For instance, Moreno et al. (2021) [15] sought to make the textual content of web interfaces more understandable to people with cognitive impairments. To achieve this, they designed and implemented an easier web system based on design patterns of cognitive accessibility. Research has also shown that it is now feasible to quantify the complexity of an image. Yu et al. (2014) modelled visual clutter perception. To achieve this, they proposed proto-object segmentation that imitates human cognition. The level of visual clutter is determined mainly according to the number of objects in the image in addition to the colour variation [34]. The simplification of images is still classified as pre-processing specific to visual accessibility. By contrast, most people who have difficulty understanding text may find it difficult to understand the corresponding image as well. Indeed, the visual focus of some people with autism spectrum disorder (ASD) seeks to avoid social elements in an image. As a result, they fail to understand the purpose of the image in the same way as others. ASD has also been linked to atypical visual perception (Chung & Son, 2020) [9], which may be altered by attention, higher-order cognitive functions, or a disturbed social network of the brain. According to neuroimaging research, this can increase difficulties in dealing with complicated social cues or improve specific abilities in those with the savant syndrome.

Therefore, it is necessary to establish the cognitive accessibility of the image. It should no longer be measured by what the eye has seen, but rather by what the brain has perceived (mental perception of the image). To achieve this, we must focus on the semantic accessibility of the image. For people with certain cognitive impairments or learning difficulties, the textual alternative is not always the best solution. Therefore, it becomes interesting to offer them a new means of interaction more suited to their specific needs, which also considers their cultural practices [18]. There is a need to new alternatives. In this context, Morrison et al. (2017) [17] discussed their development and management of a tactile ideation workshop with visually impaired people from India and the UK.

III. TOWARDS NEW ALTERNATIVES

The web has undergone a significant evolution. From the beginning, the W3C has sought to promote the usability of images for everyone, especially those with disabilities. First, it sought to ensure the dissemination of image information by rendering text in case of difficulty in accessing a given image. Then, adaptive images [30] offer two new attributes, namely, SRCSET and SIZES. They make it possible to define several sources of different sizes for the same image, and it is up to the browser to select the most appropriate source. This adaptation is beyond the user's control. However, it may enhance image accessibility, especially for partially sighted users. Moreover, by allowing multiple sources to be defined for the same image, the web opens the door to the use of visual alternatives to improve accessibility. Likewise, the two HTML5 elements, PICTURE and SOURCE, provide artistic direction or allow the user to define different image formats, depending on the orientation of the device and its characteristics [30]. It is worth noting that the Web has considered the media used by visually impaired users. Indeed, the media queries have helped identify different types of media—aural, tty, embossed, and braille—to subsequently associate them with particular styles. Media queries can also be used to determine the number of bits used to encode a color on a terminal, or to check if it supports touch events.

For several years, blind people have used only mobiles equipped with a keypad. Nowadays, they are gradually moving toward the use of touchscreen smartphones. Indeed, keyboard access and the textual alternative are no longer the only relevant accessibility mechanisms. For instance, mobile interfaces can offer non-speech sound alternatives and vibrotactile feedback. These new modes of interaction can be coupled with the potential offered by Artificial Intelligence to make images on the web more accessible. Research has shown the potential for automating the production of tactile images, which offers new promise for accessibility to digital image.

A. Inferring Cropped Images

Unlike some visually impaired people who have no light perception at all, others have some useful vision. Both are in need of cropped and simplified images. It is for this reason that they prefer the tactile image to a complex color image. Tactile graphics specialists know how to eliminate unnecessary information from the image. Web technologies have made it possible to automatically infer the best crop of an image. Thus, the new alternative should offer a concise representation of the image by considering only the most relevant information.

Art direction is one of the common uses of the HTML5 PICTURE element. Although it is a powerful technique for creating responsive images, its utility as an accessibility solution is still unknown. It should be remembered that art direction allows one to crop an image or load a simpler version on smaller screens. Of course, this potential can contribute to better accessibility to the image for visually impaired people who use mobile devices to browse the web. Image cropping allows one to focus on the most relevant part of the image. The space allocated to displaying the entire image is devoted only to the cropped part, which allows for it to be viewed with larger dimensions.

As a result, the cropped image is more readable because it is easier to understand due to the elimination of irrelevant peripheral details.

Web designers can see the manual preparation of multiple crops of each image as tedious work, but this can be automated. For instance, the DADI CDN is an open-source asset manipulation and delivery platform that allows for the cropping of images on the fly (Bouças, 2016) [5]. The web designer has to specify only the width and height of the new image in the HTML code, and to provide the coordinates of the crop that correspond to the upper-left corner of the image. Moreover, the cropping coordinates can be inferred based on an entropy analysis of the image content [11]. Thus, the user can get the best crop for an image with the given dimensions.

B. Non-speech Sound Alternatives

Other than the textual alternative offered by web specifications, researchers have investigated the possibility of using non-speech sound alternatives such as earcons, auditory icons, and audems. Thapa et al. (2017) [26] have claimed that audems [3] are better-suited than earcons or auditory icons to represent an image. Moreover, they proved through an empirical study that audems can offer a better UX compared with the textual alternative. Table II gives a comparison among these three non-speech alternatives.

TABLE II
IMAGE TO NON-SPEECH SOUND TRANSLATION

Alternatives	Earcons	Auditory icons	Audems
Presentation	Abstract synthetic tone	Direct representation of an associated concept	Combination of various sound effects (natural, artifact context, abstract sounds, music excerpts)
Sample	Sound when receiving an email	Sound of crumpling piece of paper when deleting a file	"Neighing of a horse" enriched with sounds to further focus the meaning (horserace/riding/polo)
Affordance	No natural association between sound and object	Natural sound of an object	Meaning derived from semiotic structure + intuitive link between sounds and natural events.
User	Difficult to learn/frustrating	Intuitive	Enhanced usability + increased task performance.
Designer	Easier to use and create	Difficult to create/classify for every concept	Relies on the designer's empirical knowledge and preferences.

C. Offering Tactile Images

The development of responsive images has made it possible to define several sources for the same image and associate them with different media. In this way, graphical browsers can now offer the user with the source that best suits their platform and its disposition. In addition, the media braille and embossed have been proposed to improve the UX during non-visual browsing. However, this opportunity has not yet been adequately implemented to define image sources for use by the blind. Web/graphic design specialists lack the skills to create these accessible graphics. In addition, they have no automatic system to accomplish this task, but a few online training and free tools are available for use. This study encourages the development of automatic tools to produce tactile images based on intelligent techniques.

Abou-Zahra et al. (2018) [1] highlighted the potential of Artificial Intelligence for digital accessibility, not just by personalizing information or converting it from one form to another, but also by interpreting it to offer an augmented and alternative communication. From this perspective, Brock (2013) [7] proposed the design of interactive maps for visually impaired people. She described the analysis, design, prototype, and evaluation of the participatory design cycle that she used. She used a classic raised-line map paper placed as an overlay over a multi-touchscreen, and implemented double tap on the touchscreen to play speech for every region. The evaluation showed that users preferred the interactive map to a classic line-raised map containing braille code. Replacing braille with speech has made it possible to simplify the tactile element and facilitate access for people who have not mastered braille. Brock's approach is inspired by the traditional process of creating visio-tactile maps, which consists of placing the tactile element above the visual element.

Unlike Brock, who made the layer below this interactive, Bouhlel et al. (2014) [6] proposed automating the production of tactile elements. Their solution is essentially based on image segmentation, boundary simplification, and character recognition algorithms to convert text into braille. Likewise, Sorge et al. (2019) discussed techniques for making scientific documents, and especially diagrams, accessible on the web. This is achieved not only through screen reading but also via sonification and audio-tactile interaction [25].

Although these studies targeted blind people, the tactile images generated can be used by everyone. For instance, Sayago et al. (2021) [22] showed that 3D printing is more democratic for older people with low literacy, especially if we focus on interaction issues and spatial visualization.

IV. Conclusion

The objective of universal Internet access is still a work in progress, and various accessibility specification and guidelines have been published to this end. Each of them provides new ideas or clarifications on ways to realize accessibility. As a result, web designers and accessibility experts have become sequential learners of accessibility, focusing on the details in order to comply with a new guideline or implement a new specification in their tools. However, achieving an advanced level of accessibility requires a broader view of the situation. Thus, this paper attempted to bridge the gap by proposing a holistic view of research issues and emerging trends in image accessibility on the web. It also discussed new research perspectives.

We conclude that we must think of offering all that technology allows: not only regarding the web but also image adaptation techniques. It has become possible to implement machine learning and image processing algorithms using web programming languages. Thus, this study promotes cross-disciplinary collaboration around the theme of image accessibility. In addition, most research on image accessibility has focused on providing blind users with alternative text. In contradistinction, this study recommends moving toward offering cognitive accessibility for all users. The presented perspectives show that technology may provide us with a new inclusive alternative. For instance, the new authoring tools may allow one to adapt the complexity of the image and its visual clutter. Better yet, they may generate an image abstraction that aids comprehension. In brief, HTML allows assigning many sources to an image, and research suggests other alternatives (i.e., auditory icons, audems, cropped or tactile images). As a result, web pages may soon offer a new image alternative to complement the textual one.

References

[1] Abou-Zahra, S., Brewer, J. M., & Cooper, M. C. (2018). Artificial Intelligence (AI) for Web Accessibility. *Proceedings of the 15th International Web for All Conference*. https://doi.org/10.1145/3192714.3192834

[2] Alahmadi, T. A., & Drew, S. (2018). Evaluation of image accessibility for visually impaired users. *Journal of Accessibility and Design for All: JACCES, 8*(2), 125–160. https://doi.org/10.17411/jacces.v8i2.167

[3] *Audeme - Dictionary*. (2016). https://audemes.org/dictionary_2014/dictionary_2016.html

[4] Barreto, A., & Hollier, S. (2019). Visual Disabilities. *Human-Computer Interaction Series*, 3–17. https://doi.org/10.1007/978-1-4471-7440-0_1

[5] Bouças, E. (2016, July 18). Image art direction using the HTML picture element and DADI CDN. *Build Times*. Retrieved September 5, 2021, from https://eduardoboucas.com/blog/2016/07/18/image-art-direction-using-html-picture-element-dadi-cdn.html

[6] Bouhlel, N., & Rojbi, A. (2014). New tools for automating tactile geographic map translation. *Conference on Computers and Accessibility*. https://doi.org/10.1145/2661334.2661335

[7] Brock, A. (2013). Touch the map! *ACM Sigaccess Accessibility and Computing, 105*, 9–14. https://doi.org/10.1145/2444800.2444802

[8] Calvo, R., Seyedarabi, F., & Savva, A. (2016). Beyond Web Content Accessibility Guidelines. *Proceedings of the 7th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-Exclusion*. https://doi.org/10.1145/3019943.3019955

[9] Chung, S., & Son, J. (2020). Visual Perception in Autism Spectrum Disorder: A Review of Neuroimaging Studies. *Journal of the Korean Academy of Child and Adolescent Psychiatry, 31*(3), 105–120. https://doi.org/10.5765/jkacap.200018

[10] Clark, J. (2002). Building Accessible Websites. New Riders. ISBN 0-7357-1150-X

[11] DADI CDN Documentation. (2016). Retrieved September 5, 2021, from https://docs.dadi.cloud/cdn/3.4

[12] Initiative, W. W. A. (2023a, February 17). *WAI-CooP*. Web Accessibility Initiative (WAI). https://www.w3.org/WAI/about/projects/wai-coop/

[13] Initiative, W. W. A. (2023b, February 17). *WAI-Tools*. Web Accessibility Initiative (WAI). https://www.w3.org/WAI/about/projects/wai-tools/

[14] Low, C., McCamey, E., Gleason, C., Carrington, P., Bigham, J. P., & Pavel, A. (2019). Twitter A11y. *Conference on Computers and Accessibility*. https://doi.org/10.1145/3308561.3354629

[15] Moreno, L., Alarcon, R., & Martínez, P. (2021). Designing and Evaluating a User Interface for People with Cognitive Disabilities. *International Conference on Human-Computer Interaction*. https://doi.org/10.1145/3471391.3471400

[16] Morris, M. R. (2021). Accessibility as an Opportunity and Challenge for Intelligent User Interfaces. *Intelligent User Interfaces*. https://doi.org/10.1145/3397481.3457419

[17] Morrison, C., Cutrell, E., Dhareshwar, A., Doherty, K. E., Thieme, A., & Taylor, A. S. (2017). Imagining Artificial Intelligence Applications with People with Visual Disabilities using Tactile Ideation. *Conference on Computers and Accessibility*. https://doi.org/10.1145/3132525.3132530

[18] Pereira, L. S. F., Ferreira, S. B. L., Braga, H., Salgado, L., & Nunes, R. J. (2014). Using Cultural Viewpoint Metaphors to Provide Web Accessibility for the Visually Impaired Users. *Procedia Computer Science*. https://doi.org/10.1016/j.procs.2014.02.022

[19] Pereira, L. S. F., Guerreiro, J. F., Rodrigues, A., Santos, A. L. Q., Vicente, J. B., Coelho, J., Guerreiro, T., & Duarte, C. M. (2021). Suggesting text alternatives for images in social media. *ACM SIGACCESS Accessibility and Computing, 130*, 1–6. https://doi.org/10.1145/3477315.3477318

[20] Rojbi, S., Rojbi, A., & Gouider, M. S. (2018). Toward an Inclusive Digital Information Access: Full Keyboard Access & Direct Navigation. *Communications in Computer and Information Science*, 28–39. https://doi.org/10.1007/978-3-030-02846-6_3

[21] Sanchez-Gordon, S., Estévez, J. C., & Luján-Mora, S. (2016). Editor for accessible images in e-Learning platforms. *Proceedings of the 13th International Web for All Conference*. https://doi.org/10.1145/2899475.2899513

[22] Sayago, S., Blanco-Arnau, P., & Blat, J. (2021). 3D Modeling and Printing with Vulnerable Adults. *International Conference on Human-Computer Interaction*. https://doi.org/10.1145/3471391.3471405

[23] Scariot, A. P., Montane-Jimenez, L. G., & Mezura-Godoy, C. (2021). Towards the creation of accessible charts for the visually impaired. *International Conference on Human-Computer Interaction*. https://doi.org/10.1145/3471391.3471425

[24] Seeman, L., & Lewis, C. (2019). Cognitive and Learning Disabilities. *Human-Computer Interaction Series*, 49–58. https://doi.org/10.1007/978-1-4471-7440-0_4

[25] Sorge, V., Ahmetovic, D., Bernareggi, C., & Gardner, J. (2019). Scientific Documents. *Human-Computer Interaction Series*, 397–415. https://doi.org/10.1007/978-1-4471-7440-0_22

[26] Thapa, R. B., Ferati, M., & Giannoumis, G. A. (2017). Using non-speech sounds to increase web image accessibility for screen-reader users. *International Conference on Design of Communication*. https://doi.org/10.1145/3121113.3121231

[27] *Tingtun Page Checker - Find Barriers in your Web Page*. (n.d.). Retrieved February 17, 2023, from http://checkers.eiii.eu/

[28] W3C. (2021). *Web Content Accessibility Guidelines (WCAG) 2.2. W3C Working Draft 21 May 2021*. https://www.w3.org/TR/WCAG22/

[29] W3C. (2023). *ARIA in HTML : W3C Recommendation 15 February 2023*. https://www.w3.org/TR/html-aria/

[30] WHATWG. (2023). *HTML Living Standard — Last Updated 27 February 2023*. https://html.spec.whatwg.org/multipage/obsolete.html#non-conforming-features

[31] Web Accessibility. (2019). *Human-Computer Interaction Series*. https://doi.org/10.1007/978-1-4471-7440-0

[32] Wu, S., Wieland, J. C., Omid, F., & Schiller, J. (2017). Automatic Alt-text. *Conference on Computer Supported Cooperative Work*. https://doi.org/10.1145/2998181.2998364

[33] Yan, S., & Ramachandran, P. G. (2019). The Current Status of Accessibility in Mobile Apps. *ACM Transactions on Accessible Computing*, *12*(1), 1–31. https://doi.org/10.1145/3300176

[34] Yu, C., Samaras, D., & Zelinsky, G. J. (2014). Modeling visual clutter perception using proto-object segmentation. *Journal of Vision, 14*(7), 4. https://doi.org/10.1167/14.7.4

[35] Zhong, Y., Lasecki, W. S., Brady, E., & Bigham, J. P. (2015). RegionSpeak. *Human Factors in Computing Systems*. https://doi.org/10.1145/2702123.2702437