Visual Accessibility of Websites

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CSC 486 Spring 2019

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Abstract

An oft overlooked aspect of designing websites is accessibility. The following report examines the accessibility of websites for the visually impaired, with a specific focus on blindness, partial blindness, and color blindness. There are many different visual afflictions which can inhibit an individual's ability to perceive a website's content effectively and different ways to help ensure that the greatest possible audience is reached.

Tools for evaluating accessibility use a variety of different standards, including those set forth by or promoted by the American Foundation for the Blind (AFB), the Americans with Disabilities Act (ADA), Web Content Accessibility Guidelines (WCAG).

I will try to find and assess tools that rate accessibility of websites, enhance accessibility of websites, or provide some in between tools (e.g. simply providing color suggestions or providing contrast ratio of two given colors).

Introduction

I will be looking into visual accessibility of websites: Specifically, what makes a website accessible to people with any form or level of vision, what measures can be taken to improve access, and what tools can be used to increase accessibility?

There are a lot of factors that can influence how a human interacts with a website. In terms of visual impairments, colorblindness inhibits an individual's ability to perceive a website if the color contrast is insufficient, low acuity hinders a person's ability to use a website if fonts are not big enough or if they cannot successfully zoom in (for example, layout changes with zoom or certain things cannot be magnified), and blindness can prevent a user from navigating a website if the layout is not coherently organized or alt text is missing or unhelpful.

Whether or not a website meets standards that make the aforementioned issues better is also relevant to individuals that have what most would regard as "normal" vision. If a user is in the sun, for example, the screen is much harder to see because of the additional light interfering with the light from the screen. If a website has higher contrast, the user will be more likely to be able to use the site successfully.

Similarly, a website experience can change greatly based on the type of device on which the site is being viewed. Depending on how a website is set up, the layout of images, text, buttons, and sections can change dramatically if a user looks at it on a laptop, tablet, or phone. The changed layout would make it hard for a blind user to navigate the page successfully if the associated alt text loses value and coherency after being rearranged. Furthermore, even a user with "normal" vision would have a harder time navigating the page if the content shuffles around too much, because it could become unclear what text and images belong together.

Ultimately, our world is becoming increasingly digital. It is important that everyone has access to the tools they need to pursue a modern lifestyle and its corresponding opportunities. All digital tools should be set up in a way that they optimize usability and accessibility regardless of device type or visual ability.

Background

To understand the following material, it will be important to understand the following terms and concepts.

The following visual impairments are the conditions that will be focused on for the extent of this research paper and the corresponding project:

- Red-green colorblindness: protanomaly, protanopia, deuteranomaly, deuteranopia
- Blue color blindness: tritanomaly, tritanopia
- Full color blindness: cone monochromacy, rod monochromacy, achromatopsia
- Low acuity
- Full blindness

The following terms will be important to understand:

- alternative text (which will always be referred to as "alt text")
- screen readers
- color contrast

The names of different types of colorblindness describe the condition. The suffix "-anomaly" describes an abnormality of function while the "opia" suffix refers to a lack of function. A "protan" is a red cone cell, a "deuteran" is a green cone cell, and a "tritan" is a blue cone cell. So, for example, "protanopia" refers to a lack of red green cells, while "deuteranomaly" indicates abnormalities in the green cone cells. ("Facts About Color Blindness")

Monochromacy and achromatopsia refer to a lack of color vision, low acuity is a decrease in focus that can cause blurry vision, and full blindness can entail anywhere from very little to no vision.

Alternative text, or alt text, is a way of allowing non-text items on a page to be labelled with text, either to provide additional information for a more motivated user or to provide something textual that can dictated aloud.

Screen readers are programs that in some capacity determine the contents of a computer or browser and then dictate the findings out loud to the user. They have different levels of ability band some can even display the information on a braille display instead of just being read aloud. ("The Visually Impaired Web User's Technology")

Braille displays raise and lower pins to display braille characters. ("Refreshable Braille Displays")

The **color contrast** on web pages is primarily relevant when it comes to text. It refers to how the relative luminances of two particular colors compare. The following formulas and information are

from "G17: Ensuring That a Contrast Ratio of at Least 7:1 Exists between Text (and Images of Text) and Background behind the Text.".

The actual contrast ratio is determined by the following calculation:

$$(L1 + 0.05) / (L2 + 0.05)$$

In that formula, L1 and L2 are the relative luminances of the lighter color and darker color, respectively. These values are found using the following formula:

$$L = 0.2126 * R + 0.7152 * G + 0.0722 * B$$

Here, R (red), G (green) and B (blue) can be determined as follows, where X is R, G, B:

if X sRGB <= 0.03928 then X = X sRGB /12.92, else X = $((X \text{ sRGB} + 0.055) / 1.055)^{2.4}$

and R sRGB, G sRGB, and B sRGB, where R, G, and B are represented by X, are defined as:

X sRGB = X 8bit /255

Example calculation: #155540 (Cal Poly green) and #FFFFFF (white)

#155540 → RBG → 21, 85, 64	#FFFFFF → RBG → 255, 255, 255
R sRGB = 21/255 = 0.08235 G sRGB = 85/255 = 0.33333 B sRGB = 64/255 = 0.25098	R sRGB = 255/255 = 1 G sRGB = 255/255 = 1 B sRGB = 255/255 = 1
R = $((0.08235 + 0.055) / 1.055)^{2.4}$ = 0.0074986 G = $((0.33333 + 0.055) / 1.055)^{2.4}$ = 0.0908398 B = $((0.25098 + 0.055) / 1.055)^{2.4}$ = 0.0512693	R = $((1 + 0.055) / 1.055)^{2.4}$ = 1 G = $((1 + 0.055) / 1.055)^{2.4}$ = 1 B = $((1 + 0.055) / 1.055)^{2.4}$ = 1

L = 0.2126 * R + 0.7152 * G + 0.0722 * B
L = 0.2126 * 0.0074986
  + 0.7152 * 0.0908398
  + 0.0722 * 0.0512693
 	
L2 = 0.07026447
	L = 0.2126 * R + 0.7152 * G + 0.0722 * B
	L = 0.2126 * 1 + 0.7152 * 1 + 0.0722 * 1
	
	L1 = 1

Contrast Ratio: (L1 + 0.05) / (L2 + 0.05) = (1 + 0.05) / (0.07026447 + 0.05) = **8.73**	

Standards for Accessibility of Websites for the Visually Impaired

The American Foundation for the Blind (AFB) is an organization that serves to help those with loss of vision as they navigate society in the world. They provide information for individuals who seek assistance in understanding their resources and rights in the workplace and in the world. Additionally, they help to bring awareness to the issue of accessibility and promote making the world more accessible through fighting for legislature, business help, and more. ("What We Do")

While the work of organizations like the AFB is incredibly helpful, many people will feel as though it is not their responsibility to ensure the accessibility of a website. Between lawyers, designers, managers, and web developers, there are a lot of people at any given company that could ensure a successfully accessible website design but that will feel as though they personally are not responsible. Furthermore, some people will not even have it on their radar that accessibility should be on their minds during website design and development. The real question is, once companies and their employees are aware of potential accessibility issues, how can they be incentivised to make their website accessible?

One way in which companies should be motivated to increase their accessibility is through the enhanced Search Engine Optimization (SEO). By having useful alt text and metadata, companies are more likely to see traffic on their websites and on the images from their websites.

Furthermore, there can be legal and financial repercussions to having websites that don't meet certain standards of accessibility. A few years ago, a blind user who was unable to successfully navigate the Winn-Dixie website decided to sue the company. This demonstrates the consequences other companies may want to avoid by making their sites compliant. ("The Basics of ADA Compliant Web Design [Case Study]")

The Americans with Disabilities Act (ADA) became law in 1990 and offers individuals with physical or mental impairments legal protections. It drew inspiration from the Civil Rights Act of 1964 in that it should help provide all with "equal opportunity". Especially relevant to website accessibility are the ADA Standards for Accessible Design, which have been updated since the law's conception. However, there is room for improvement in terms of specifications for standards. For example, the ADA only seems to specify that for contrast purposes, text and symbols either need to be light on a dark background or dark on a light background, but do not explicitly state what is defined as dark or light. ("Search ADA.gov")

The Web Content Accessibility Guidelines (WCAG) give much clearer instructions on how to maximize accessibility. In addition to outlining numerical standards which have easily reproducible results, there are different levels of guidelines in which more advanced levels correspond to stricter rules thereby giving more people access. For example, a website following WCAG A may not be accessible to someone with full color blindness. However, a website that adheres to WCAG AAA is more likely to be accessible to individuals with any type or severity of visual impairment. (Web Content Accessibility Guidelines (WCAG) 2.0)

The following list is an outline of the guidelines set forth by WCAG levels A, AA, and AAA, with the information provided by Web Content Accessibility Guidelines (WCAG) 2.0:

- WCAG A
    - Hierarchy of information can be determined through text or code
    - The order of sequential information can be determined through text or code
    - Colors may not be the only avenue of communication.
- WCAG AA
    - Large text must have a contrast ratio of 3:1 and all other text must have a contrast ratio of 4.5:1.
    - There is no contrast requirement for logotypes (text in logos) and text that is decorative (i.e. text that is not functional)
    - Text can be losslessly enlarged up to 200%.
    - Images of text may be used purely decoratively. Information is portrayed through text. Information may be presented through images of text instead of text when the text can be customized for the user and when using plain text instead of the image would cause information to be lost.
- WCAG AAA
    - Large text must have a contrast ratio of 4.5:1 and all other text must have a contrast ratio of 7:1.
    - There is no contrast requirement for logotypes and text that is decorative (i.e. text that is not functional)
    - From Web Content Accessibility Guidelines (WCAG) 2.0:
        "Foreground and background colors can be selected by the user.

        Width is no more than 80 characters or glyphs (40 if CJK).

        Text is not justified (aligned to both the left and the right margins).

        Line spacing (leading) is at least space-and-a-half within paragraphs, and paragraph spacing is at least 1.5 times larger than the line spacing.

        Text can be resized without assistive technology up to 200 percent in a way that does not require the user to scroll horizontally to read a line of text on a full-screen window."
    - Images of text may be used purely decoratively. Information is portrayed through text. Information may be presented through images of text instead of text ONLY when using plain text instead of the image would cause information to be lost.
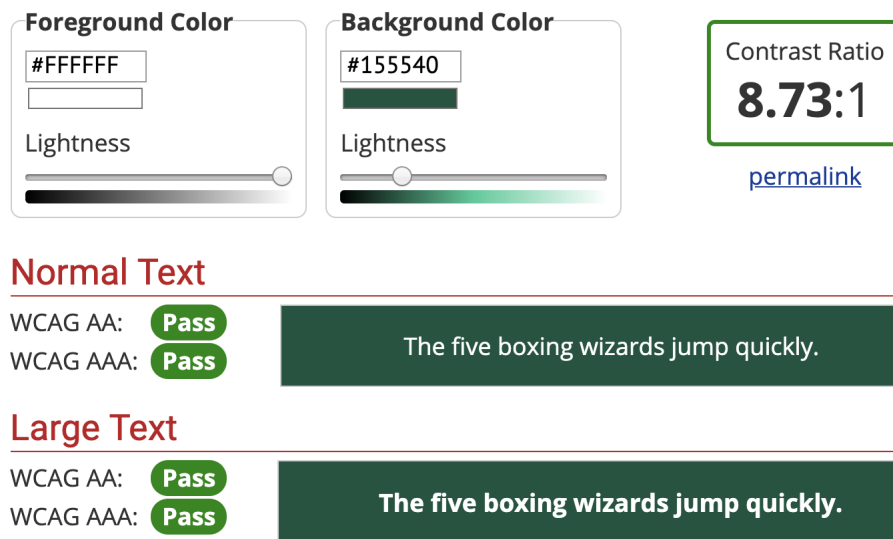
Figure 1: *This image is a screenshot of WebAIM's (Web Accessibility in Mind) Color Contrast Checker in action, with Cal Poly green as the background color and white as the foreground color. As shown in the image, the contrast ratio between the foreground and background color is 8.73:1, which passes all levels of the WCAG. This is the color combination shown in some screenshots of CalPoly.edu below.*

Tools which Evaluate Visual Accessibility of Websites

The **WAVE Web Accessibility Evaluation Tool** provides a report on the accessibility of a website given the URL. It takes a look at many aspects of the page and puts clickable tags next to items for explanations. (WAVE Web Accessibility Tool)

This tool evaluates many aspects of a website's accessibility. It gives information on the HTML and CSS, such as labelling headers like "H5" and "H2" or telling if there is some form of list present; information about hyperlinks is given, such as if a nearby hyperlinks go to the same URLs, if the text of the link is unhelpful, or if the link goes to a PDF; and alt text is labelled in the report, for example images with alt text have labels, linked images that have or are missing alt text are labelled, and items or images with null or "" alt text are labelled. (WAVE Web Accessibility Tool)

For example, the images below show some aspects of this tool in use when calpoly.edu is entered into the tool. This tool is able to navigate through multiple pages as well, so Figures 2.2, 2.3, and 2.4 are actually specifically from https://afd.calpoly.edu/parking/. In Figure 2.2, the red text "SOLD OUT" has insufficient color contrast with the white background, as the contrast ratio is only 4:1. In Figure 2.4, the white text on light green background has insufficient contrast, though the contrast becomes high enough when a user mouses over the button as that causes the button background to turn dark green.

That dark green is the shade and hue of green used in previous examples of color contrast, including the example calculation in the Background.
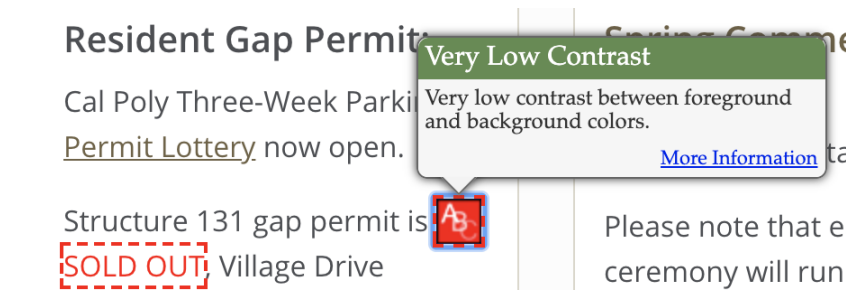
Images below are screenshots of the tool evaluating www.calpoly.edu in Figure 1.1 and https://afd.calpoly.edu/parking/ in Figures 1.2, 1.3, and 1.4. Images created by the author.
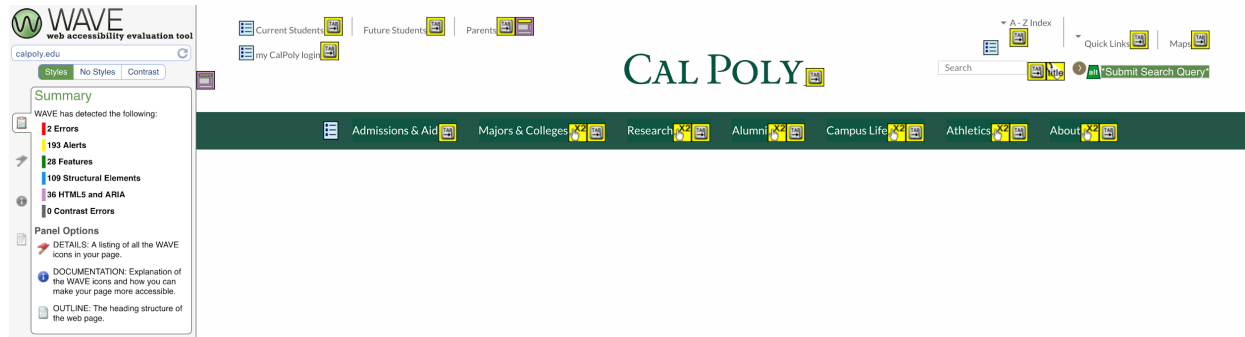
Figure 2.1: *Screenshot of tool when calpoly.edu is entered into the tool.*

Figure 2.2: *Contrast of red text on white background is too low*

Figure 2.3: *Contrast Evaluation of page.*
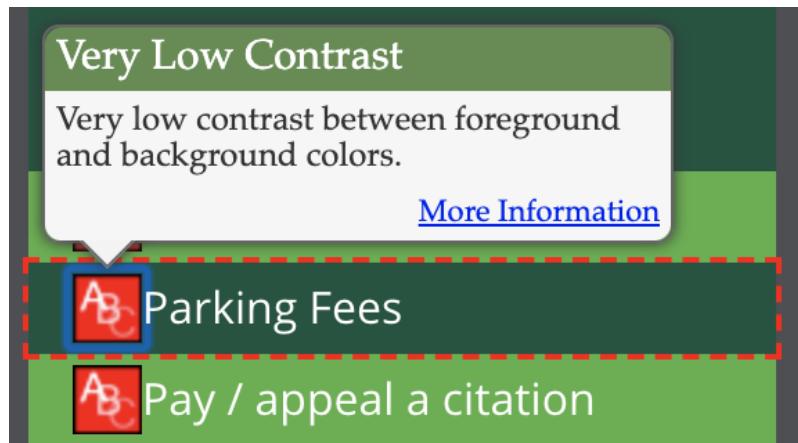
Figure 2.4: *Contrast of white text on light green background is too low, though the light green becomes dark green when the mouse hovers over it which results in sufficient contrast*

The **Colour Contrast Analyser** determines color contrast of text and images and outlines everything that passes the WCAG. Images below are from "Color Contrast Analyzer."

| *Figure 3.1*: NCSU website | *Figure 3.2:* Same website using tool |

Tools that Simulate Visual Impairments

The following two tools do not strictly evaluate the accessibility of a website. Rather, they create a visual of an image or website that simulates what a person with a visual impairment might see. While this function does not give explicit guidelines on making a page accessible, it allows a website developer to gain insight on the experiences of some of their users, build empathy, and use their own judgement of whether the integrity of the website's design and functionality are intact with people of different vision.

The **NoCoffee** Chrome extension simulates the vision of someone with any combination of visual impairments from the predetermined list, including low acuity, low contrast sensitivity, color deficiency, Nystagmus, and obstructed visual field. The different types and aspects of visual impairments exist on a scale, and this tool shows that range. This allows a web developer to see the site through a greater range of severity and type of visual impairments. Image below is from the Chrome Extension page. ("NoCoffee")

Figure 4: NoCoffee Vision Simulator Chrome Extension showing the extensions simulation capabilities on the BBC website.

Photoshop offers a view option which allows the user to see the screen with a color filter applied. The color filter mimics the red deficiency caused by red-green colorblindness. Photoshop specifically allows the user to choose between two types of colorblindness: Protanopia and Deuteranopia. Pictures depicting the Cal Poly website with and without both views shown below. Images created by author.

Figure 5.1   Figure 5.2   Figure 5.3

Figure 5.1: calpoly.edu with the Deuteranopia view
Figure 5.2: calpoly.edu with normal view
Figure 5.3: calpoly.edu with the Protanopia view

Tools which Enhance Accessibility of Websites for Visual Impairments

The desktop application **NVDA (NonVisual Desktop Access)** is a screen reader which reads aloud the text on a screen. It has other features that enhance the quality of transmission of information. The makers of NVDA felt strongly that the purpose of accessibility is that it is accessible. More specifically, they believed that even the poorest blind people all over the world should have a right to accessibility and should therefore be able to use their tools. For that reason, NVDA is a free download made possible by donations, is supported by most browsers and braille displays, and can be used in over 50 languages. ("About NVDA")

Figure 6: Non-visual Access company logo and slogan

The website **Color Safe** uses the WCAG to suggest a color palette based on a given background color, font family, font size, font weight, and WCAG AA or AAA. While this tool does not necessarily make using a website instantly easier to use, web developers can take advantage of the color suggestions to make their sites as accessible as possible without necessarily sacrificing aesthetic. Color suggestions are sorted by color family. The following images are screenshots from the website, created by the author.

Figure 7.1: User enters background color; font family, size, & weight; WCAG standard
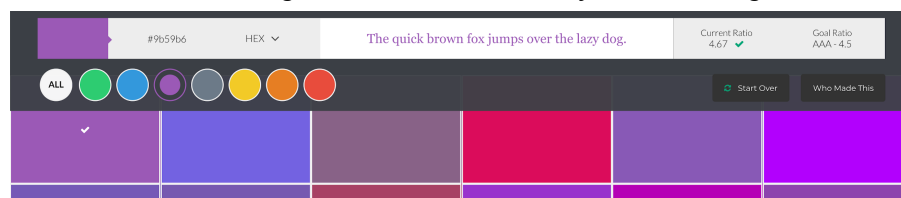
Figure 7.2: The user can choose from a range of colors and then copy and paste the corresponding hexadecimal or RGB value of the selected color.

Conclusion

There are a lot of extremely useful tools that can help individuals with visual impairments navigate websites or can help website developers ensure that their sites are accessible to all. However, at the moment, it seems as though most of these tools are either lacking in the Graphical User Interface or are only able to help in a few ways. For example, Color Safe can suggest colors but does not assess websites, and the WAVE Web Accessibility Evaluation Tool is useful for analyzing sites but can take a little time to learn because it does not feature especially intuitive or attractive design.

A useful tool would be something that has an attractive design, assesses all aspects of a site, and can make suggestions to improve a site. If such a tool with all instead of some of those components exists, I was not able to find it.

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