– Independent Work Report Spring 2020 –

Color Charts

Karen Ying
Adviser: Alan Kaplan

Abstract

This paper describes a Chrome extension called Color Charts that aims to increase the readability of charts, graphs, and diagrams on the web. Visuals that depend on colors to convey information may be hard to read for people with color blindness. This extension aims to improve upon existing extensions by using researched color blind friendly palettes. It allows for filtering of visuals on a web page, with the option to choose between 4 different color blind friendly palettes. Built with vanilla JavaScript, Color Charts interacts with HTML <img> elements in the Chrome browser, utilizing HTML canvas and base64 encoding to filter the images. This ultimately improves the web experience for color blind users by allowing them to better interpret charts, graphs, and diagrams.

1. Introduction

Color vision deficiency (more commonly known as color blindness) represents a group of conditions relating to the perception of color. In humans, there are many types of color blindness. Three of the most common types in order of frequency are red-green, blue-yellow, and complete. This condition affect approximately one in twelve men and one in two-hundred women of Northern European descent. [3]. In America, around thirteen million people are color blind [3].

Color blindness leads to a reduced ability to distinguish between certain colors like red and green, or blue and yellow. Most visual content, such as charts, graphs, and diagrams, rely on the use of many colors to better convey their data and information. Thus it can be difficult for color blind people to effectively process these visuals. Figure 7 shows a what an example graph looks like to a person with normal color vision. Figure 2 is the same graph processed with a protanopia (red-green color blind) filter, simulating the condition. The absence of the (long wave) L-cone in the eye makes it so that a person with protanopia cannot distinguish between red and green.

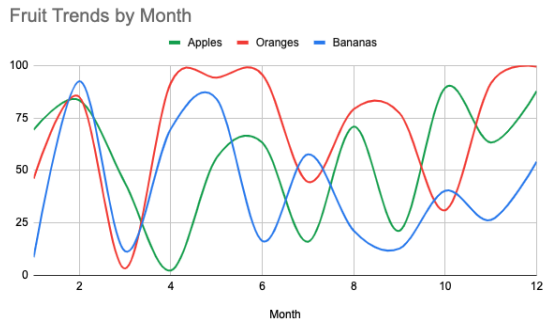

Figure 1: Example graph.

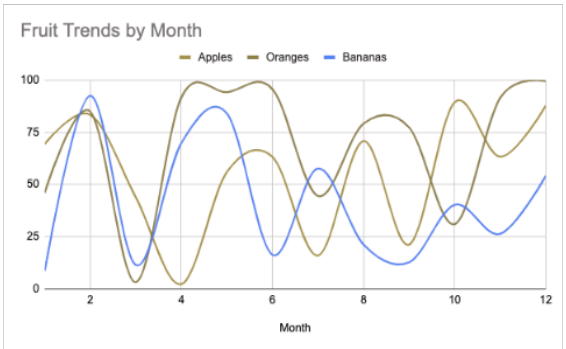

Figure 2: What someone with protanopia sees.

A simple line graph that may seem intuitive for a person with normal color vision to read can be difficult for a person affected by color blindness to interpret.

The goal of Color Charts is help color blind people better interpret charts, graphs, and diagrams on the web. Reading articles or papers with such visuals could be difficult for people with color blindness if the visuals do not consciously choose color blind friendly palettes.

Currently, the Chrome extension store offers a couple of color blind accessibility extensions that process the entire browsing experience. However, these extensions filter based on the original input, creating an output that depends on the input colors. They also do not filter only images, instead applying the color transformation to the entire browser window. Concurrently, there has been research done on optimal color blind friendly palettes. Color Charts aims to combine these two applications into a Chrome extension which selectively changes visual content, specifically charts, graphs, and diagrams, to preset color blind friendly palette colors.

[SUMMARY OF IMPLEMENTATION]

[SUMMARY OF RESULTS]

2. Background and Related Work

Color Charts aims to combine these two fields of research — Color blind friendly palettes and available Chrome extensions for color blindness.

2.1. Color Blind Friendly Palettes

Canadian scientist Martin Kyrzywinski has conducted research on color blind friendly palettes, creating suggestions for 12-color, as well as 15-color palettes[4]. Figure 3 shows Kyrzywinski's 12-color palette along with that the twelve colors would look like for people with deuteranopia, protanopia, and tritanopia.

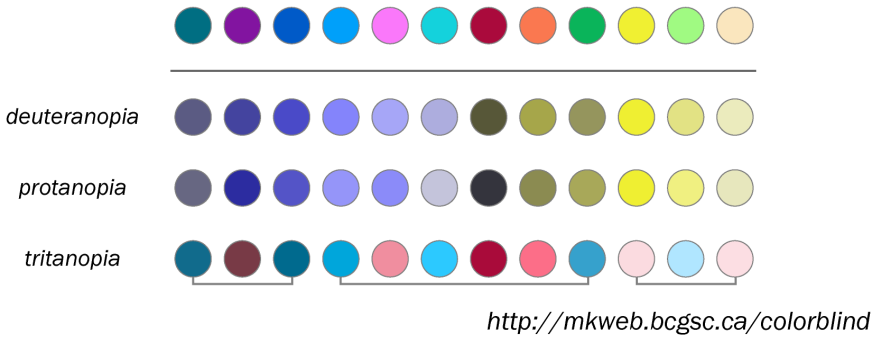

Figure 3: Kyrzywinski's 12-color palette[4].

Additionally, Japanese scientists Masataka Okabe and Kei Ito have proposed an 8-color palette[5]. Figure 4 shows the palette along with what the palette would look like to people with protanopia, deuteranopia, and tritanopia.

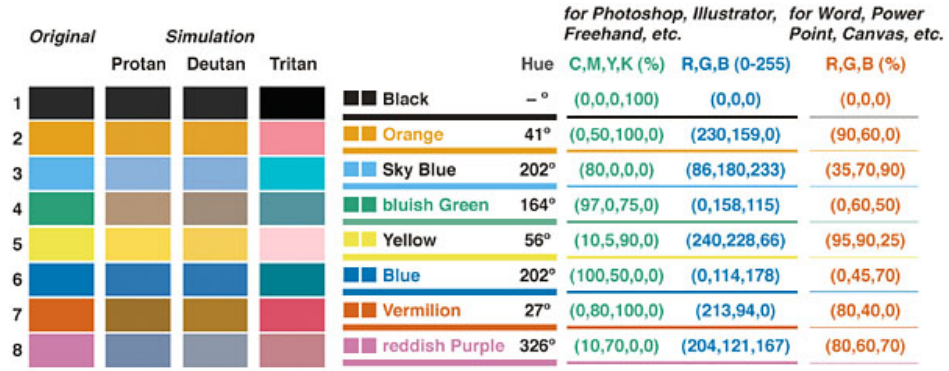

Figure 4: Okabe and Ito's 12-color palette[5].

Finally, Instrument Scientist Paul Tol created several qualitative color palettes in varying shades of brightness. Figure 5 shows the palettes with varying brightness.

Figure 5: Tol's palettes with varying brightness[6].

This project aims to incorporate this existing research done on color blind friendly palettes in the form of a Chrome extension to process charts, graphs, and diagrams.

2.2. Color Blind Accessibility Chrome Extensions

Chrome offers a couple of color blind accessibility extensions in their web store. Under "Use Chrome with accessibility extensions", Chrome suggests a third party extension called Color Enhancer[1]. Under setup, the extension asks the user for their preferences to calibrate the output colors. Figure 6 shows the setup process. Based on user preferences, Color Enhancer filters the entire browser.

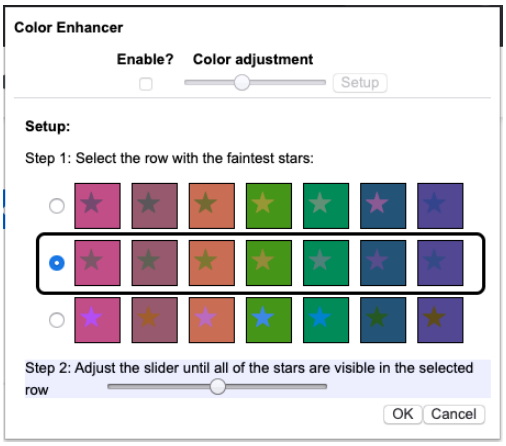

Figure 6: Color Enhancer Calibration Setup.

After setting up the preferences, the user can enable the filters and adjust the filter strength. Figure 7 shows the original graph from earlier and Figure 8 shows the filtered image after Color Enhancer is

enabled. Based on the setup settings, Color Enhancer takes the original colors and applies a filter to the entire browser, changing the colors to the user's preferences. Output colors *are dependent* on input colors.

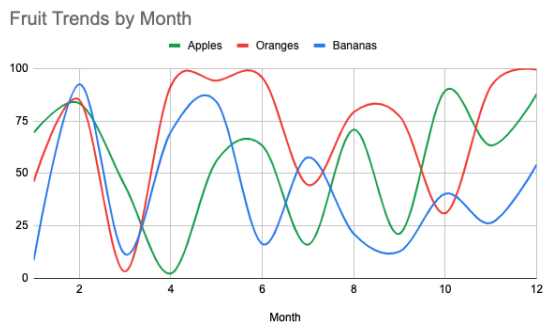

Figure 7: Example graph.

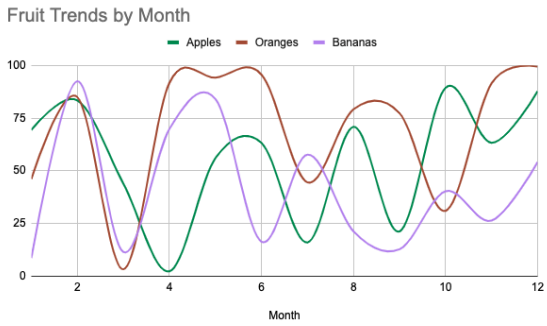

Figure 8: Example graph after Color Enhancer.

Another popular Chrome extension is "Colorblind - Dalton for Google Chrome[2]". It operates in a similar manner to Color Enhancer — it also takes in user preferences to filter the entire browser based on the original input colors.

These two extensions have common product designs — the user takes an adjustment test in the beginning which determines how the extension changes their Chrome browser's colors. The initial calibration changes the original colors on the screen according to an algorithm. This means the colors of the end result *depends* on the color of the input. It also means the *entire* page changes colors. This may not be ideal if the user is only concerned with better reading graphs, charts, and diagrams. A better solution for increasing readability for color blind users is if one could change the colors of the visual to preset palettes, instead of relying on algorithmic changes to the visual's original colors.

3. Approach

The key idea behind the approach of Color Charts is a Chrome extension that filters images (specifically visuals such as charts, graphs, and diagrams) on a page with researched color blind friendly palettes. The user has the option to apply the filter to *all* images found on the page, or to only apply filtering on selective images. The colors of the filtered images will only consist of the

ones in a specific color blind friendly palette. Unlike Color Enhancer and Dalton, the output colors will *not* be dependent on input colors. This ensures that the colors of these visuals are consistent across different web pages that use different original colors. By having preset colors that are known to be color blind friendly, these charts, graphs, and diagrams can be better read by color blind web users

4. Implementation

4.1. Problem Overview

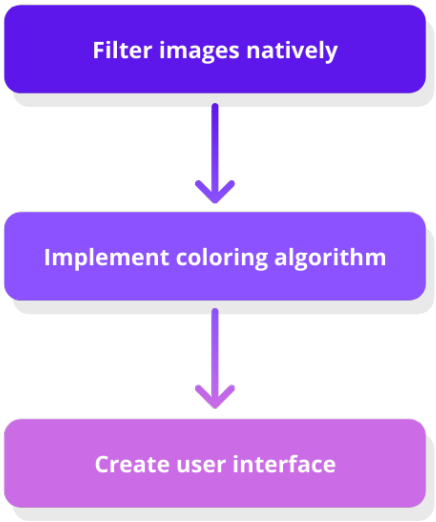

Figure 9: Color Charts problem overview.

4.1.1. Filtering Images Natively

Color Charts intends to filter images a web page. It has to access the <img> tag of the image that is being filtered. Every <img> tag contains a src attribute that is set to the URL of the image so the browser knows where to pull the image from. Since Color Charts filters this image, it needs to either replace the image with another kind of HTML element such as a <canvas> element, or it needs to supply the image's src with the URL of the filtered image.

4.1.2. Coloring Algorithm

4.1.3. User Interface

4.2. Extension Architecture Overview

Built on vanilla JavaScript, Color Charts consists of several scripts and HTML files. Figure 10 shows how the different files interact with each other.

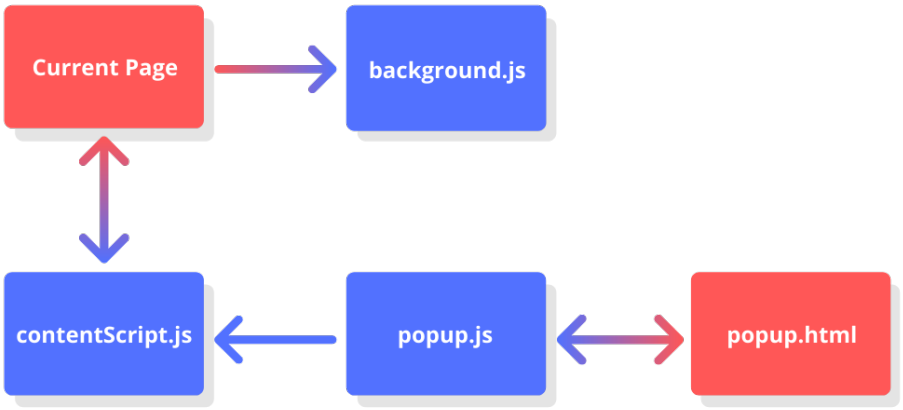

Figure 10: Color Charts architecture.

A content script is a JavaScript file that runs in the context of web pages. It interacts with pages that the browser visits, sending and receving data. In the case of Color Charts, this is the file that captures image data, filters the images, and injects the filtered image back into the page that the user sees. The user interacts with the extension through the popup interface. They can adjust preferences such as selecting which palette to use and if they want selective filtering. The popup consists of an HTML file controlled by a script. The content script receives information from the popup script, changing the filter effects as dictated by the received information. Finally, the page also interacts with a background script. The background script, as the name suggests, runs in the background of the extension, receiving information from the current page such as right-clicks on an image.

4.2.1. Popup

The popup is the front-facing interface that the user interacts with. Upon clicking the extension's logo to the right of Chrome's address bar, the popup displays on the screen. Figure 11 shows Color Chart's popup.

The section below the title is a menu of researched color blind friendly palettes. The credited names and palette are shown next to each option. It includes Okabe and Ito's 8-color palette[5],

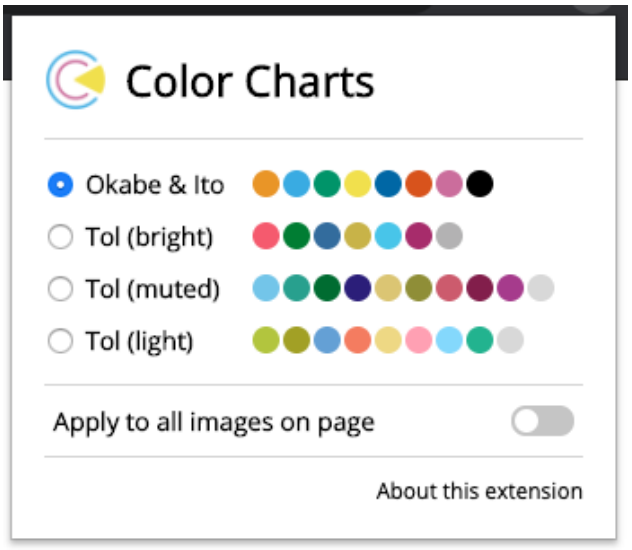

Figure 11: Color Charts popup interface.

as well as three Tol palettes[6]. Upon selection, the popup script uses Chrome extension message passing, tabs.sendMessage() to send the selected palette to the content script.

The next section features a toggle "Apply to all images on page". The toggle's default status is off. When the toggle is off, users are able to selectively choose which images they want to filter by right-clicking on the image. When toggled on, the popup script sends a message to the content script to apply the selected palette to all images on the page.

4.2.2. Content Script

4.2.3. Background Script

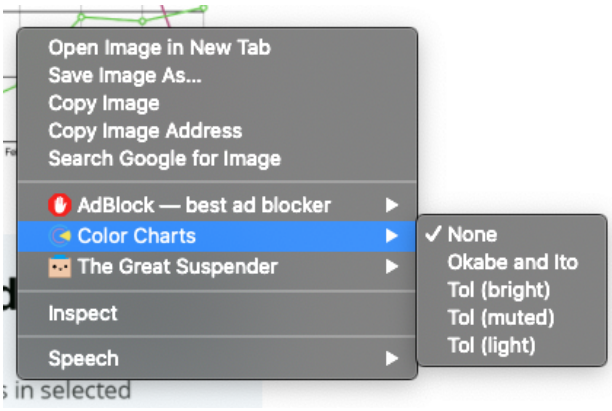

Figure 12: Color Charts context menu.

5. Evaluation

6. Summary

6.1. Future Work

References

[1] [Online]. Available: https://chrome.google.com/webstore/detail/color-enhancer/ipkjmjaledkapilfdigkgfmpekpfnkih

[2] [Online]. Available: https://chrome.google.com/webstore/detail/colorblind-dalton-for-goo/afcafnelafcgjinkaeohkalmfececool

[3] "Color vision deficiency - genetics home reference - nih." [Online]. Available: https://ghr.nlm.nih.gov/condition/color-vision-deficiency

[4] M. Kyrzywinski, "Color palettes for color blindness." Available: http://mkweb.bcgsc.ca/colorblind/

[5] M. Okabe and K. Ito. Available: https://jfly.uni-koeln.de/color/

[6] P. Tol. Available: https://personal.sron.nl/~pault/#sec:qualitative