# ANALYSIS OF SIMULATORS AND ASSISTIVE TECHNOLOGIES WHICH SUPPORT DESIGNERS TO SEE LIKE COLORBLINDS

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## 1 Introduction

Some people are called colorblind by their difficulty to perceive colors [Bruni and Cruz, 2006]. Among 6% and 10% of man and from 0,4% to 0,7% of woman are colorblind in the world [Gordon, 1998]. There are some colorblindness types, usually classified according to color perception capability. Achromatopsia is a rare condition when someone can see just black, gray tones and white. More common types of colorblindness preclude visualization of one primary color. Protanopia prevents perception of red, deuteranopia of green and tritonopia of blue.

A large amount of information is communicated through computer systems. It is common to use colors to represent system feedback or value of variables, to represent differences in maps or charts; or even to represent ideas through a colored image. When information is represented by color, colorblinds could not perceive it.

Those who design user interfaces should consider that a significant portion of the world population cannot perceive certain colors. Different color vision capabilities [Farina et al., 2006] represent a big challenge to designers. A non colorblind person perceives the world in a different way from a colorblind. Even colorblinds can perceive the world in different ways, because there are some colorblindness types.

Several studies have been done on interaction of colorblinds with colored artifacts; for example with maps [Maia and Spilillo, 2013] and road signs [Soares, 2009]. On digital world, initiatives to facilitate interaction of colorblinds have sought to develop tools that simulate colorblindness and assistive tools to support deal with colors.

This work analyzes some simulators and assistive technologies to instrument non colorblind designers to perceive and deal with colorblind user needs during computer systems use.

## 2 Method

We conduct a search on Google, Android app store and Chrome extension store, using terms: “simulator”, “colorblindness”, “assistive technology” and their equivalents in Portuguese. Only free and working tools were analyzed. These tools have been grouped into types that highlight common features, as described below.

## 3 Colorblindness Simulators as Support to User Interface Design

For those who see a wider range of colors, it is very difficult to imagine how it would be to perceive the world with an important restriction of colors. This is usually an unfeasible mental exercise. This lack of non colorblind designers perception prevents their value judgment on user interface solution been conceived for colorblinds. Therefore, non colorblind designers may have difficult to conduct formative and summative evaluations [Barbosa and Silva, 2010] taking into account colorblinds as users.

Colorblindness simulators can be very useful tools to support designers overcome their difficulty in seeing interface as colorblind user would do. We identify four types of colorblindness simulators that apply filters on: image files, computer screen, websites and camera of mobile devices. Most of them simulate protanopia, deuteranopia and tritonopia.

### 3.1 Simulator of Images

Some colorblind simulators receive image files with whole range of visible colors for a non colorblind designer and return other image with what colorblinds would be seeing. We found four websites which simulates colorblindness: *Colour Blindness Simulator*, *Chromatic Vision Simulator* e *Vischeck* e Coblis.

We compare the quality of simulated images. All of them have some problems during transition of colors, but the severity varied. The *Vischeck* presented the better fidelity in color transition on conversion of colors. Each simulated image was obtained by sending a file to the respective website, and selecting the desired colorblindness type. In *Colour Blindness Simulator* and *Vischeck*, the file was sent six times to obtain the results for quality comparing. In *Chromatic Vision Simulator* and *Coblis* was necessary only one sending.

If designer want perceive how his user interface solution would be seeing by colorblinds, he should send for a website all image files that represent the interface. How-

ever, not always designer would be willing to do this, either because of the involved effort or because of secrecy. Simulators of image files allow designers to analyze user interface only in a static way, without the dynamic of interaction process.

### 3.2 Simulator of Computer Screen

Some colorblind simulators apply filters on everything that is being displayed on the computer screen. We found two simulators of computer screen: *Color Oracle* and *Sim Daltonism*. They allow designers to see computer screen like colorblinds, without the need of saving image files and sending them to a website. This represents a significant advantage over image simulators in terms of secrecy, efficiency and use of internet connection. *Color Oracle* and *Sim Daltonism* have a good quality of simulation, however the first just allow static analysis of user interface, and the second allow both static and dynamic analysis.

### 3.3 Simulator of Websites

Some colorblind simulators apply filters on websites. We found eleven Chrome extensions: *Colorblinding*, *Chromacy*, *ChromeLens*, *Dalton*, *Eye*, *I want to see like the colour blind*, *mr gray*, *NoCoffee Vision Simulator*, *Prism*, *RGBlind*, *Spectrum*. Almost all simulate protanopia, deuteranopia and tritonopia, except *mr gray* which simulates just achromatopsia and the *RGBlind* which does not simulate tritanopia. Chrome extensions can locally process the whole page for the simulation. Then, website colors can be quickly modified to alternate among colorblindness types simulation. Only *Colorblinding*, *Chromacy*, *mr gray*, *NoCoffee Vision Simulator* and *Prism* allow static and dynamic analysis of user interface. The others allow just a static analysis.

### 3.4 Simulator of Mobile Device Cameras

Some colorblindness simulators use the camera of mobile devices. We found twelve Android apps: *Chromatic Vision Simulator*, *Colorblind Augmented Reality*, *Colorblind Vision*, *Colorblind VR*, *Color Blinder*, *ColorBlindness SimulateCorrect*, *Color Blindness Simulator*, *Color Blindness test*, *Daltonizer*, *Exposição Diamond*, *Eyeteq* e *NowYouSee*. These apps simulate one, two or three types of colorblindness simultaneously. Only *Chromatic Vision Simulator* and *Colorblind VR* allow simultaneous simulation of three types of colorblindness. All apps allow static and dynamic analysis, except *Eytep* that allow just static analysis.

Designer may need to analyze accessibility for colorblinds of user interfaces represented on non digital media or in devices beyond their control. For example, he may need to analyze user interfaces represented on paper, projected onto a surface, or even on computer that he cannot use. In these cases, the previous simulators types are not useful, but mobile app simulators would help.

## 4 Assistive Technologies for Colorblindness

Sometimes, the user interface solution became accessible when used together with assistive technology. For example, websites may be used by blinds with screen readers. Then, designers also need to know assistive technologies to conceive accessible solutions to colorblinds. We found assistive technologies that identifying colors and recolor images.

### 4.1 Assistive Technologies to Identify Colors

Discovering the color names of certain objects may help colorblinds. Thus, they can access culturally established meanings and make better use of colors. We found two types of assistive technologies to identify colors: website and mobile applications. The website *Colblindor* allows users to identify name of colors from RGB codes. This may be not useful alone, but it is better when used with another "dropper tool". We identified fifteen Android apps to identify colors: Color Analyzer, Color Assist, Colorblind Assistant, ColorBlindClick, Color Blind Free, Color Blind Pal, Color Detector, Color Grab, Colorblind Helper1, Color Blind Helper2, Color ID, Color Identifier, Color Vision, Dalton-H and LedScope.

### 4.2 Assistive Technologies to Recolor Images

Recolor images is a common strategy to help colorblinds to perceive the world. The intention is usually to highlight color in image, to distinct colors by shape patterns draw on color in an image, to shift the range of colors of an image or to automatically increase the contrast between used colors. We identified assistive technologies to recolor images from different sources: screen, website and camera of mobile device.

*Visolve* was the only desktop software to recolor computer screen. For websites, we found three Chrome extensions: *Color Enhancer*, *FreshEyes* e *Vision*. On Android apps, we found seven options: *Color Assist*, *Colorblind Assistant*, *Color Blind Fixer*, *Color Blind Pal*, *Colorblind Vision*, *Eyeteq* and *NowYouSee*.

## 5 Conclusions

This work presents an analysis of simulators and assistive technologies for colorblindness. The goal was instrument non colorblind designer to design user interface for colorblinds. We identified a set of tools to support formative and summative evaluation of user interface being conceived.

Simulators of images and of computer screen are adequate to inspect interface without consider interaction, because they are able to simulate colorblindness on static images. Only the computer screen simulation *Sim Daltonism* allows static and dynamic

analysis. Most of websites and of mobile device cameras simulators allow designers inspect the user interface during interaction, not disregarding the dynamic experience colorblinds would have.

When it is difficult to conceive a good user interface without representing information by colors, designers could analyze if their solution used together with an assistive technology could be accessible for colorblinds.

Although some people consider that the challenging of designing an accessible user interface for colorblinds could be addressed with a contrast study turning all colors into tones of gray [Silva, 2010], we believe the study of simulators and assistive technology presented here is relevant to support designer work in a broader and operational way.

## 6 References


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