Toward Internationalization and Accessibility of Color-based Goal Model Interpretation

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Abstract

Goal model analysis helps individual select between alternatives. Given the amount of information contained within these models, it can be difficult for users to make selections over larger models. Recent work has demonstrated the value of coloring model elements to communicate the level of satisfaction over goals and tasks of interest to users. This work is limited because our choice of color palette may not be applicable to an international audience. In this workshop paper, we describe our efforts to make color visualizations adaptable and appropriate for international users, as well as those with a color vision deficiency. We describe a set of color palettes we developed and how we integrate them into existing tooling. Additionally, we allow individuals to create their own custom palettes.

Keywords

Internationalization, Visualizations, Goal Modeling

1. Introduction and Motivation

Goal models, such as iStar [1], are used to represent a system's objectives, requirements, and desired outcomes. Goal modeling typically involves creating graphical notations such as goal diagrams, goal trees, or strategic dependency diagrams—all of which aim to provide a comprehensive view of the system's objectives and the dependencies of the involved parties (i.e., stakeholders) [2]. Once analysts specify the relationship between the different goals (i.e., dependencies, contributions, or conflicts), then they use the models to make predictions, simulate, or visualize possible trade-offs in achieving the system's objectives. Thus, the process ensures that the design of the system meets the needs and expectations of the stakeholders.

In our broader research group, we focus on supporting stakeholders in decision making by enabling them to consider future projections of model elements and by improving the interpretation of analysis results. Our research tool, BloomingLeaf (see Fig. 1), enables stakeholders to consider trade-off decisions with evolutionary models [3]. Our evaluation visualization overlay (EVO) feature displays the satisfaction value of each intention in the model as a color, where blue denotes satisfaction, red denotes denial, and purple denotes conflict [4]. The efficacy of our EVO feature has been validated and shown to expedite user comprehension [5]. However, EVO does not account for the cultural significance of color, and the existing color scheme may

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not be immediately intuitive to all users. For example, while red is commonly associated with positive events in China, it is used to indicate a denied value in EVO. As a result, users with a Chinese cultural background may misinterpret red as a positive indicator. Thus, we aim to make EVO, and by extension BloomingLeaf, applicable to a global user-base.

Goal model evaluation with color was first introduced in jUCMNav for GRL (Goal-oriented Requirements Language) models in 2009 [6, 7], with green denoting satisfaction and red denoting denial. Subsequently, color has been used to identify legal requirements in GRL models [8], the impacts of a model change [9], and the difference in design choice levels [10]. Additionally, Oliveira and Leite used the RGB (red, green, and blue) color spectrum to indicate the level of satisfaction over elements in non-functional requirement (NFR) models [11]. All of this work has internationalization issues similar to EVO and these issues have not been discussed by the community. Through this workshop paper, we aim to foster a discussion within the community about the use of color in visual representations of goal models.

Contributions. In this paper, we present our international approach for coloring evaluation labels in goal models. Specifically, we present our extension to the evaluation visualization overlay (EVO) feature in BloomingLeaf, which consists of four additional color palettes, as well as a custom palette. This extension is represented in the right-hand side of Fig. 1 (i.e. the drop-down menu and the custom palette editor). The left-hand side of the figure shows the tool as it existed before our extension where the EVO toolbar icon was not clickable.

After a brief introduction of the EVO feature in Sect. 2, we use the concrete example of a secure application to demonstrate each palette in Sect. 3. In Sect. 4, we provide broader contextualization for the community and discuss possible impacts.

2. Background: Evaluation Visualization Overlay (EVO)

Evaluation visualization overlay (EVO) is a color visualization feature of BloomingLeaf developed to facilitate stakeholders making decisions more efficiently [4]. We present our international extension to EVO by updating the i* password example created by Horkoff and Yu [12]. Consider a generic application (App) determining what security features to implement to make user accounts secure. Fig. 1 (left-side) shows the model on the center canvas of BloomingLeaf. The App actor consists of two types of intentions: tasks and soft goals (see legend on left panel of Fig. 1). Analysts are trying to satisfy Attract Users and Secure System by choosing between the three tasks: Ask Security Questions, Require Strong Passwords, and 2-Factor Authentication.

BloomingLeaf allows users to specify whether each element is fulfilled using nine evaluation labels, where each label is assigned a color within EVO. This mapping is shown in the *EVO Legend* in Fig. 1. Since combining red (denied) and blue (satisfied) in color theory results in purple, conflicting values are purple, with more reddish [resp. blueish] shades denoting more denied [resp. satisfied] [4]. Since the EVO slider is in the On position on the top tool bar of BloomingLeaf (see Fig. 1), each intention in the App actor is colored. For example, 2-Factor Authentication is Fully Satisfied (F, $\perp$), which is colored blue, while Attract Users has the conflicting label (P, P) and is colored light purple. Initially, intentions are colored based on evaluation label assignments made by the user. After analysis or simulation, the colors show the final evaluation for each intention, which results from propagation.

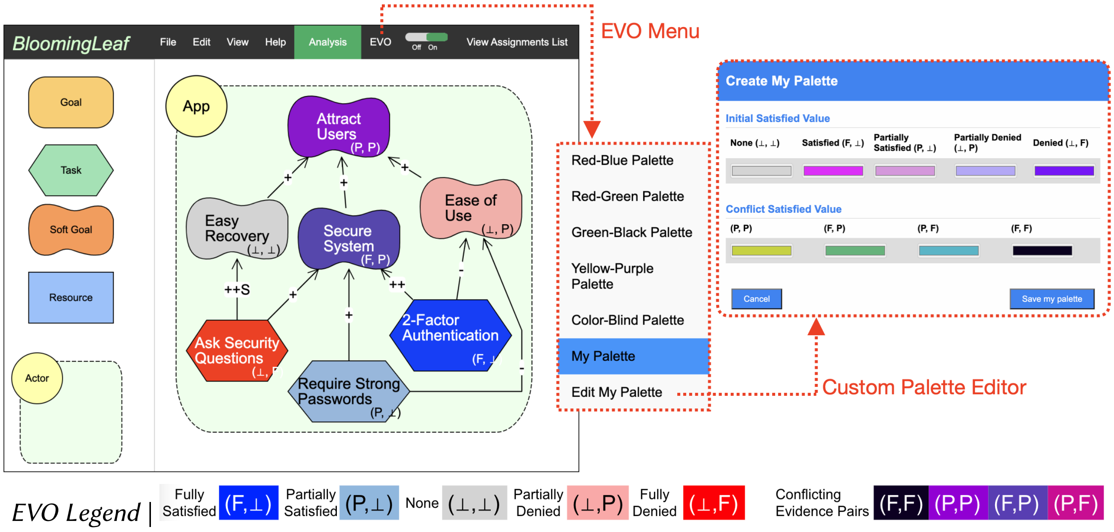


Figure 1: From left to right, the secure App model shown on the canvas of BloomingLeaf, with EVO enabled; the EVO Menu items from the top toolbar; and the custom palette editor pop-up window from the Edit My Palette menu item. Below, the EVO Legend with the original color palette.

3. Results: Color Palettes

As introduced in Sect. 2, users can turn on EVO using the slider in the top toolbar (see Fig. 1). When enabled, users can select from one of six available palettes from the EVO menu. We illustrate the appearance of the EVO palette menu options via the red dashed box and arrow, originating from the EVO toolbar icon in Fig. 1. The Red-Blue Palette is the default and original color scheme. In the remainder of this section we discuss the five new color palettes.

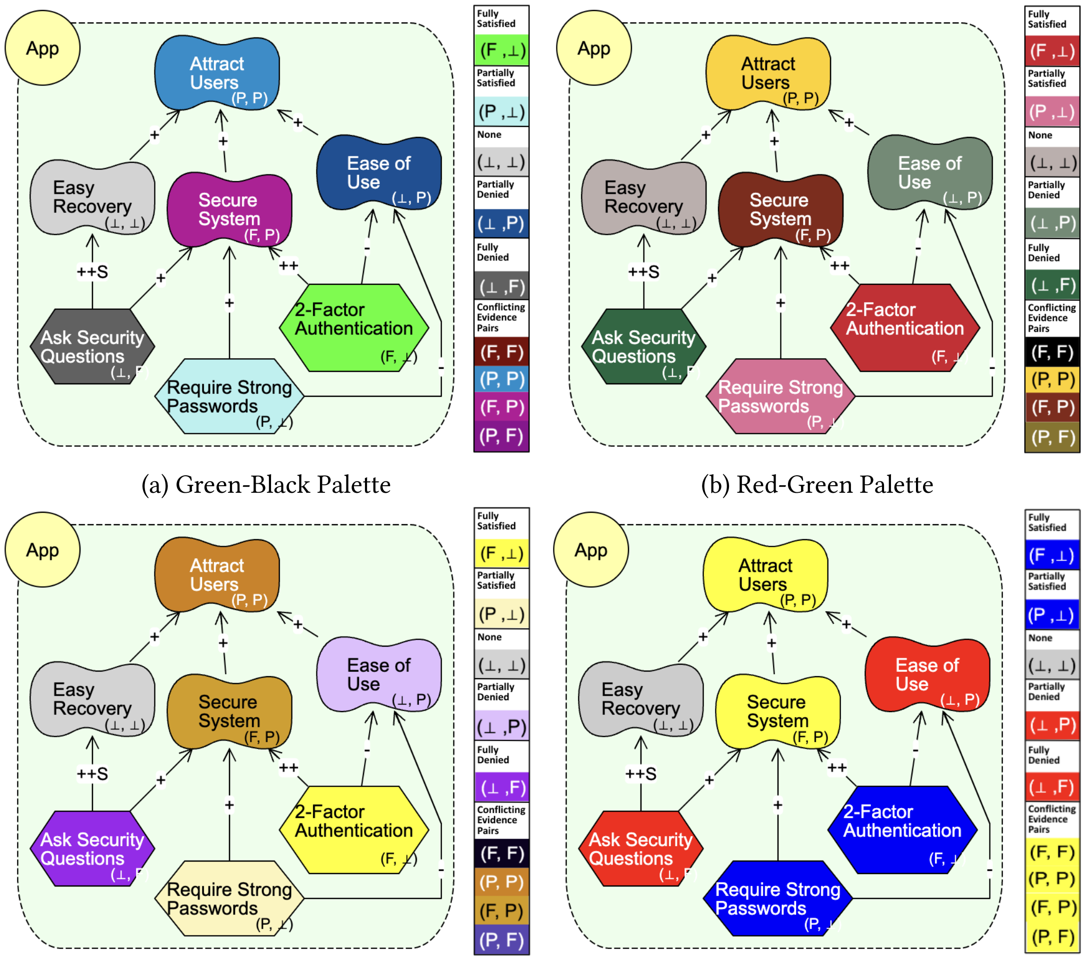
International Palettes. We add three new international color palettes based on the preferences of Brazil, East Asia, and the Arab world. We selected these regions by reviewing the list of top authors in goal modeling [13] and reviewing the proceedings of the iStar workshop[1]. Further research is required to validate this selection. Unlike in the original coloration for EVO (see Sect. 2), we do not mix the satisfied and denied colors for conflicting values in our international color palettes. We illustrate each palette in Fig. 2, showing both the palette legend and coloration of the secure app model (see Sect. 2 for model details). Within BloomingLeaf, users can see the legends for all palettes located in the Help menu of the top toolbar (not shown).

Fig. 2(a) - Green-Black Palette: This palette is based on the Arab interpretation of colors where green is indicative of wealth and prosperity (satisfied), while grey is considered the color of mourning (denied).

Fig. 2(b) - Red-Green Palette: This palette is based on the East Asian interpretation that commonly associates red with good luck, happiness, and prosperity (satisfied) and green with ominous events (denied).

Fig. 2(c) - Yellow-Purple Palette: This palette corresponds to the Brazilian interpretation that associates purple with mourning (denied values), and yellow with pride, wealth, and prosperity (satisfied value).

[1] *https://dblp.org/db/conf/istar/index.html*



(a) Green-Black Palette

(b) Red-Green Palette

(c) Yellow-Purple Palette

(d) Color-Blind Palette

Figure 2: Secure App model shown on four color palettes, with associated legends.

Color-Blind Palette. To make BloomingLeaf more accessible, we designed a Color-Blind palette to provide visual cues for color-deficient users. Roughly 75% of people with a color vision deficiency are anomalous *trichromats*, meaning the green wavelengths are shifted towards the red peak or vice versa. The other 25% are *dichromats* with one of the red, blue, or green pigments missing [14]. Among the *dichromats*, impairment in the blue spectrum is the rarest affecting one out of 10,000 individuals. While it is difficult to target all types of color deficiencies, colors with RGB values made up of 0, 51, 102, 153, 204, and 255 are the safest to use [14]. The R, G, and B values could be any of the specified numbers, for example, (0,0,0) or (153,255,204).

Our Color-Blind palette avoids colors in between red and green [15]. We chose a four-color palette (see Fig. 2(d)): blue for full and partially satisfied, red for full and partially denied, gray for none, and yellow for conflicting values. We expect Deutranopes (green-deficient), Protanopes (red-deficient), and trichmoats users to differentiate between the chosen colors. These users may mistake one of the colors for maroon, green, or white, but will see four distinct colors.

Custom Palettes. Since it would be impractical to create color palettes for all traditions and cultures, we give users the ability to create their own custom palettes, called My Palette (see menu option in Fig. 1). Users can create their own palettes by clicking Edit My Palette from the EVO Menu, then the custom palette editor will appear, as shown in the pop-up on the right-hand side of Fig. 1. In the Create my Palette window, users select each color label by clicking on the current color and then either selecting from a color pie or entering RGB values.

4. Discussion: Future Plans, Related Work, and Summary

We implemented the new palettes introduced in Sect. 3 as part of Release 2.5 of BloomingLeaf (see *https://github.com/amgrubb/BloomingLeaf/releases/tag/v2.5*). Our implementation enables for greater flexibility in reviewing models, allowing users to choose the color palette that most meets their needs. Yet, we have not address how multiple palettes will function in a group setting. For example, when collaborating in a diverse team, groups may need to agree on a single palette for projection on a central display. Alternatively, individuals could load and review the model on separate displays with their preferred color palette, but this would limit the groups ability to use color names in subsequent discussions.

Users can select any RGB values for evaluation labels within My Palette. To ensure sufficient contrast between the text and background colors, we automatically update the text color (i.e., black or white) of each intention. However, allowing unrestricted selection of colors leads to difficulty in error checking. We currently verify uniqueness between the RGB values of satisfied, denied, none, and *strong conflict* (F,F). For example, when the user chooses the same RGB values for satisfied and none, BloomingLeaf displays an error message. But if the user chooses slightly different shades of the same color, their selection is accepted and the model is updated accordingly. Doing so unintentionally may lead to user confusion; yet, reducing visual clutter is an acceptable use case of this action, as in our Color-Blind palette (see Fig. 2(d)).

Future Plans. As mentioned above, we only minimally restrict color selections within My Palette. Future work will investigate how to detect erroneous selections from preferred color duplication. We hope to make BloomingLeaf more accessible to color-blind users. Future work focuses on tritanopes (i.e., people who have difficulty distinguishing shades of blue) and monochromats (i.e., people whose vision is limited to a small range of wavelengths).

Finally, we will validate our palette options through two surveys: one with individuals from the international goal modeling community, and another with individuals with a color vision deficiency. We investigate their usage with both individuals and groups.

Related Work. We are not the first to investigate the use of color in goal models. The colors used for model elements (i.e., actors and intentions) in BloomingLeaf are adopted from REDEPEND [16]. This color palette has also been adopted by GrowingLeaf [17] and CreativeLeaf [18], while a second color palette is used by piStar [19] and OpenOME [20]. Some tools, such as piStar, extend their color palette by allowing users to change an element's background color. Goal modeling tools have been used internationally without much discussion of the color of the elements, with the notable exception of the work by Moody et al. investigating the cognitive effectiveness of the visual syntax of i* models [21]. EVO differs in that it provides coloration for satisfaction and denial of the intentional elements in the model, which have positive and negative connotations for the project. Others have used colors to identify additional model attributes. For example, Sartoli et al. used blue to denote legal requirements within GRL models [8]. Perera et al. used color to denote the level of design choice for associated features in GRL models [10], while Alkaf et al. used color to denote change impacts across model elements [9]. These recent works extend the evaluation colors already present in the jUCMNav tool [6, 7], which uses colors on the green-red spectrum. Similarly, Oliveira and Leite used the RGB color spectrum to indicate the level of satisfaction over elements in non-functional requirement (NFR) models [11]. Using green to denote satisfaction, red to denote denial, and blue to denote unknown values, Oliveira and Leite automatically propagate color values throughout the NFR graph [11]. Thus, like EVO, past goal evaluations research has used colors on the green-red spectrum with red for denial. We hope our investigation of color palettes for international and color deficient users will assist researchers of other goal modeling approaches.

Summary. In this workshop paper, we describe our efforts to make color visualizations in goal modeling appropriate for an international audience, as well as users with a color vision deficiency. We contribute a set of color palettes and integrate them into the EVO feature of BloomingLeaf. Additionally, we enable users to design their own custom palette. We believe that the predefined palettes provide a general sense of preferable model states, while the customized palette enables users to further adjust EVO to their specific needs. Our ongoing work aims to empirically validate that our implementation is better at assisting international users and those with color deficiencies in reasoning about goal models.

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