Color Sommelier

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ABSTRACT
We present Color Sommelier, an interactive color recommendation system based on community-generated color palettes that helps users to choose harmonious colors on the fly. We used an item-based collaborative filtering technique with Adobe Color CC palettes in order to take advantage of their ratings that reflect the general public's color harmony preferences. Every time a user chooses a color(s), Color Sommelier calculates how harmonious each of the remaining colors is with the chosen color(s). This interactive recommendation enables users to choose colors iteratively until they are satisfied. To illustrate the usefulness of the algorithm, we implemented a coloring application with a specially designed color chooser. With the chooser, users can intuitively recognize the harmony score of each color based on its bubble size and use the recommendations at their discretion. The Color Sommelier algorithm is flexible enough to be applicable to any color chooser in any software package and is easy to implement.

Author Keywords
Interactive color recommendation; collaborative filtering.

INTRODUCTION
With the emergence of various types of digital authoring software, even non-designers have become able to produce digital content in daily life, such as documents and presentation slides. When authoring digital content, they often need to choose colors, which significantly influence to the resulting quality. However, for most people with insufficient knowledge and experience regarding color theory, it is not an easy task to choose harmonious colors that will produce a pleasing affective response [1].

To ease this situation, online communities such as Color CC (formerly Kuler) and COLOURLovers have emerged. In such communities, users generate, share, and rate color palettes. Color palettes with high ratings can be considered harmonious, qualified by the preferences of the general public.

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However, users still have difficulties in applying color palettes from such communities to their work at hand. They have to explore a vast set of color palettes and decide on one even before starting their work. They are also challenged when trying to add more colors to a chosen palette with a fixed number of colors (typically 5) and to make partial changes to the palette, inevitably resulting in harmony degradation.

Thus, we present *Color Sommelier*, an interactive color recommendation system based on community-generated color palettes (Figure 1). Color Sommelier enables users to easily choose harmonious colors for their workflow at their discretion, while utilizing the online community's collective knowledge of color harmony.

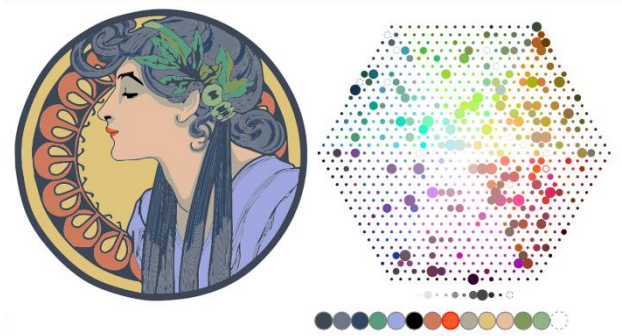

Figure 1. A screenshot of an interactive coloring application with a color chooser implementing Color Sommelier.

COLOR RECOMMENDATION ALGORITHM
In order to recommend harmonious colors, we paid attention to algorithms that are frequently used by e-commerce web sites such as Amazon.com to recommend products to each customer. However, we did not aim at personalized preference modeling that they commonly use because modeling the inexperienced color-choosing schemes of non-experts would reproduce similar unskilled results. Thus, instead of modeling general *user-item* relations [4], we set up qualified *color-palette* relations in order to recommend harmonious colors to both non-experts and experts.

Our algorithm consists of color-palette relation prediction and interactive recommendation. In the prediction stage, we first built a sparse color-palette matrix with community ratings of palettes, each of which composed of only 5 colors. We then estimated all unknown color-palette relations using collaborative filtering. In the recommendation stage, for user-selected colors, Color Sommelier calculates the harmony scores of the remaining colors in real time based on the pre-calculated full color-palette matrix.

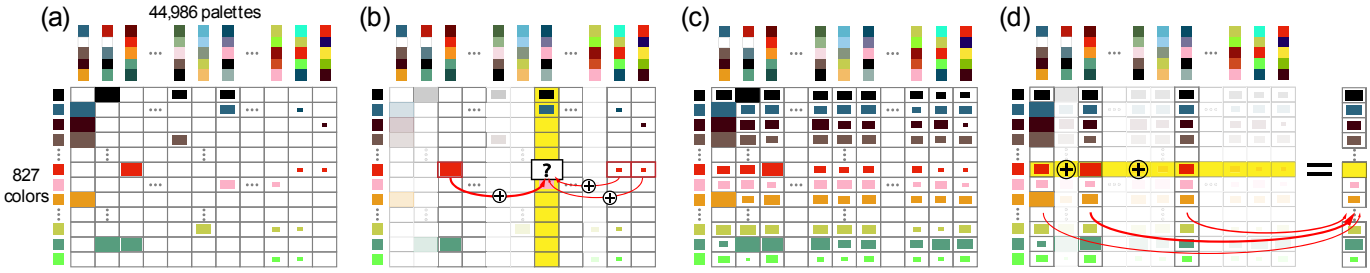

Figure 2. Conceptual overview of the Color Sommelier algorithm: (a) an initial sparse color-palette matrix built from quantized Color CC palettes, (b) prediction of color-palette relations using collaborative filtering, (c) the resulting full matrix, and (d) calculation of the harmony scores of the remaining colors for a chosen color (highlighted).

Predicting Color-Palette Relation by Collaborative Filtering

We used the 44,986 Color CC palettes with their community ratings, which were publicized by O'Donovan and Hertzmann [3]. We first discretized color space into a finite number of color buckets (we chose 827 for our color chooser implemented in Figure 1, right) evenly distributed in the perceptually uniform $CIEL^*a^*b^*$ color space ($\Delta L^*=\Delta a^*=\Delta b^*=10$). We then set up a color-palette matrix (827×44,986 in our case) in which each row corresponds to a color, each column to a palette, and each element to the community rating of each palette (Figure 2a). Because a Color CC palette has 5 colors, each column initially has only 5 non-empty elements.

To fill empty elements of the matrix, we used an item-based collaborative filtering technique [5]. For the value of an empty element of a column, which implies how much the corresponding color is harmonious with the corresponding palette, we calculated the weighted average of the non-empty elements on the same rows of other palettes (Figure 2b), where the weight of each palette is determined by how much it is similar to the given palette having the empty element of interest. We defined palette similarity as the inverse of palette distance, a root mean squared $CIEL^*a^*b^*$ distance between two palettes with the closest-first matched color pairs. After it completes the matrix (Figure 2c), Color Sommelier is ready to make a recommendation.

Interactive Recommendation with Color-Palette Matrix

When a user chooses a color, Color Sommelier calculates the harmony score of each of the remaining colors that matches the chosen color (Figure 2d) from the matrix. The harmony scores are calculated by weighted averaging column vectors, where the weight of each column is the rating of the chosen color within that column. If multiple colors are chosen, the weight is the sum of the ratings. Each time the user chooses different color(s), Color Sommelier updates the harmony scores. This interactive recommendation enables users to iteratively choose colors until they are satisfied.

INTERACTIVE COLORING APPLICATION

To show the usefulness of Color Sommelier, we built a coloring application (Figure 1). A user picks a color on the color chooser on the right, and applies the color to the outlined image on the left by clicking an area to fill. Used colors are added to the user palette at the bottom for later use. The user can reuse one of them by clicking on it in the palette, and remove one from the palette by flicking it away.

For the coloring application, we designed a special color chooser similar to Microsoft's hexagonal color chooser [2] to help users see all colors at a glance without having to navigate 3D color space, allowing them to find their desired colors quickly (Figure 1, right). We split chromatic colors into six hue groups and located each on a triangular area of the hexagonal grid in such a way that lightness decreases radially. We positioned grays separately under the hexagon.

Our color chooser provides an unobtrusive recommendation; the more harmonious a color is with a chosen color(s), the bigger the bubble that is displayed (Figure 1, right). Users can intuitively recognize a recommendation and use it at their discretion (they may even ignore it).

CONCLUSION AND FUTURE WORK

In this paper, we suggested a novel method of interactive color recommendation utilizing collective knowledge on color harmony. The Color Sommelier algorithm is flexible enough to be applicable to any color chooser in any software and is easy to implement. We look forward to seeing Color Sommelier help users orchestrate color harmony in a wide range of application areas that go beyond drawing and coloring, including creating documents and charts.

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REFERENCES

1. Burchett, K. E. (2002). Color harmony. *Color Research & Application*, 27(1), 28-31.
2. Busch, B., Ho, R., Keller, M., Ruescher, H., Wilfrid, E., & Harris, C. (1999). *U.S. Patent No. 5,903,255*. Washington, DC: U.S. Patent and Trademark Office.
3. O'Donovan, P., & Hertzmann, A. (2011). Color compatibility from large datasets. In *Proc. SIGGRAPH '11*.
4. O'Donovan, P., Agarwala, A., & Hertzmann, A. (2014). Collaborative filtering of color aesthetics. In *Proc. CAe '14*, 33–40.
5. Sarwar, B., Karypis, G., Konstan, J., & Riedl, J. (2001). Item-based collaborative filtering recommendation algorithms. In *Proc. WWW '01*, 285-295.