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Emotion-based interior design image recommendation system using color image scale

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***Abstract*— Color is a visual element that psychologically affects people's emotion. Most professional designers reflect colors in their product catalogs. In many cases, catalogs display similar products with different colors according to the emotion given by the color combination. However, it is not easy for non-experts to align colors according to emotion. In this paper, we present a novel system that explores design images using a color combination based on color image scale theory. In our system, similar to the catalog example, users explore design images that have a coherent emotion in order to find appropriate images more easily. In this paper, we propose a novel method that estimates emotion based on the color image scale, which is a famous color theory in the field of design, and displays interior design images coherently according to the emotion using our proposed image recommendation method.**

***Keywords*—color image scale, emotion, interior design image**

I. Introduction

Color is one of the visual elements that psychologically affect people's emotion. Although there are slight differences based on culture, several studies in color psychology have found that most single colors generally have meaning or emotion [1, 2]. In addition, the combination of colors also significantly affects emotion [3]. Many people apply these principles knowingly or unknowingly in their daily life, for example, to coordinate clothes, select furniture color, etc.

Most professional designers also reflect these principles on their product catalogs. In many cases, catalogs display similar products with different colors based on the emotion generated from the color combination. For example, in order to assist a customer to select the paint color for the walls in a room, an interior designer might provide the customer with a catalog that shows the walls painted with several color combinations, while the picture of the wall is ordered by emotion. Consequently, the customer can easily select the exact color of the product from those with similar emotion. However, it is not easy for non-experts to align colors according to their emotion.

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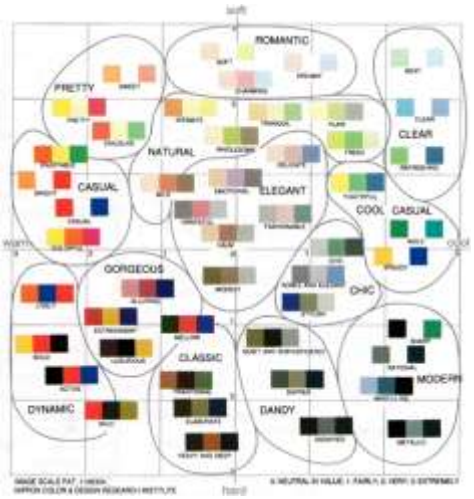
In this paper, we present a novel system that recommends and explores interior design images using the emotion estimated from images based on the color images scale theory. In our system, similar to the catalog, users explore interior design images with coherent emotion in order to find appropriate images more easily. We establish an emotion prediction model using a machine learning technique. For this, we find the relationship between the emotion and the properties of the color combination in the color image scale. Then, we extract the main colors from the image. Finally, we estimate the emotion of the image via the properties of the main colors extracted. Once the prediction model is ready, any other knowledge is not required for our system. In our system, we recommend and display images coherently according to their emotion using our proposed emotion connection graph. A preliminary version of this paper was published in [4]. Compared with [4], we have improved the algorithm, which now includes a new method for image recommendation and exploration.

The remainder of this paper is organized as follows. In Section 2, we present the background of the color image scale and related work. Then, in Section 3, we explain our approach for finding emotions from input design images using our established model. In Section 4, we present our system, which recommends and explores images based on their emotion. Then, in Section 5, we demonstrate the results of our proposed method and discuss the algorithm used and its limitations. Finally, we conclude this paper in Section 6 with a summary of our ideas and outline of future work.

II. Related Work

In psychology, many studies on emotions evoked by a single color or a color combination were conducted for a long time . Following these studies, it is known that a single color has its own meaning [1], evokes a measurable emotion [5, 6], and has a strong universal trend [7]. Furthermore, several studies [8, 9] have shown that color combinations evoke their own emotions.

The color image scale [9, 10, 11] is a theory studied by Shigenobu Kobayashi and the Nippon Color & Design Research Institute. In their psychophysical research, they presented over 1000 color combinations to express any emotion, taste, or lifestyle that belongs to 174 semantic keywords on the emotion perceived from color. They labeled each combination of three colors with one of 174 keywords. In addition, they devised a two-dimensional emotion space, the color image scale, which consists of two axes that correspond to the scales cool-warm and soft-hard. On the color image scale, they located every keyword according to its two scales measured by several studies. Figure 1 presents the concept that illustrates several examples of three-color combinations, along with their keywords, plotted in the color image scale. In this scale, they also defined 15 categories such that each keyword belongs to one of the categories.



(a) Three-color combinations

(b) The emotion keywords

Figure 1. Three-color combinations and emotion keywords on color image scale.

(a) Input image

(b) Normalized image with Hue & Tone 130 colors

(c) Colors used in normalized image

(d) Top three colors frequently used

Figure 2. Extracting three-color combinations from input image. We normalize an input image using Hue & Tone 130 system, and extract the three colors most frequently used in the image.

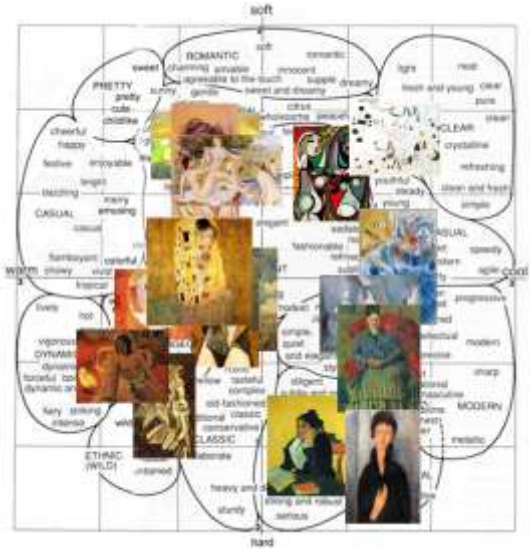
III. Estimating Image Emotion

A. *Establishing emotion prediction model from three-color combinations*

In order to estimate an emotion from an image, we use the three-color combinations surveyed by Kobayashi [10]. His research provides such combinations tagged as the name of the emotion, and thus we can estimate emotion from an image by extracting a color combination from the image. Kobayashi's research also provides the name of each color combination and the emotion position in the color image scale. Because the positions of the emotion keywords are graphically represented in [10], we estimate the position by acquiring the center position of the text in the graph obtained from [10]. Consequently, we obtain three-color combinations that include the name of three colors and of the emotion tagged on the combinations, and the emotion position in the color image scale.

Although Kobayashi provided several three-color combinations tagged with emotions, he did not cover all available three-color combinations in every image. Thus, estimating an emotion from random color combination is important in order to find the relationship between each color in Kobayashi's three-color combination. In order to estimate such relationship, we employ a machine learning technique. First, we extract features from the colors in the combination, such as the hue/saturation/luminance difference between two colors, and the average hue/saturation/luminance value of three colors. Consequently, we obtain a 12-dimensional feature for each three-color combination. Next, we generate data pairs with the features and two-dimensional position of the emotion tagged on the data, three-color combination . Finally, we acquire a prediction function that estimates the emotion coordinates from the random three-color combination using linear regression [12].

(a) Ground truth



(b) Our results

Figure 3. Ground truth color image scale of 16 images used by [10] and our results.

For our experiment, we used 936 three-color combinations and 174 emotions. In order to ignore the order of the colors in the combination, we generated all possible combinations from the given 936 three-color combinations, such that six combinations are generated from each three-color combination. The range of both coordinates in the color image scale is [-3:+3]. In our experiment, the prediction error magnitude was recorded at 0.64. In our analysis, the significant factors seem to be average (avg.) hue, hue difference, avg. saturation, and intensity.

B. *Estimating emotion by extracting color combinations from image*

In the previous section, we establish a model for predicting emotion from three-color combinations. Therefore, if we obtain three-color combinations from images, we can estimate the emotion of the image. In this study, we assume that the three colors used predominantly in an image affect human emotion similarly to three-color combinations. Therefore, we use the three colors most frequently used in an image to estimate emotion.

In general, digital color images have 24-bit depth color. There are too many discrete colors in an image, and thus finding the most frequently used colors is not meaningful. For this reason, we normalize an image by enforcing a limited number of colors. Kobayashi used Hue & Tone 130 system in [9] to construct the image scale of three-color combinations, and thus we normalize image colors using the same color system (Figure 2).

After normalizing the colors, we estimate the emotion coordinates in the color image scale of an image using the prediction function described in Section 2. Kobayashi showed the coordinates of 16 famous painting images in [10] (Figure 3(a)). Similarly to the emotion names, we acquire the image coordinates by calculating the center position of each image on the figure in his book. For 16 images with ground truth emotion, we estimate emotion as the coordinates in the color image scale (Figure 3(b)). In our experiment, the mean error magnitude was recorded at 2.08.

In our experiment, the performance of emotion estimation from an image is lesser than that of the emotion estimation from the three-color combination. In general, digital image colors for the same image differ slightly from each other, and thus a prediction depends mainly on the color of the image. For our experiment, we did not use the same images employed by Kobayashi, and thus the predicted emotion can differ from Kobayashi's ground truth. Moreover, we obtain the three-color combination from an image by the naïve approach; therefore, there is no guarantee that the extracted three-color combination successfully represents the image. Consequently, a more robust approach for obtaining the three-color combination from an image is required.

IV. Emotion-based Interior Design Image Recommendation and Exploration System

In this section, we present our exploration system that finds the desired image based on the emotion estimated as described in Section 3. For our purpose, we propose a two-dimensional parameter-based emotion exploration method. Our system consists of two parts: one is an image exploration window, and the other is an information panel that shows a selected image and its emotion on the color image scale in graph form (Figure 3).

In our method, we recommend and display images using the two parameters employed for establishing the axes of the color image scale, cool-warm and soft-hard, as shown in Figure 4. In this method, a two-dimensional graph is provided to adjust the parameters. On the left panel, the center image indicates the nearest image from the coordinates that correspond to the current parameters. Around the center image, more warmer-cooler and softer-harder images are displayed. The coordinates of these images are near to the coordinates of the center image. To find these images, we generate a Voronoi diagram [13] using the points on the image coordinates and obtain the neighboring cells of the center image. Initially, the value of

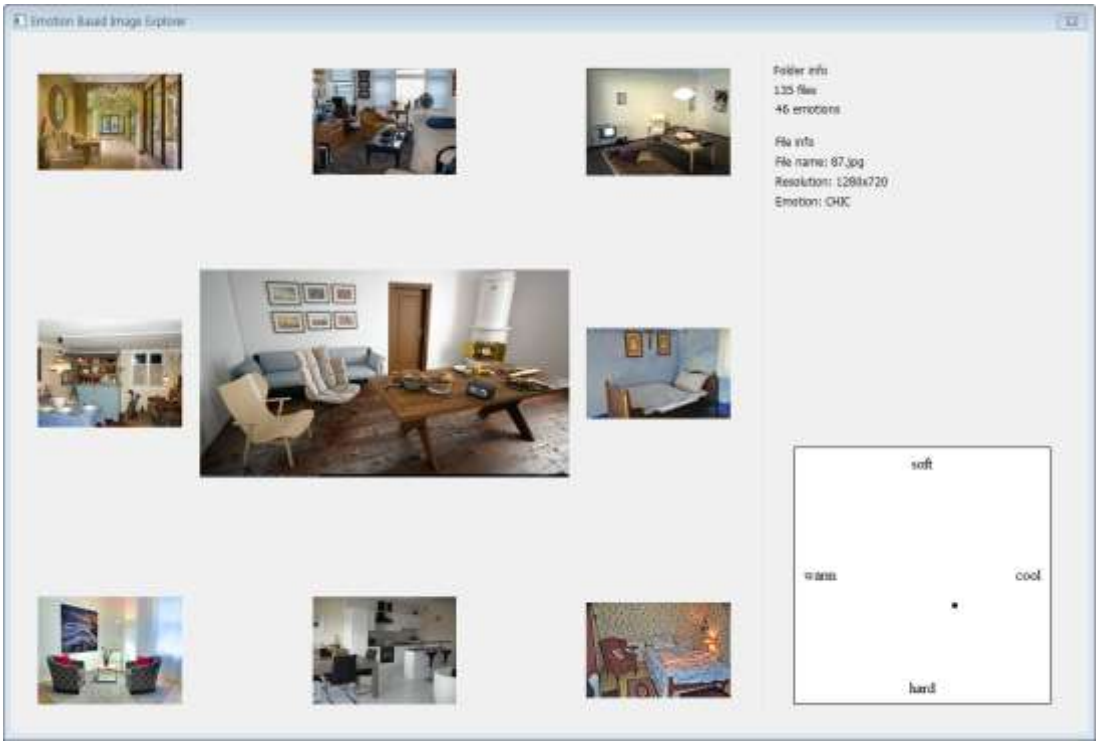


Figure 4. User interface for our interior design image recommendation and exploration system.

Figure 5. Sample question for labeling color image scale of given image.

each parameter is set to zero, which is the origin of each axis. When the user drags a point on the graph to find his/her appropriate emotion, the parameter value changes. Then, our system displays recommended interior design image on the center of right panel. Consequently, images near to the current parameter are displayed around the center image.

Figure 6 shows recommended images of given emotion keywords on proposed system.

V. Experiment Results

In order to evaluate our emotion estimation as described in Section 3, we gathered ground truth data of experimental images using a Crowdsourced user study, Amazon mTurk [14]. The ground truth annotations of 47 interior design images were generated by aggregating the study participants' labels over each image. Figure 5 shows a sample question for labeling the color image scale of a given image. For each image, we asked over 50 participants to select a degree of the two factors, warm-cool and soft-hard, considering color and tone only..

After obtaining the ground truth color image scale of 47 images, we evaluated the performance of our emotion estimation algorithm. In our experiment, the mean errors for warm-cool and soft-hard were measured by calculating the distance between the ground truth and estimated emotion coordinates, and the corresponding values are 0.13 and 0.21.

VI. Conclusion

In this paper, we proposed a novel system that explores images based on the emotion estimated from the image. For this, we constructed a color scheme profile by referring to the color image scale, a well-known theory in design fields, and proposed a method that estimates the emotion of an image using our color scheme profile. Based on this method, we established a system that explores given images according to their emotions. In our system, we provided a method for finding an image that has a desired emotion. Finally, we demonstrated that our method provides effective ways for exploring given images with emotions by conducting empirical studies.

(a) A recommended image from 'provincial'

(b) A recommended image from 'simple and Elegant'

(c) A recommended image from 'mysterious'

Figure 6. Recommended images of given emotion keywords on proposed system.

Our experiment mainly depended on Kobayashi's research. Human emotions affected by color can be altered based on era and culture. However, our method is based on profile , and thus we can easily adapt our method to new one by changing the profile.

The limitation of our work is that the method considers only color schemes. However, the factor that affects the emotion of images is not only color. In our future work, we will find other factors that can affect the emotion of images, such as composition, texture, and more, and modify our emotion estimation method by employing them

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