Emotion-Aware Design Image Recommendation using Color Image Scale

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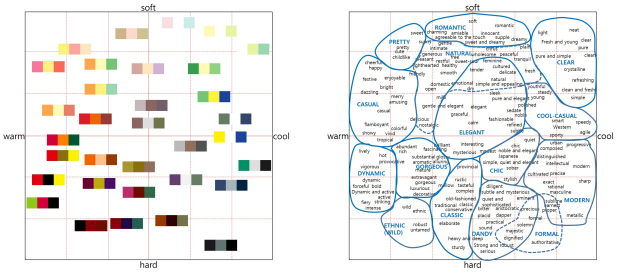
***Abstract*—Color is one of the visual elements that psychologically affect people's emotion. Although there are slight differences based on culture, several studies in color psychology have found that most single colors generally have meaning or emotion. Therefore, most professional designers use colors in their works to express the emotion. In this paper, we present a novel method that recommends design images using a color combination based on the relation between color and emotion. To achieve this, we estimate emotion based on the color image scale, which is a famous color theory in the field of design, and recommend design images according to the emotion.**

Keywords–color image scale; emotion; design image; color combination.



(a) Three-color combinations (b) The emotion keywords

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

I. INTRODUCTION

Color is a visual element that psychologically affects people's emotion. Generally, it is known that single colors have their own meaning or emotion [1]. In addition, the combination of colors also significantly affects emotion [2]. Many people apply these principles knowingly or unknowingly in their daily life, for example, to coordinate clothes, select furniture color, etc.

The color image scale [3] [4] is a theory studied by Shigenobu Kobayashi at 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(a) presents the concept that illustrates several examples of three-color combinations, along with their keywords, plotted in the color image scale [4]. In this scale, they also defined 15 categories such that each keyword belongs to one of the categories.

Most professional designers also reflect these principles in their works. To convey intended emotion, they intuitively employ the color combination in their design. At this time, color combinations which are used for an emotion can be different to each other, because it is known that there are lots of available combinations for an arbitrary emotion. Consequently, the colors used in the works depend on designers' knowledge and experiences, so that it is not an easy task for non-experts and beginners to use colors appropriately according to their emotion.

In this paper, we present a novel method that recommends design images using the emotion estimated from images based on the color images scale theory. 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 in our method, and design images are recommended according to input emotion.

The remainder of this paper is organized as follows. In Section II, we explain our approach for establishing emotion prediction model from color combinations. Then, we present our method for estimating emotion by extracting color combinations from image in Section III. In Section IV, we demonstrate the results of our proposed method and discuss the algorithm used and its limitations. Finally, we conclude this paper in Section V with a summary of our ideas and outline of future work.

II. ESTABLISHING EMOTION PREDICTION MODEL FROM THREE-COLOR COMBINATIONS

To estimate an emotion from an image, we use the three-color combinations surveyed by Kobayashi [4]. His research provides such combinations tagged as the name of the emotion, and thus we can estimate emotion from an image by extracting

 ISBN: 978-1-61208-627-9

(a) (b) (c)

Figure 2. Extracting three-color combinations from input image. (a) Input image, (b) normalized image, and (c) top three colors frequently used.

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 the work [4], we estimate the position by acquiring the centre position of the text in the graph (Figure 1(b)). 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.

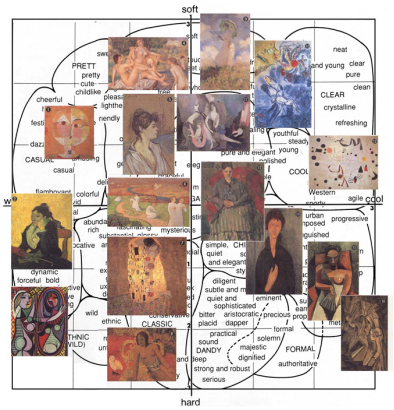
Kobayashi's work [4] did not cover all possible three-color combinations. Thus, estimating an emotion from random color combination is important to find the relationship between each color in his three-color combination. To estimate such relationship, we employ a machine learning technique. First, we 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 [5].

For our experiment, we used 936 three-color combinations and 174 emotions. 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.

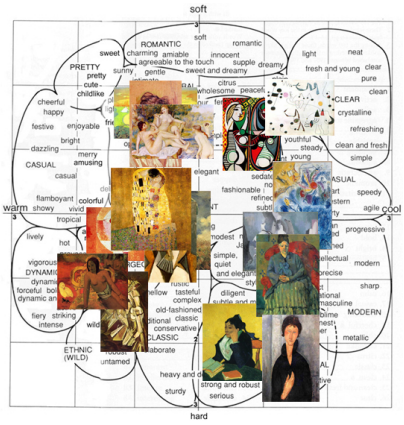
III. Estimating Emotion by Extracting Color Combinations from Image

Once the model for predicting emotion from color combinations is established, it is enabled to estimate the emotion of image by using the color combination of 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



(a) Kobayashi's ground truth [4]



(b) Our results

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

[3] 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 II. Kobayashi showed the coordinates of 16 famous painting images in [4] (Figure 3(a)). Similarly to the emotion names, we acquire the image coordinates by calculating the centre position of each image. 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.

We then recommend several images of which emotion estimated by our method is closer to the input emotion on the color image scale.

IV. Experimental Results

For machine learning methodology, we used linear regression by using Weka library [5]. We evaluated our prediction performance by using 10-fold cross validation. Figure 4 shows recommended images of given emotion keywords on proposed method.

To evaluate our emotion estimation as described in Section III, we gathered ground truth data of experimental images

 ISBN: 978-1-61208-627-9

(a) ‘provincial’

(b) ‘simple and elegant’

(c) ‘mysterious’

Figure 4. Recommended images of given emotion keywords.

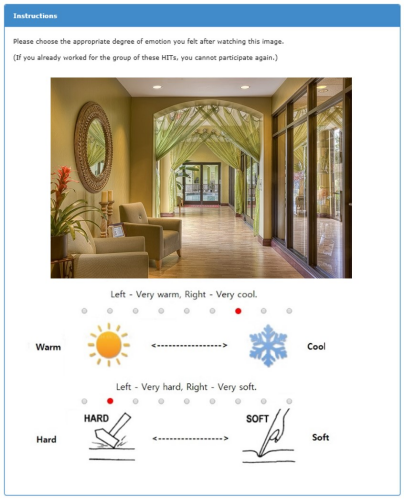


Figure 5. Sample question for labeling color image scale of given image.

using a Crowdsourced user study, Amazon mTurk [6]. The ground truth annotations of 47 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.

In our experiment, the performance of emotion estimation from an image is worse 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 according to image format and compression rate. Therefore, the prediction performance depends mainly on the color of the image.

V. Conclusion

In this paper, we proposed a novel method that recommends images based on the emotion estimated from the image. For this, we established emotion prediction model by using the color image scale, a well-known theory in design fields, and estimated the emotion of image using top three colors and the model. Then we recommended images of which estimated emotion was closer to input emotion on color image scale. In addition, we conducted crowdsourced user study to evaluate our results.

Our experiment mainly depended on Kobayashi’s research. Moreover, we obtained the three-color combination from images by naïvely extracting top three colors frequently used; therefore, there is no guarantee that the extracted three-color combination successfully represents the image. Also, it is known that human emotions affected by color can be altered based on era and culture. Consequently, a more robust approach for estimating human emotion is required in our future work.

In this paper, we consider only color. However, the factor that affects the emotion of images is not only color. In our future work, we will study other factors that can affect the emotion of images, such as composition and texture, and improve our emotion estimation by employing these factors.

Acknowledgment

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (No. NRF-2017R1A2B4007481).

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 ISBN: 978-1-61208-627-9