A NEW IMAGE RE-COLORING METHOD

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Abstract: In this paper, we propose a new method to transform colors in the image according to the user's emotion. First, we labeled the images into four basic emotions such as happy, sad, fear and anger from the users' evaluation. After that, we compute color histograms using 36 quantized HSV scheme. After that, we intersect color histograms and finally construct color templates for basic emotions. To reflect the user's preferences in color perception for specific emotion, we designed interactive genetic algorithm. First, we generate first stage individuals using color templates from the input image. From them, we extract chromosomes for HSV color space and then generate next stage individuals using crossover and mutation operations. After a few number of iterations, we stop the process and extract personalized color templates from the finalized image. Using personalized color templates, the user can generate an affection-based color transformed image according to his own preference. Survey results show that desirable results are obtained from our proposed personalized color templates.

1 INTRODUCTION

Colors are deeply related to our emotions and feelings. For example, the color blue is associated with comfort and yellow is perceived as cheerful (Mahnke, 1996). In particular, if we can transform colors in the contents interactively with the user's affection, it provides various tools for the intelligent human computer interaction. So, it is desirable to analyze color-emotion associations and implement an effective method to reflect the user's own affection in the colors of the contents or media arts.

There have been several attempts to examine color-emotion associations. Boyatzis and Varghese found that light colors are associated with positive emotions and dark colors reveal negative emotions (Boyatzis and Varghese, 1994). Saito found that black elicited both negative and positive responses among Japanese subjects and that black was often a preferred color among young people (Saito, 1996).

In this paper, we propose a new method to transform colors in the image according to the user's affection. In particular, we construct affection-based color templates to transform colors in the image based on the user's preferences using interactive genetic algorithm. Section 2 discusses affection analysis in color information. Section 3 presents color transformation method according to user's affection and Section 4 discusses personalized color templates using interactive genetic algorithm. Section 5 shows our experimental results.

2 AFFECTION ANALYSIS IN IMAGES USING COLOR INFORMATION

To represent affective content, we use a two-dimensional model used by Lang (Lang, 1995), where the horizontal axis represents valence and the vertical axis represents arousal. Valence refers to the affective responses ranging from positive state to negative state. Arousal refers to the responses ranging from excited to the calm. Figure 1 shows two-dimensional expression of four basic common emotions such as fear, anger, sadness, and happiness (Picard, 1997). Color information can also be represented roughly in two dimensional emotion space (Valdez and Mehrabian, 1994, Shreier and Picard, 1999).

To analyze the relationship between basic emotions and colors, we have performed the empirical study on images. First, we showed 150 color images to 42 students and asked the students to choose the appropriate color images for each emotion. We labeled the images into four basic emo-

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Figure 1: Two Dimensional Emotion Space.

tions such as happiness, sadness, fear and anger (Picard, 1997). Secondly, we select most favorable 10 images for each emotion based on the survey results we conducted in the first stage. From selected color images, we compute histograms in HSV color space. We used 36 quantization scheme as in Lei (Lei *et* al., 1999) because this scheme shows good performance in representing color based on human perception. Figure 2 shows Hue and VS panel quantization scheme. Hue is non- uniformly quantized into the colors of red, orange, yellow, green cyan, blue and purple from 0 to 360. In Figure 2, SV panels of two primary colors are shown.

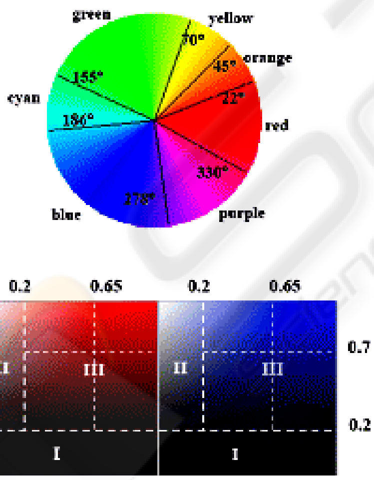

Figure 2: Hue panel quantization (Top) and SV panel quantization (Bottom).

For example, if V<= 0.2, region-I can be perceived as a black area regardless of H and S. If S<0.2, region-II is perceived as a gray area. It can be quantized into 7 indices. Only region –III can be perceived as a colored area. 4x7 indices are obtained from region-III. Using 36 color quantization scheme, we extract color histograms from the given images for each emotion. Then, we execute histogram intersection. Finally, we construct HSV templates like Figure 3. These color templates are similar to the color representation in Figure 1.

3 COLOR TRANSFORMATION USING AFFECTION-BASED COLOR TEMPLATES

Using affection-based color templates, we generate a new color transformed image. Because we constructed HSV color templates, the colors in the image are transformed according to Hue, Saturation and Value.

The re-coloring method of hue in images using templates is similar to the one in Cohen-Or *et* al.(Cohen-Or *et* al., 2006). We re-color the image by shifting the hues according to the affection-based hue templates so that transformed hues reside inside the hue template.

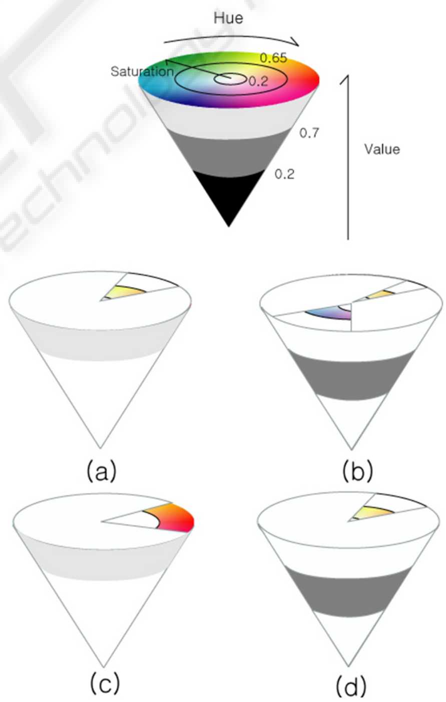

Figure 3: HSV templates (HSV space (top), happiness, sadness, fear, anger template (clockwise)).

The new hue value is computed by

$$H'(p) = C(p) + \frac{w}{2}(1 - G_\sigma(\| H(p) - C(p) \|)) \quad (1)$$

where C(p) is the central value of the sector associated with the pixel, and w is the arc width of the template sector, and G_σ is the normalized Gaussian function with standard deviation σ. According to the σ, the concentration of hues is determined. In our implementation, we use $\sigma = w/2$ for the best color balance.

To transform the saturation value in the image, we shift the whole saturation histogram of the image instead of shifting each pixel to generate smoothed transformed image. From the saturation histogram, we select the pixel value which has the highest count as the representative saturation value. The transform saturation value S' is as follows.

$$S' = S_{cur} + w*(S_{tar} - S_{\max}) \quad and \quad 0 \le S' \le 1 \tag{2}$$

where $S_{\max}$ is the representative value, S_{tar} denotes center value of the sector, S_{cur} is the current saturation value and w is the weight ranging from 0 to 1.

To transform the brightness value, we implement a non-linear characteristic function like Weber's law. The brightness value at pixel p is transformed by

$$p' = T(p) = (\frac{p}{255})^{\frac{1}{\lambda}} \times 255 \tag{3}$$

where in our implementation λ is 2.0 for happiness, 0.4 for sadness, 0.5 for anger, and 0.3 for fear, respectively.

4 PERSONALIZED COLOR TEMPLATE USING INTERACTIVE GENETIC ALGORITHM

Usually, every person has different color preferences for each emotion. So, it is desirable to modify the color templates according to the user's preference. In this Section, we will discuss the personalized color template using interactive genetic algorithm. The interactive genetic algorithm is a Genetic Algorithm where the evaluation part of it is subjectively handled by a user (Sugahara et al., 1998). Actually, the user's preference cannot be numerically quantified because it depends on the perception of the user. So, optimization is performed by human evaluation.

The chromosome representation of the color image can be done by histograms of color space. For example, each color image consists of three chromosomes such as H, S and V which are shown in Figure 4. For example, the chromosome of H consists of 12 genes. Each gene carries numeral information concerning the Hues at every 30 degrees because Hue is represented by hue circle. The value of each gene is computed from normalized histograms. Saturation and Value chromosomes consist of 10 genes whose values are computed from histograms similarly to Hue.

The procedure of the constructing personalized color templates with interactive genetic algorithm is shown in Figure 5. The process of each stage is as follows.

- Generation of the first individual: From the original image, we generate 7 individuals (or color transformed images) from H, S and V templates by using H, S, V, HS, HV, SV and HSV transforms.
- Evaluation: In response to each presented individual, the user is asked to use buttons to give evaluation based on his own subjective view. The evaluation scores are used as fitness values within the interactive genetic algorithm. In addition, if the user select keep button, the selected individual is transferred to the next generation.
- Termination: The procedure is terminated by the user's decision when the user finds a desirable individual.
- Selection: The tournament selection is used where 2 individuals from the population are randomly selected, leaving only those with the highest fitness level.
- Crossover: The crossover operation is executed from mother and father and the crossover point is determined by the mother and father's fitness value. For example, in Figure 6, the crossover point is 8 because mother's fitness value is two times larger than father's fitness value. From the generated individuals, we construct Hue, Saturation and Value templates like Figure 6 by choosing large genes and converting them to the H, S and V values.
- Mutation: The gene values in H, S and V are altered with 1 % rate. The altered values are randomly decided by the system.

With the termination of the interactive genetic algorithm, we obtain the desirable image. From this image, we can extract chromosome information for H, S and V. Finally, we can construct color templates which reflected the user's color preference for each emotion. Using these templates, we can generate personalized affection-based color transformed images.

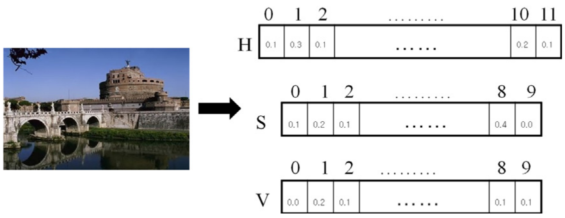

Figure 4: Three chromosomes of the image.

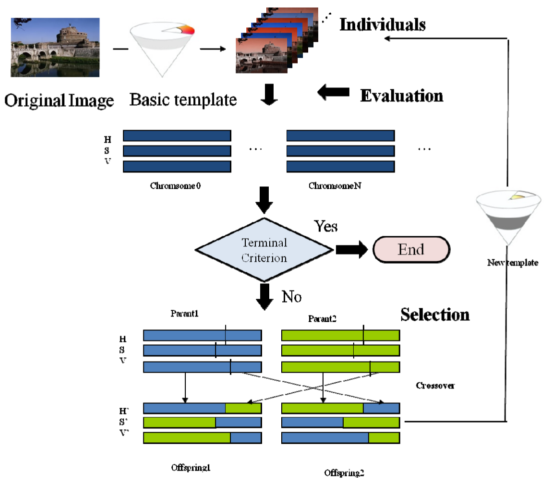

Figure 5: Interactive genetic algorithm procedure.

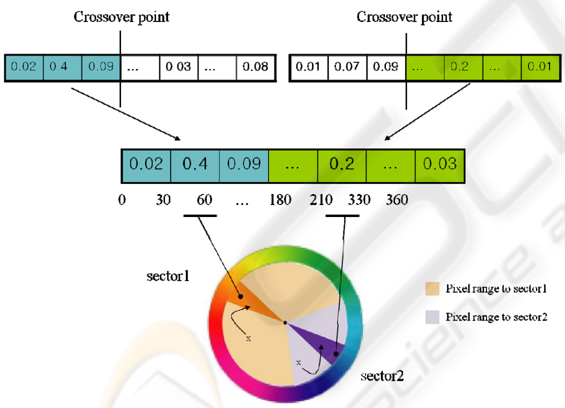

Figure 6: Crossover operation.

5 EXPERIMENTAL RESULTS

We implemented our method as shown in Figure 7. First, we construct color templates of H, S and V for basic emotions such as happiness, sadness, fear and anger Figure 8 shows the results using color templates. The results are checked with 32 students and 25 students among them are satisfied with the color transformed images. The satisfaction percenta ge is 78% approximately.

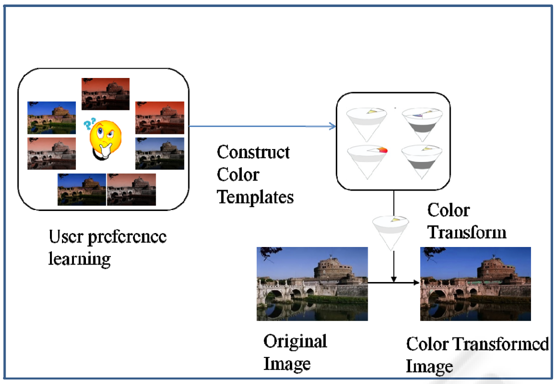

Figure 7: Overview of the proposed method.

With these images, we experimented user's preferences using interactive genetic algorithm. Figure 9 shows the user interface. The user inputted his evaluation score from 0 to 5. If the user pressed the keep button, the image is transferred to the next stage. After a few number of iterations, the user stopped and selected the most favorable image. From that image, the modified color templates are constructed. Using these templates, the color transform is executed. Figure 8 shows the results using personalized color templates. We also measure the satisfaction for the generated image. After testing 32 students, the satisfaction percentage is rated as 84%. So, the satisfaction rate is increased compared to the basic color templates. Desirable results are obtained from our proposed personalized color templates.

6 CONCLUSIONS

In this paper, we proposed new personalized color templates to transform colors according to the user's affection. Based on the survey results from many subjects, we construct basic color templates for each emotion. After that, the user evaluates the generated images from basic color templates. Based on the fitness score, the images are selected using tournament method and the offsprings are generated. After iterating this process, the user stopped the process if he finds his favorable image. From that image, we construct color templates.

These modified templates reflect the user's preferences for color. Our experiments show desirable results.

In the future, it is desirable to examine the relations between color preferences according to gender and age. In addition, cross-cultural research could shed the light on the issues about how cultural differences vary in color-emotion associations.

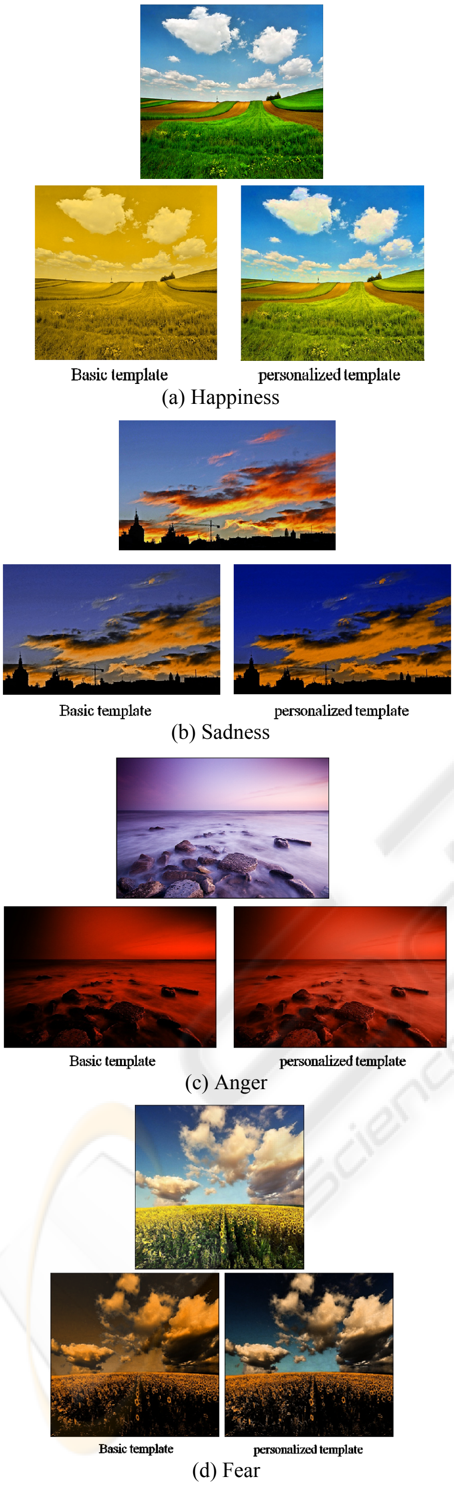

Figure 8: Experimental Results.

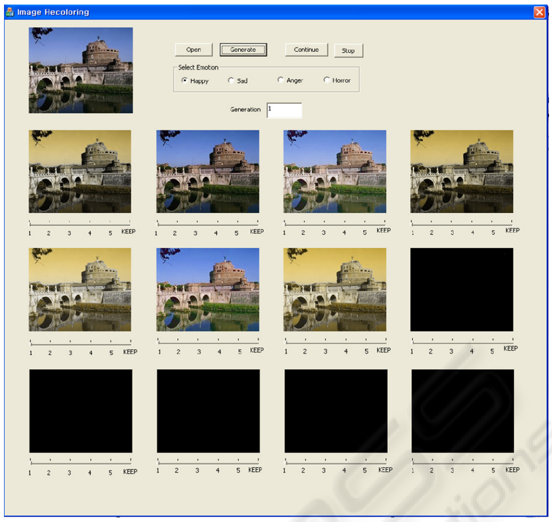

Figure 9: User Interface.

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