1. INTRODUCTION

A color scheme is a significant element in most designs. Recently, some color websites, such as COLOURlovers and Adobe® Kuler have been available for general use. These websites allow users to share artists’ color schemes and utilize them freely. However, obtaining their desired color schemes from a large dataset is difficult. Hence, people who do not have sufficient skills or knowledge of colors need to devote more time and effort to obtain their favorite color scheme.

In previous studies, an interactive evolutionary computation (IEC) has been applied to some color support systems for color scheme creation or color design. Existing IEC-based color schemes generating systems provide users with several suggested color schemes [1, 2]. Other existing systems support color design for clothing, interior accessories, and products [3-6]. An IEC-based approach gives users various color scheme candidates by changing color patterns; hence, users can find their favorites among all candidates. Furthermore, this method uses some human inputs; consequently, it is possible to gradually narrow the candidates based on user kansei (sensibility, preference, and aesthetic). Conventional IEC-based systems directly encode all color data in RGB, HSB, or L*a*b* color space; thereby, these approaches can cause combinatorial explosion with the number of target colors increases. In fact, most previous studies did not target more than three colors. Because of this limitation, it may be difficult that a color scheme creation method using the conventional IEC method gives users their desired color patterns with over three colors.

To overcome this limitation, we adopt an IEC method based on statistics. This new approach has two advantages. First, it decreases the computing cost compared to conventional IEC-based approaches because the proposed approach fixes the number of data; second, it maintains overall color scheme impressions. Previous studies have reported that people respond similarly to specific colors or color schemes [7-10]. The common responses or impressions are related to combinations of hue, saturation, and brightness. The statistics-based approach enables the overall impressions to be changed by using the statistics of a color scheme. In contrast, conventional IEC-based approaches do not consider the overall color scheme impressions. The proposed method enables users to find a desired color based on their kansei.

In addition, this system introduces four similarity search (SS) functions based on hue, saturation, brightness, and color differences. Consequently, we expect that the combination of the proposed IEC method and four SS functions will enable users to obtain their desired color schemes based on their kansei.

2. RELATED WORK

Color is an effective graphic design element and can change the impressions of almost all advertising media. To fully utilize the effects of color, color harmony is significant because an appropriate combination of colors enables people to convey information efficiently and
effectively. Moon & Spencer summarized a color harmony theory and quantified it as an aesthetic measure [11-13]. Matsuda has created a color harmony model by summarizing some forms, schemes, and relationships in a practical color coordinate system developed by the Japan Color Research Institute [8]. Previous studies were able to model or theorize color harmony. By referring to these outcomes, other studies have reported some color support methods for color transfer, color scheme creation, and other applications.

2.1 Color support methods

O’Donovan et al. and Lin et al. used a similar approach to investigate color compatibility or color impressions [14, 15]. This approach uses large color datasets or data of user experiences. By analyzing these large datasets, O’Donovan et al. studied color compatibility theories and Lin et al. proposed two methods: a probabilistic factor graph model for coloring and a method for extracting color themes from images using a regression model. These methods allow users to utilize colors effectively. However, people also use an inharmonic color scheme intentionally to attract attention in advertising material. Therefore, our proposed method also considers inharmonic color schemes.

Wang et al. and Murray et al. proposed an automatic color transfer method [16, 17]. Wang et al. used a large dataset to learn concept color schemes. By utilizing these learning sets, the user can obtain good recolored photographs by specifying an appropriate color concept. Murray et al. used a convex clustering algorithm to set color model complexity. This method can use photographs and illustrations and control the level of the adopted concept colors. Both methods allow users to change the colors of a target image to change its impression. However, these methods do not consider individual preferences. Our proposed method considers each user preference.

2.2 IEC-based color support methods

Inoue et al., Kinoshita et al. and Tobitani et al. have presented IEC-based color creation methods [1, 2, 18]. In particular, The method of Kinoshita et al. incorporated Moon and Spencer’s color harmony equations. Sugahara et al., Ito et al., Miki et al., and Hsiao et al. have proposed colorization methods for Japanese kimonos (Japanese-style clothing), t-shirts, office space design, and product color design, respectively [3-6]. The advantage of IEC is the incorporation of human evaluations into the results. Thus, IEC-based method makes it possible to obtain a desired result.

3. STATISTICS-BASED IEC METHOD FOR COLOR SCHEME SEARCH

Conventional IEC-based color support systems do not consider the characteristics of colors. Previous studies have introduced an objective function to adjust color scheme candidates based on color harmony theory [2, 18, 19]. This is a good solution for the creation of harmonious color schemes; however, the use of the object function becomes a hindrance when obtaining a favorite color scheme. In addition, it is difficult for novice users to take color harmonics into consideration when generating a desired color scheme.

To overcome these issues, we utilize enormous color scheme dataset available from color websites. Consequently, the effective color scheme search method is required. This section describes our proposed statistics-based IEC method for color scheme search.

3.1 Statistics data of color scheme in IEC

Our proposed statistics-based IEC uses basic statistics: average values, standard deviations, or coefficient of variations in a color scheme. We focus on the overall color scheme impression. The impression is related to hue, saturation, and brightness. For example, when a user wants a warm color scheme, he/she will look for a reddish color scheme. We consider the statistics of overall impressions for color schemes. Human perception of colors is an important factor when choosing color schemes. Generally, HSV and HLS color models are utilized for hue, saturation, and brightness values. However, these models do not consider human perceptions. L*a*b* color space is a well-known perceptually-based color model. Color difference in L*a*b* indicates the Euclidean distance in the color space, and this distance corresponds to human perceptions. We uses L*c*h* values, which are represented in L*a*b* color space. L*c*h* means brightness, saturation, and hue values respectively. Note that \( c* = \sqrt{(a*)^2 + (b*)^2} \) and \( h* = \arctan(b*/a*) \). \( L* \) are calculated in L*a*b* color space. To consider human perception as much as possible, this study adopts the perceptually-based saturation \( S = \sqrt{a^2 + b^2}/(a^2 + b^2 + L^2 \times 100% \) reported by [20] instead of \( c* \). Therefore, we adopted the average values \( L_{ave}, S_{ave}, h_{ave}, c_{ave}, h_{ave} \), the coefficient variations \( L_{ave}^*, S_{ave}^*, h_{ave}^* \), and the standard deviation \( h_{SD}^* \). Note that \( L_{ave}^*, S_{ave}^*, h_{ave}^* \), and \( h_{SD}^* \) are normalized [0, 1] by their extreme values in a color scheme database (DB).
3.2 Interactive genetic algorithm for a color scheme search

In this study, we adopted an interactive genetic algorithm (IGA), which is a commonly used IEC method. Next, we describe the statistics-based IGA for color scheme search. The IGA processes are described in the following seven steps. GA parameters and the genetic operations are shown in Table 1.

STEP 1. Generate initial population

Statistics for an individual are provided in Figure 1. An initial population of IGA is strongly associated with IGA search performance. In this study, the search space is a dataset of color schemes; therefore, all generated individuals are color scheme data in the color scheme DB. The IGA used here utilizes probability distributions of each cluster to generate various candidates in the initial population. The process of generating the initial population is as follows.

The first process uses multidimensional scaling (MDS) for the color scheme DB. Then the color scheme DB is visualized as a 2D map. The next process applies a k-means clustering technique to categorize the 2D map. Note that the number of neighboring clusters is set as $k=9$ based on the dendrogram result. Figure 2 shows the results of k-means clustering. Each point is a color scheme in the DB. The coincident colored points have same cluster ID. Nine black points indicate the center of gravity of each cluster. Final process assigns nine probability distributions on the basis of the Euclidean distances between each point and its center of gravity. The upper right portion of Figure 2 shows the probability distribution of the brown cluster. The gradation colors show the probabilities. The reddish color denotes color schemes that have higher probabilities, and the bluish color denotes color schemes that have lower probabilities. A candidate is selected from the color scheme DB based on a probability distribution. Hence, nine candidates are stochastically chosen from the color scheme DB based on the probability distributions of each cluster as the initial population.

STEP 2. Replace all genes

General IGAs are used to generate fonts or musical content by combining parameters (genes). In this study, the IGA does not generate color schemes; it displays color scheme candidates. This method replaces each gene of an individual color scheme with each statistic of the color schemes in the DB. First, the fitness value is calculated by comparing an individual with each DB color scheme. Then, all genes of the individual are replaced with the set of statistics that has the maximum fitness value among the dataset in the DB. The fitness value $f$ is defined as follows:

$$ f = 1.0 - \sum \omega_i A_i / \sum \omega_i, \quad A = \{\Delta L^*_{ave}, \Delta S^*_{ave}, \Delta h^*_{ave}, \Delta L^*_{C,F}, \Delta S^*_{C,F}, \Delta h^*_{SD}\} $$

(1)

Here $\omega$ is a weighting parameter and $A$ is a set of the difference values between the current selected color scheme and a DB color scheme with each statistic. Note that $\Delta h^*_{ave}$ is a sharp angle and normalized $[0.0, 1.0]$ dividing by 180. In this study, all weighting parameters

<table>
<thead>
<tr>
<th>Table 1: GA parameters and genetic operations</th>
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<tbody>
<tr>
<td>Population size</td>
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<td>Population size</td>
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<tr>
<td>9</td>
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<tr>
<td>Crossover</td>
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<td>Uniform Crossover</td>
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**Figure 1:** Configuration of an individual

**Figure 2:** Result of k-means clustering
are set to $\omega=0.2$ ($i=1, 2, \ldots, 6$). In the future study, appropriate weighting parameters determined by user feedback will be investigated.

**STEP 3. Display candidates**

Nine candidate color schemes are displayed. These candidates are determined by each individual after the readout of the color schemes from the DB.

**STEP 4. Evaluate candidates by user**

A user evaluates the displayed candidates by choosing a candidate that is close to their desired color scheme. This method accelerates IGA search because the user performs an evaluation at each iteration [21]. If the user finds a desired color scheme, the process is terminated.

**STEP 5. Select individuals**

Here, the IGA uses Elite Selection and Roulette Selection as individual selection methods. In Elite Selection, the selected individual in STEP 4 (Elite A) and the individual with the maximum fitness (Elite B) become elites. In Roulette Selection, seven individuals are selected stochastically based on Eq. (2).

$$P_i = f_i / \sum_{i=1}^{N} f_i$$  

(2)

Here $f_i$ is the fitness value between Elite A and each individual $i$, $N$ is the number of all individuals excluding Elite A. This study sets $N=8$. Note that Elite A remains a selected individual each time.

**STEP 6. Crossover**

The IGA has adopted the uniform crossover technique. This technique exchanges the corresponding statistics. In this IGA, four pairs of individuals are selected from all individuals including the two elites. This process considers color compatibility on the basis of hue and tone (brightness and saturation) [8, 14, 22, 23]. Thus, for brightness and saturation, an average value and a coefficient of variation are paired. Two pairs exchange the statistics with each value. For hue, the average value and the standard deviation are exchanged individually. Note that the probability of exchange is 50% for each statistic item.

**STEP 7. Mutation**

The mutation process also considers color compatibility. This process has three replacement target patterns: statistics in brightness and saturation, statistics in hue, and all statistics. Note that the replacement target pattern is determined by a one-third probability. This mutation process randomly chooses a color scheme from the DB. Each statistic value of an individual is replaced with each corresponding statistic of the chosen color scheme. Note that the probability of running this process is determined by the mutation ratio.

4. COLOR SCHEME SEARCH APPLICATION

A color design support application has been implemented by using the proposed method. Furthermore, this application incorporates four SS functions. The combination of the proposed method and the four SS functions improve the search performance. This section describes the application and the details of the four SS functions. In addition, this application has a color transfer function. This section also illustrates the process flow. Figure 3 shows screenshots of each function in the implemented application.

4.1 IGA mode

Figure 3 shows a screenshot of the color scheme search function, named IGA mode. The IGA mode applies the proposed statistics-based IGA. The statistics-based IGA enables searching of a color scheme based on an impression of overall color scheme. Thus, the various color scheme candidates can be displayed. Normally, users use this mode to search for various types of color
schemes as a global search. This system consists of undo and redo buttons, the display area for each color scheme, and an initialize button. This mode simultaneously shows 10 color schemes. The biggest color scheme shown in Figure 3(a) indicates the currently selected candidate. The other color schemes are the selectable candidates. This system displays various color scheme candidates based on user evaluation, and the displayed candidates are gradually narrowed with iteration of the user selection operation. The evaluation is performed by clicking on a favorite color scheme. When the user chooses a candidate, the system presents other candidates.

4.2 SS mode

Figure 3(b) presents a screenshot of the SS mode. The SS mode has four different SS functions. One function is based on the color difference in L*a*b* color space. The color difference based function shows results based on the similarity \( s \) given by Eq. (3).

\[
\begin{align*}
 s &= \min D, \\
 D &= \{d_1, d_2, \ldots, d_n\}, \\
 d_i &= \sum_{j=1}^{n} \text{diff} \left( C_{i,j}, C_{j} \right), \\
 C_{\text{set}} &= \left\{ c_{11}^i, c_{12}^i, \ldots, c_{1n}^i \right\}, \\
 C &= \left( \begin{array}{cccc}
 c_{11} & c_{12} & \cdots & c_{1n} \\
 c_{21} & c_{22} & \cdots & c_{2n} \\
 \vdots & \vdots & \ddots & \vdots \\
 c_{n1} & c_{n2} & \cdots & c_{nn}
\end{array} \right),
\end{align*}
\]

where \( D \) is a set of the sum of values of color differences for every combination of a selected color scheme and each DB color scheme. \( d_i \) is the sum of color difference between a selected color scheme and the \( i \)-th DB color scheme. Here, \text{diff} is a formula to calculate the Euclidean distance between two colors in L*a*b* space using CIEDE2000 [24], which is a more sophisticated formula than normal Euclidean distance. \( C_{\text{set}} \) and \( C \) are the set of color schemes in the selected color schemes and DB color schemes, respectively. \( c \) denotes a color value, \( n \) is the number of DB color schemes, and \( \alpha \) is the number of colors in a color scheme. Note that this study set \( n = 7850 \) and \( \alpha = 5 \). All DB color schemes have a precomputed similarity \( s \). This SS function shows results in ascending order.

The other functions are based on hue, saturation, and brightness. These SS functions also shows results in ascending order, respectively. In addition, we set two constraint parameters \( \phi^1 \) and \( \phi^m \) to preserve overall color impression. \( \phi^1 \) is relative to the average values of hue, saturation, and brightness (\( L_{\text{ave}}, h_{\text{ave}}, \) and \( S_{\text{ave}} \)). \( \phi^m \) is relative to the coefficient variations of saturation and brightness, and the standard deviation of hue (\( L^*_{C.V.}, S_{C.V.}, \) and \( h^*_{C.V.} \)). Figure 4 shows a conceptual model for determining the SS results in the case of \( L^*_{\text{ave}} \) (brightness). The orange cylindrical volume shows the acceptable volume for the \( L^*_{\text{ave}}, S_{\text{ave}}h^*_{\text{ave}} \) space. The origin is the currently selected color scheme. Each colored circle denotes DB color schemes in the space. The red and blue arrows indicate the constraint parameters \( \phi^1 \) and \( \phi^m \). Note that \( \phi^1 \) must set two different values when hue is constraint variable. In Figure 4, the constraint parameters are the major and minor radii of the \( S_{\text{ave}}h^*_{\text{ave}} \) plane. The color schemes denoted by green circles are chosen are not selected. The SS results show all selected candidates on \( L^*_{\text{ave}} \) and \( L^*_{C.V.} \). Thus, this process is also conducted for the coefficient of variation. SS results for hue and saturation are determined in the same manner. For example, in the case of brightness, the SS function candidates fulfill the following condition; \[ |\Delta L^*_{\text{ave}}|/\bar{L}^* + |\Delta S_{\text{ave}}|/\bar{S}^* \leq 1 \land |\Delta S_{\text{ave}}|/\bar{S}^* + |\Delta C.V. |/\bar{C.V.} \leq 1. \] These parameters as \( \phi^1 = 18, \phi^m = 5, \) and \( \phi^m = 0.1 \) respectively.

4.3 Color transfer function

This application has a color transfer function that changes the color pattern of a scalable vector graphics (SVG) image. SVG images do not deteriorate by color transfer processing and can be rendered most web browsers. The color scheme search function targets five colors. However, some SVG images are composed of more than five colors. Thus, a color reduction process is required for color transfer processing. The color reduction process continues to merge a pair of colors with the smallest color difference until the number of colors becomes five. This process is based on a process presented in [25]. The color reduction process applies the specified SVG image. When the user chooses a color
scheme using the color scheme search function, this color transfer function changes the color pattern of a SVG image based on the chosen color scheme. Each color assignment is determined by the color difference of CIEDE2000. The function computes the sum of color differences for all assignment patterns, and the assignment pattern with minimum value is applied.

5. EXPERIMENTAL EVALUATION

The proposed color search method can search a desired color scheme without the user having any knowledge or skills regarding colors. We considered that setting a user's desired color scheme is difficult for novice users because the desired color scheme is often unclear in the user's mind. Furthermore, the user may frequently change the desired color scheme during the color scheme search. Therefore, it is impossible to evaluate whether the user can actually obtain a desired color scheme. Section 1 described some common impressions that people characteristically have of specific colors and color schemes. We conducted an experiment that focused on this characteristic. In addition, we also conducted an experiment using the color transfer function. The goal of the second experiment was to investigate the effectiveness of the practical use of the proposed method.

5.1 Details of the two experiments

The task of first experiment was to find a suitable color scheme for some concept words. Figure 3(c) shows the experimental function. This function has a start and stop button, a timer, a display area for a concept word, a display area for the selected color scheme, a visual analog scale (VAS) area (an evaluation area), a counter, and a next button. First, the participant searched for a suitable color scheme for the displayed concept word using the color scheme search system. If the participant found the best color scheme or exceeded the time limit, the experiment was terminated. The proposed method adopted a VAS [26]. The evaluation item of this experiment was “agree-disagree” scale. The SVG images were displayed sequentially, as is shown in Figure 3(d). The size of the display area was fixed at 500×500 pixels, and each SVG was scaled to fit in the entire display area. In both experiments, the time limit was 2 min. Ten male graduate students in their 20's participated in the experiment. The experimental equipment included the LCD monitors (FlexScan M1950-R, Size: 19 inch, Resolution: 1280×1024) and PCs (Intel Core i7 2.3GHz, 8GB RAM). In some cases, different equipment of equal performances was used. The color of the LCD monitor was adjusted by using the following values: color temperature, 6500K; contrast, 50; brightness, 30. The distance between each participant and the LCD monitor ranged from 40 to 50 cm. All participants performed this experiment in the same room. The first experiment used 35 concept words described by [7]. The second experiment used 10 vector images selected from a website1. The DB was constructed by using 7850 color schemes from COLOURlovers.

5.2 Experimental results

We recorded all evaluation items and operation times for both experiments. Figures 5 and 6 show the results of the first and second experiment respectively.

In both results, the letters are the participants ID. The red dashed line indicates the average values of the experimental results. The black dashed line indicates the center value. Note that all evaluation values are normalized in the range [0, 100]. In the first experiment, 0 indicates “agree” and 100 indicates “disagree.” The results are shown for each concept word. In the second experiment, 0 indicates “like” and 100 indicates “dislike.” IDs, such as “I1,” indicate each illustration. The average time for the first experiment was 47.30 s. The average time for the second experiment was 51.97 s.

In Figure 5(a), all average values indicate “agree.” The results for the concept word “Tranquil” strongly indicate an “agree” response. Figure 5(b) shows examples of the selected color schemes for “Tranquil.” These examples have two features. Some color schemes consist of (1) similar tone (saturation and brightness) patterns and (2) similar hue patterns. The results indicate that the statistics-based approach works effectively.

This result indicates that the proposed method allowed users to obtain a desired color scheme based on concept words. Furthermore, the average operation time was

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Statistics-based Interactive Evolutionary Computation for Color Scheme Search

In the experiment discussed by [1], which targeted three colors, the average operation time was approximately 1.5 min. However, the proposed method targeted five colors, and the operation time was less than that of the existing method proposed by [1].

In Figure 6(a), all average values indicate “like” responses. The results for “I9” strongly indicate “like” responses. Figure 6(b) shows examples of recolored images for “I9.” The common feature is that the silhouette regions (castle and bats) are darker colors. We suppose that the castle and the bats in the image gave the specific meaning as “silhouette,” thereby the participants fixed a darker color. From this assumption, the participants would focus on the other four colors in their color choice. Consequently, the participants could determine a favorite color pattern more easily and efficiently.

The operation time was only 3 s slower than the first experimental result. The participants could obtain a favorable colored illustration using the color scheme search. Therefore, we assume that the proposed method has an acceptable level of practical usability. Figure 7 show some examples of the recolored illustrations. Note that the ID numbers corresponding to Figure 6(a).

Figure 6: Results of the second experiment

47.30 s. In the experiment discussed by [1], which targeted three colors, the average operation time was approximately 1.5 min. However, the proposed method targeted five colors, and the operation time was less than that of the existing method proposed by [1].

In Figure 6(a), all average values indicate “like” responses. The results for “I9” strongly indicate “like” responses. Figure 6(b) shows examples of recolored images for “I9.” The common feature is that the silhouette regions (castle and bats) are darker colors. We suppose that the castle and the bats in the image gave the specific meaning as “silhouette,” thereby the participants fixed a darker color. From this assumption, the participants would focus on the other four colors in their color choice. Consequently, the participants could determine a favorite color pattern more easily and efficiently.

The operation time was only 3 s slower than the first experimental result. The participants could obtain a favorable colored illustration using the color scheme search. Therefore, we assume that the proposed method has an acceptable level of practical usability. Figure 7 show some examples of the recolored illustrations. Note that the ID numbers corresponding to Figure 6(a).
6. COMPARISON EXPERIMENT

Despite the fact that a conventional IEC-based method has the potential to cause combinatorial explosion; we need to completely verify the search ability. To compare a conventional IEC-based color scheme creation application (see 2.2) and our proposed color search scheme application, we conducted an experiment in which the participants used and evaluated the two applications. The purpose of this experiment was to investigate the search abilities of the proposed method and the conventional method.

6.1 Procedure of comparison experiment

Five male graduate students in their 20’s took part in this experiment. The experimental equipment and conditions were the same as for experiments 1 and 2 (see 5.1). To enable users to obtain a desired color scheme, the ideal application must provide users a huge variety of their preferred color patterns. Thus, we set five specific rules: "not-specified", "pastel color", "vivid color", "dark color", and "achromatic color". Firstly, the participants’ task was to choose one preferred color pattern within 30 s on either application based on each specific rule. Next, the participants operated an unused application and conducted the same task. The order of using the two applications was determined by a random generator. The final step was to select a preferred color pattern from two color patterns participants chose in the first and second steps. The two color patterns were displayed side-by-side. The participants repeated this experimental task five times. Note that the specific rules were displayed randomly without duplication.

6.2 Details of conventional method

To implement the conventional IEC-based color scheme creation application, we must determine the data structure, genetic operations, and parameters. Here, we employed the same settings as our proposed IGA (see 3.2). The conventional IGA has three different processes: (1) an individual is created from 25 real numbers composed of five colors in HSB color space; (2) the initial population is generated randomly; and (3) the mutation process individually changes all genes based on the mutation ratio. Note that the process of Step 2 is skipped.

6.3 Results of comparison experiment

Figure 8 shows the results indicated by the number of votes. Figure 9 shows the average values of saturation and brightness calculated from the color schemes the participants selected. An HSB color space was used for the calculations.

Figure 8 shows that the results for the proposed method are better than those for the conventional method in “not-specified”, “pastel color”, “vivid color” and “achromatic
color”. The results of “not-specified”, “pastel color”, and “vivid color” indicate significant differences in a chi-square test ($\alpha=0.05$). In contrast, the case of “dark color” has lower results for the proposed method; however, the chi-square test revealed no significant difference. These results indicate that the search ability of the proposed method is superior to that of the conventional method.

Figure 9 indicates that both methods were able to satisfy each specific rule. Figure 9(a) shows that the results for the proposed method are lower than that of the conventional method for “pastel color”, “dark color”, and “achromatic color”, and higher for “not-specified” and “vivid color”. These results indicate that the proposed method was able to follow each specific rule more accurately than was the conventional method. Figure 9(b) shows that all results for the proposed method are higher than those for the conventional method. The DB of the proposed application is composed of the popular color patterns sourced from the website of COLOURlovers. These results may be due to the fact that many popular color patterns contain some bright colors.

7. CONCLUSION

We proposed a color scheme search method to obtain users desired color schemes without requiring users to have any special skills or knowledge regarding colors. Our proposed method adopted a statistics-based IEC method and four SS functions. The statistics-based IEC method considers overall color scheme impressions and provides the suggestions for various types of color scheme candidates. The four SS functions support to narrowing the candidates. To investigate the effectiveness of the proposed method, we performed two experiments. The experimental results confirm that the implemented application of the proposed method allows users to obtain a desired color scheme in less than 48 s. Relative to operation time, the proposed method is superior to the existing method proposed by Inoue et al. [1]. In addition, the results of the second experiment indicate that the proposed method enables users to obtain some favorable recolored illustrations in less than 52 s using a color transfer function. Therefore, we consider that the proposed method is valid for practical use.

Furthermore, we conducted a comparison experiment using a conventional IEC-based color creation application. The results indicate that the search ability of the proposed method is superior to that of the conventional method. The analysis results based on saturation and brightness indicate that the proposed method was able to satisfy four different specific rules.

In future, we will improve the proposed method by including the ability to respond to gradational color combinations and texture combinations.

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REFERENCES


22. Shigenobu Kobayashi; Color Image Scale, Kodansha USA, 1992.


25. Kunio Kondo, Masahiro Takahashi, Masanao Matsunaga, and Hideki Yamazaki; A Kansei Method for Retrieving Images from a Database Using Colors, The...


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