DEIM Forum 2021 D21-2

Generating Color Patterns of Impression Words for Retrieving Abstract Landscape Paintings

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Abstract This paper proposes a method to generate color patterns of impression words for retrieving abstract landscape paintings. As impression words, this paper studied *warm*, *cold*, *natural*, and *desolate*. First, to each painting, we annotate one or more of those four impression words that express the impression of the painting. After five dominant colors are extracted from each painting, candidates for colors included in the color pattern of each impression word are manually selected from the five dominant colors. Those candidates collected throughout the whole dataset of abstract landscape paintings are clustered through k-means clustering algorithm. The centers of each cluster are selected as the colors included in the color pattern of the impression word. In order to evaluate the generated color patterns of the four impression words, this paper proposes four variants of distances between the color pattern of an impression word and the dominant color of an abstract landscape painting. This paper also evaluates the proposed distances in terms of ranking paintings according to their distances from the query impression word. The color patterns of the four impression words generated by the proposed method outperformed the color patterns designed for general purpose use and published by NIPPON COLOR & DESIGN RESEARCH INSTITUTE INC. (NCD).

Key words impression word, abstract landscape painting, k-means clustering

1 Introduction

There exist several image retrieval systems that use impression words as the retrieval query keyword. Those include K-DIME [2], IRIS [7], ART MUSEUM [6], and INMUL-Kansei [4]. However, none of them does not focus on abstract landscape paintings. The proposed method in this paper focuses on retrieval of abstract landscape paintings through an impression word as the retrieval query keyword. As for the color pattern, INMUL-Kansei [4] uses the color patterns published by NIPPON COLOR & DESIGN RESEARCH INSTITUTE INC. (NCD) [3], [5], and focuses on flower images and brush paint images. However, the color patterns published by NCD are not appropriate for retrieving abstract landscape paintings.

This paper proposes a method to generate color patterns of impression words for retrieving abstract landscape paintings. Since the $L^*a^*b^*$ color space fits our impressions [4], the color space is used throughout the processes of extracting dominant colors from a painting, calculating the distance between a painting and an impression word, generating the color pattern of an impression word. As impression words, this paper studied *warm*, *cold*, *natural*, and *desolate*. First, to each painting, we annotate one or more of those four impression words that express the impression of the painting. After five dominant colors are extracted from each painting, candidates for colors included in the color pattern of each impression word are manually selected from the five dominant colors. Those candidates collected throughout the whole dataset of abstract landscape paintings are clustered through k-means clustering algorithm with $k = 5$. The centers of each cluster are selected as the colors included in the color pattern of the impression word. In order to evaluate the generated color patterns of the four impression words, this paper proposes four variants of distances between the color pattern of an impression word and the dominant colors of an abstract landscape painting.

This paper also evaluates the proposed distance measures in terms of ranking paintings according to their distances from the query impression word. The color patterns of the four impression words generated from the dataset of abstract landscape paintings outperformed the color patterns designed for general purpose use and published by NCD.

Table 1 Color Patterns of Impression Words

Impression Word	Generated by the Proposed Method	Published by NCD [3], [5]
warm		
cold		
natural		
desolate		

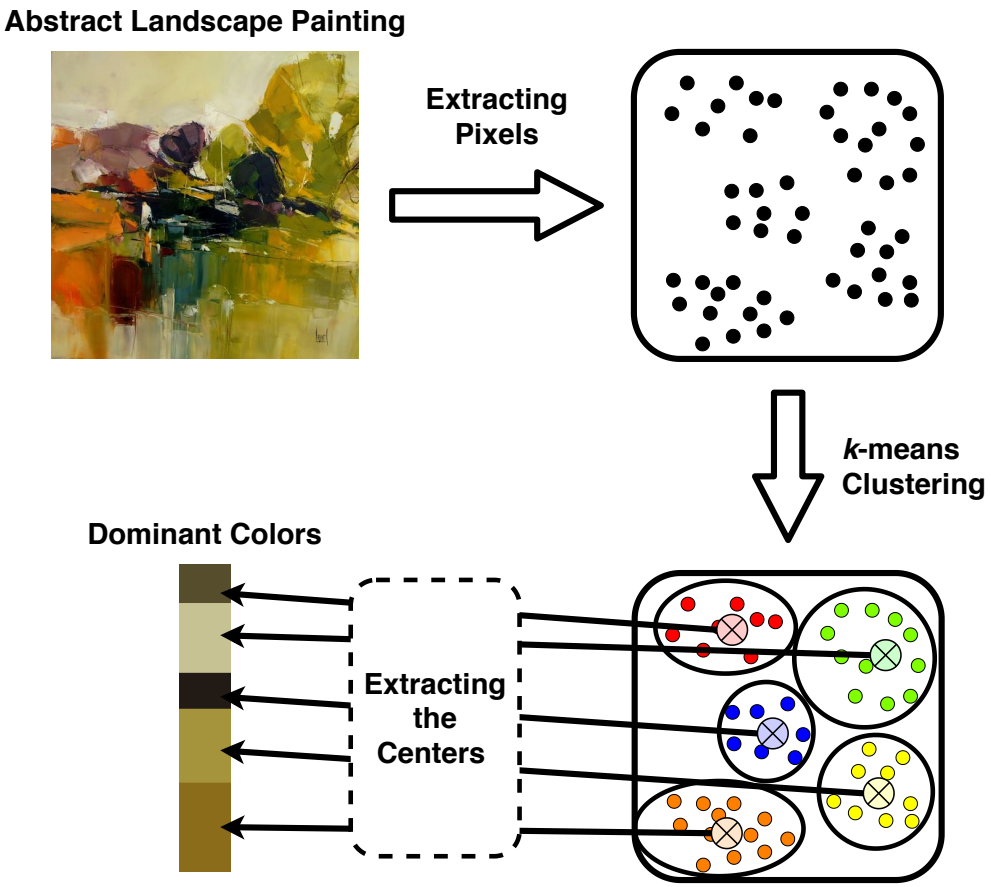

Figure 1 Extracting Dominant Colors of a Painting

2 Related Works

K-DIME [2] uses neural networks to define relationships between images and impression words. Images are interpreted as subsets of perceptual states, each of which is stated as *"the signature, or set of low-level descriptive variables, extracted by a set of image processing algorithms that describes the image in terms of color, texture, and shape features"* by Bianchi-Berthouze [2]. The neural network uses the subsets of the perceptual states as inputs.

IRIS [7] uses neural networks to define relationships between scenery images and impression words. It is stated by Kuroda and Hagiwara [7]: *"An image is divided into some regions. Next each region is roughly classified into the sky, earth and water categories by the image recognition method using a neural network. Then the image characteristics are extracted from each category."* The neural network uses the characteristics as inputs.

ART MUSEUM [6] employs the canonical correlation analysis to define relationships between paintings and impression words. A painting has 33 characteristics, and impression words are expressed as a 30-dimensional vector.

INMUL-Kansei [4] uses the color patterns published by

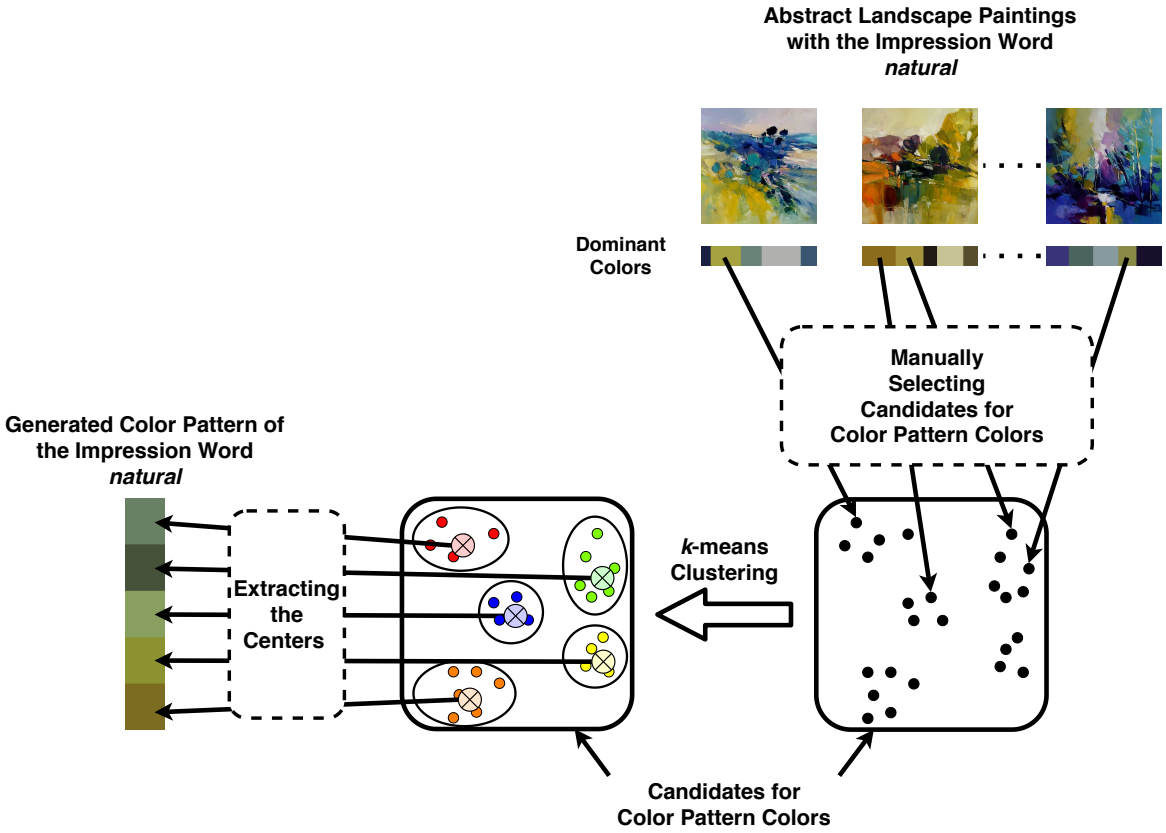

Figure 2 Generating the Color Pattern of the Impression Word, *natural*

NCD to define relationships between images and impression words. The images studied are those of flowers and brush paintings. Table 1 shows the color patterns published by NCD [3], [5] for each of the four impression words.

As for the relationships between impression words and images, some of those related works employed existing manually designed color patterns [4], while others proposed to apply neural networks [2], [7] and the canonical correlation analysis [6]. Compared to those existing approaches, this paper proposes another approach to define the relationships between an impression word and its color pattern, where we focus on abstract landscape paintings. According to the evaluation results we show in this paper, the color patterns created through the proposed approach are more suitable for retrieving abstract landscape paintings compared to the manually created color patterns published by NCD.

Bhandi and Devi K. A. [1] propose a content based image retrieval method that utilizes the pre-trained VGG16 deep CNN model [8].

3 Overview of the Framework

3.1 Extracting the Dominant Colors of a Painting

Figure 1 shows the procedure of extracting the dominant colors from a painting. First, a painting is converted to pixels in the $L^*a^*b^*$ color space. By applying k-means clustering algorithm with $k = 5$ to the pixels, five clusters are obtained. The centers of those five clusters are extracted as the colors included in the dominant colors of the painting. Together with extracting those five centers, the number of pixels in each cluster is counted and the rate of those numbers among the five clusters is used to define the proportion of each dominant color within the overall five dominant colors as shown in the left of Figure 1.

3.2 Generating the Color Pattern of an Impression Word

Figure 2 shows the procedure of generating the color pattern of the impression word, *natural*. As the first step, to each painting, we manually annotate one or more impression words that express the impression of the painting. Next, from each painting that is annotated with the impression word *natural*, five dominant colors are extracted. Then, from each painting, candidates for colors to be included in the color pattern of the impression word *natural* are manually selected from the five dominant colors. Those candidates collected throughout the whole dataset of abstract landscape paintings are clustered through k-means clustering algorithm with $k = 5$. Finally, the centers of the five clusters are extracted as the colors to be included in the color pattern of the impression word *natural*. For each of the four impression words *warm*, *cold*, *natural*, and *desolate*, Table 1 compares

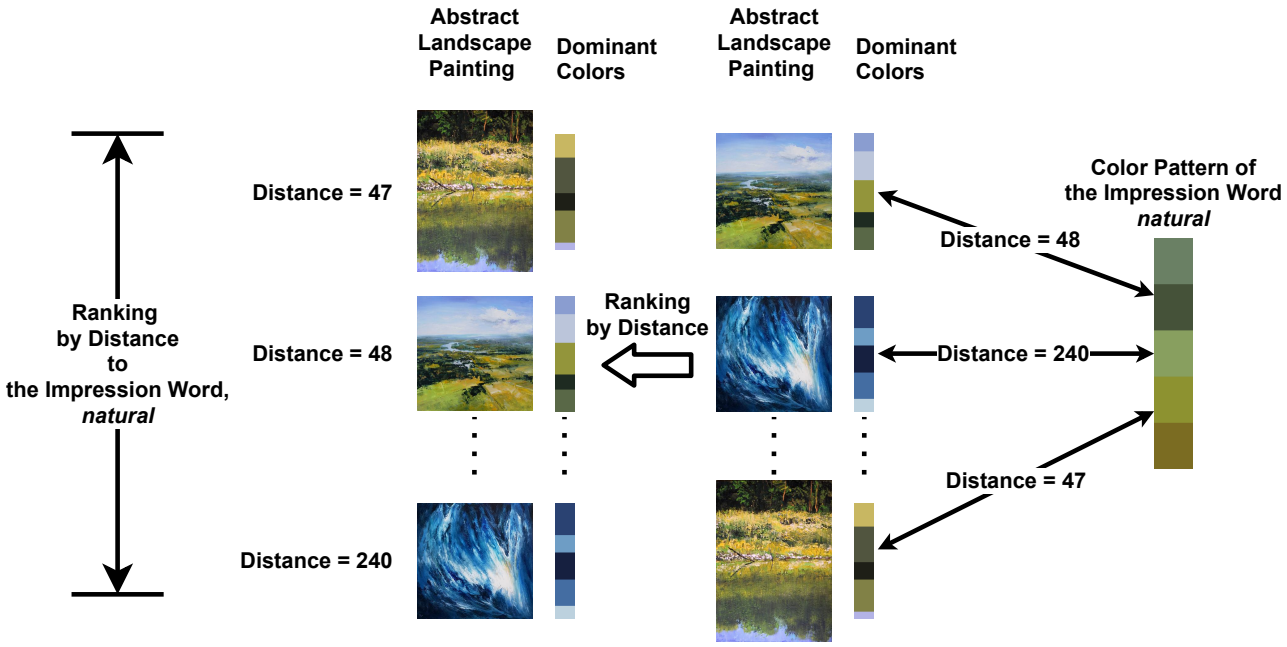

Figure 3 Retrieving Paintings with an Impression Word by Matching the Dominant Colors of a Painting and the Color Pattern of the Impression Word

the color patterns generated by the proposed method and those published by NCD.

3.3 Retrieving Paintings with an Impression Word

Figure 3 shows the overview of retrieving abstract landscape paintings with an impression word by matching the dominant colors of a painting and the color pattern of the impression word. First, a distance measure between a painting and an impression word is selected from those four variants of distance measures proposed in section 4. Then, all the paintings are ranked according to their distances in ascending order. Then, we examine whether each of the ranked paintings is suitable for the query impression word.

4 Distance Measures between the Color Pattern of an Impression Word and Dominant Colors of a Painting

This section defines the four distance measures between the color pattern of an impression word and dominant colors of a painting. In those definitions, w and c_w^i $(i = 1, \ldots, 5)$ denote an impression word and one of the five color pattern colors of w, respectively. Also, p and d_p^j $(j = 1, \ldots, 5)$ denote an abstract landscape painting and one of the five dominant colors of p, respectively. Let the following $r(w, p)$ be one of the overall 5!=120 one-to-one mappings of the five color pattern colors c_w^i $(i = 1, \ldots, 5)$ of w and the five dominant colors d_p^j $(j = 1, \ldots, 5)$ of p:

$$r(w,p) = \left\{ \langle c_w^i, d_p^{j(i)} \rangle \middle| i = 1, \ldots, 5 \right\}$$

Then, let $R(w, p)$ denote the set of the overall 5!=120 one-to-one mappings of the five color pattern colors c_w^i $(i = 1, \ldots, 5)$ of w and the five dominant colors d_p^j $(j = 1, \ldots, 5)$ of p. Next, The L*a*b* color space representations of c_w^i and d_p^j are denoted as $(L^*(c_w^i), a^*(c_w^i), b^*(c_w^i))$ and $(L^*(d_p^j), a^*(d_p^j), b^*(d_p^j))$. The number of all the pixels within the cluster whose center is the dominant color d_p^j is denoted as n_p^j $(j = 1, \ldots, 5)$. The number of all the pixels within p is denoted as N_p. The distance $d(c_w^i, d_p^j)$ $(i, j = 1, \ldots, 5)$ between c_w^i and d_p^j is defined as below:

$$d(c_w^i, d_p^j) = \frac{N_p}{n_p^j} \Big(\sum_{x \in \{L^*, a^*, b^*\}} \big(x(c_w^i) - x(d_p^j) \big)^2 \Big)^{1/2}$$

Now, we denote the distance between an abstract landscape painting p and an impression word w as $d(p, w)$, where its four variants are introduced in the following sections.

4.1 Minimum Distance over 120 One-to-One Mappings of the Color Pattern and Dominant Colors

In this variant, out of the overall 5!=120 one-to-one mappings of the five color pattern colors c_w^i $(i = 1, \ldots, 5)$ of w and the five dominant colors d_p^j $(j = 1, \ldots, 5)$ of p, the one which gives the minimum of the sum of the distance $d(c_w^i, d_p^{j(i)})$ over the five pairs $i = 1, \ldots, 5$ is selected to define the distance $d(w, p)$ as below:

$$d(w,p) = \min_{r \ (\in R(w,p))} \sum_{\langle c_w^i, d_p^{j(i)} \rangle \ (\in r)} d(c_w^i, d_p^{j(i)})$$

4.2 Single Minimum Distance Pair of a Color Pattern Color and a Dominant Color

In this variant, out of the over all 5×5=25 pairs of the five color pattern colors c_w^i $(i = 1, \ldots, 5)$ of w and the five dominant colors d_p^j $(j = 1, \ldots, 5)$ of p, the one which gives the minimum of the distance $d(c_w^i, d_p^j)$ $(i, j = 1, \ldots, 5)$ is selected to define the distance $d(p, w)$ as below:

$$d(w, p) = \min_{i,j=1,\ldots,5} d(c_w^i, d_p^j)$$

4.3 Minimum Distance Pairs over the Five Color Pattern Colors / Five Dominant Colors

For the variant of "minimum distance pairs over the five color pattern colors", for each of the five color pattern colors c_w^i $(i = 1, \ldots, 5)$ of w, one dominant color d_p^j $(j = 1, \ldots, 5)$ of p which gives the minimum of the distance $d(c_w^i, d_p^j)$ is selected. Then, their sum over the five color pattern colors below is employed as this variant of the distance $d(w, p)$:

$$d(w, p) = \sum_{i=1}^{5} \min_{j=1,\ldots,5} d(c_w^i, d_p^j)$$

For the variant of "minimum distance pairs over the five dominant colors", on the other hand, for each of the five dominant colors d_p^j $(j = 1, \ldots, 5)$ of p, one color pattern color c_w^i $(i = 1, \ldots, 5)$ of w which gives the minimum of the distance $d(c_w^i, d_p^j)$ is selected. Then, their sum over the five dominant colors below is employed as this variant of the distance $d(w, p)$:

$$d(w, p) = \sum_{j=1}^{5} \min_{i=1,\ldots,5} d(c_w^i, d_p^j)$$

5 Evaluation and Results

5.1 Evaluation Procedure

Specific abstract landscape paintings used for generating the color patterns and the evaluation are those collected from the Internet. Their source Web sites [1][2][3][4], the artists and their statistics are shown in Table 2.

In the procedure of retrieving the abstract landscape paintings with each of the four words *warm*, *cold*, *natural*, and *desolate*, we sort all the paintings for evaluation according to their distances in ascending order. Next, we regard the top ranked k paintings as predicted as *positive*. Then, for each of the four variants of the distance measures and for each of the four impression words, a precision-recall curve is plotted by varying the lower bound k from top to the bottom of the ranking.

1 : https://www.artfinder.com/beata-belanszky/#/

2 : https://islesfordartists.com/artists#/sue-charles

3 : http://poramoralarte-exposito.blogspot.com/search/label/Herv%C3%A9%20Lenouvel

4 : https://www.saatchiart.com/account/artworks/425728

5.2 Results

With the color patterns generated by the proposed method, Figure 4 shows the comparison of the four distance measures between the color pattern of an impression word and dominant colors of a painting, where the average of the precision-recall curves of the four impression words is plotted for each of the four variants. As can be seen from this comparison, "Min. Pairs over 120 One-to-One Mappings" slightly outperforms other three distance measures.

Next, for each of the four variants of the distance measures, Figure 5 shows the comparison of the color patterns generated by the proposed method and those published by NCD, where the average of the precision-recall curves of the four impression words is plotted for each of the four variants. Also, for each of the four impression words, Figure 6 shows the comparison of the color patterns generated by the proposed method and those published by NCD. Here, for each of the four impression words, out of the four variant distance measures, the one performing the best is selected for the evaluation. For each of the four impression words as well as for each of the two types of the color patterns (the proposed and those by NCD), Table 3 lists the distance measures selected as optimal. As shown in Figure 5 and Figure 6, for all of the four distance measures as well as for all of the four impression words, the color patterns generated by the proposed method outperform those published by NCD. Overall, in terms of retrieving abstract landscape paintings, the results show that the color patterns generated by the proposed method outperform those published by NCD. These results support our claim that the proposed approach is suitable for generating the color patterns that are specifically designed for the retrieval of abstract landscape paintings.

6 Conclusion

This paper proposed a method to generate color patterns of impression words for retrieving abstract landscape paintings. We also introduced four distance measures to define similarity between an impression word and an abstract landscape painting. In terms of retrieving abstract landscape paintings, the evaluation results show that the color patterns generated by the proposed method outperform those published by NCD. Future work includes introducing the state of the art deep learning based techniques to represent the relation between impression words and abstract landscape paintings. Another future work includes introducing a mechanism of accepting feedback from users of the system for retrieving abstract landscape paintings.

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Table 2 Statistics of the Dataset of Abstract Landscape Paintings

	Web site	Artist	Impression Word				Total
			warm	*cold*	*natural*	*desolate*	
For Generating Color Patterns	Artfinder	Beata Belanszky Demko	9	12	0	0	23
	Islesford Artists Gallery	Sue Charles	4	3	18	0	34
	Por amor al arte	Hervé Lenouvel	23	30	19	37	78
	Total		36	45	37	37	135
For Evaluation	Saatchi Art	Ivan Grozdanovski	44	56	20	27	116

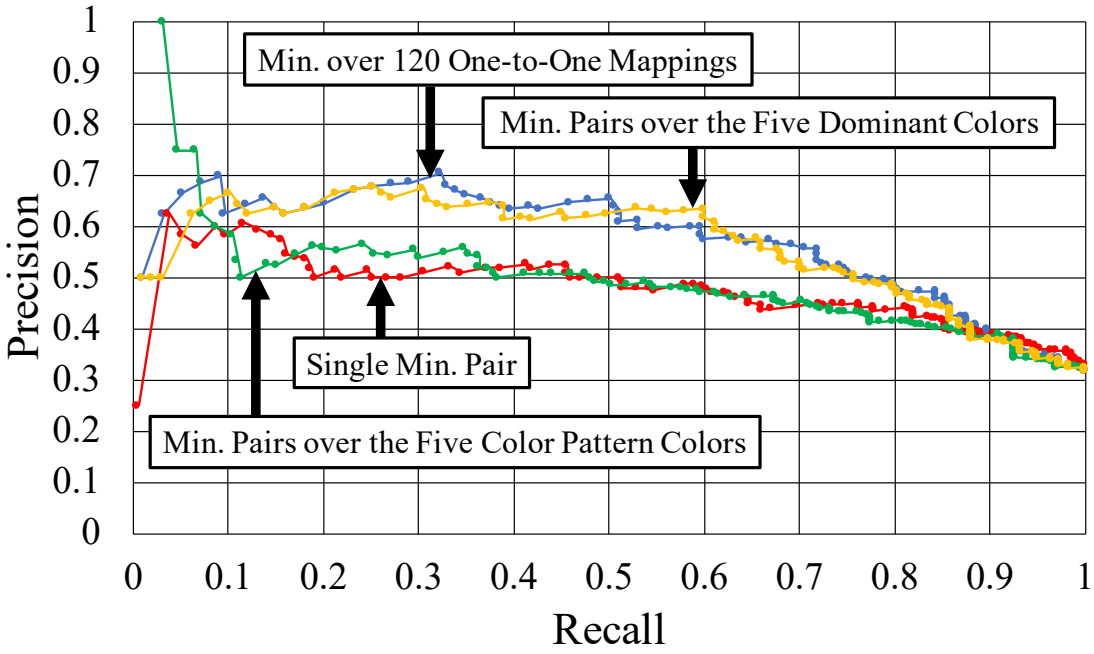

Figure 4 Comparison of Four Distance Measures between the Color Pattern of an Impression Word and Dominant Colors of a Painting (by the proposed method)

Table 3 Distance Measures selected as Optimal in Figure 6

Impression Word / Color Pattern				Distance Measure
warm	*cold*	*natural*	*desolate*	
Proposed Method NCD	NCD	—		Min. over 120 One-to-One Mappings
—				Single Min. Pair
—		Proposed Method NCD	Proposed Method	Min. Pairs over the Five Color Pattern Colors
—	Proposed Method	—	NCD	Min. Pairs over the Five Dominant Colors

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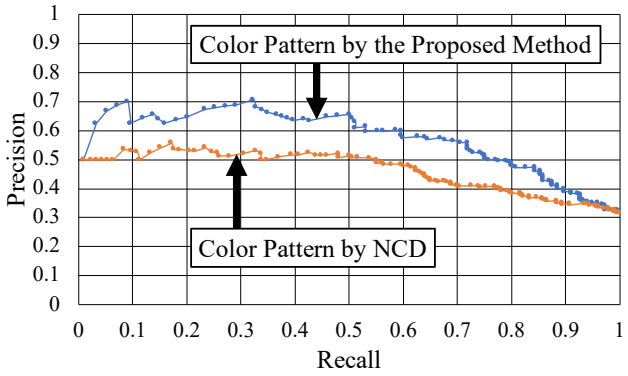
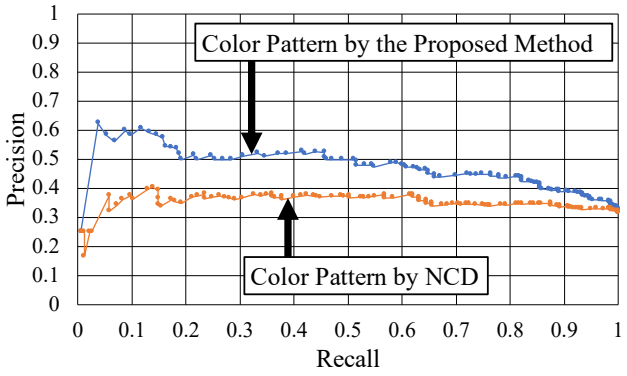
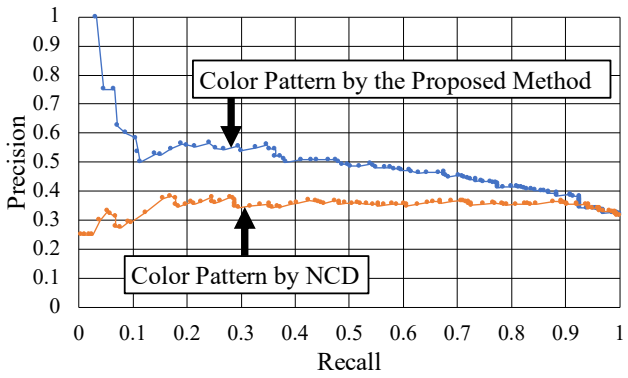


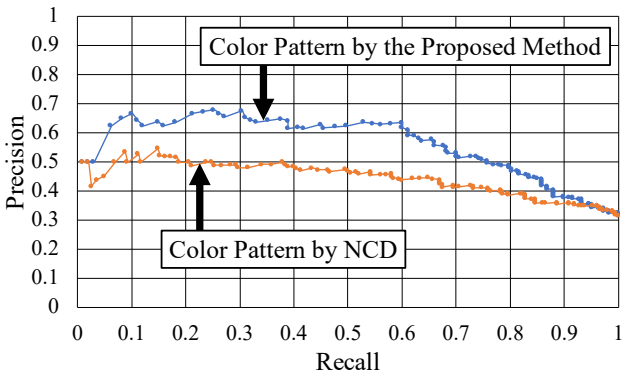
(a) Minimum Distance over 120 One-to-One Mappings



(b) Single Minimum Distance Pair

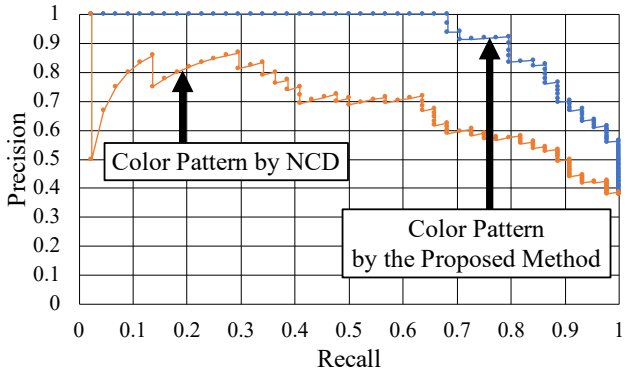


(c) Minimum Distance Pairs over the Five Color Pattern Colors

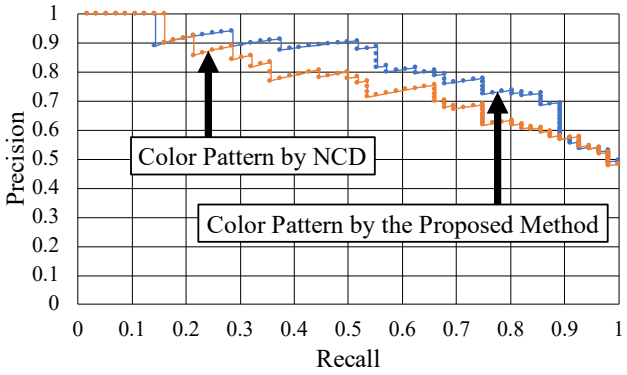


(d) Minimum Distance Pairs over the Five Dominant Colors

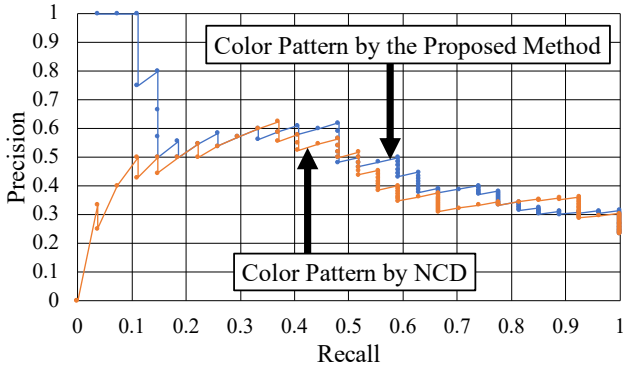
Figure 5 Comparison of the Color Patterns of the Proposed Method and NCD (1) (per distance measure)



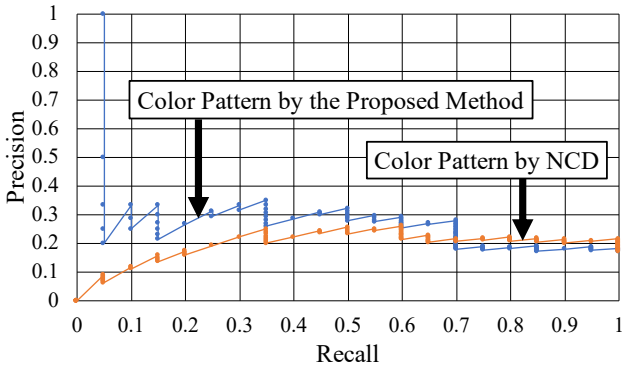
(a) *warm*



(b) *cold*



(c) *natural*



(d) *desolate*

Figure 6 Comparison of the Color Patterns of the Proposed Method and NCD (2) (per impression word)