AIA
International
Advanced
Information
Institute

An Illustration Image Classification Focusing on Infrequent Colors

Akira Fujisawa, Kazuyuki Matsumoto, Minoru Yoshida and Kenji Kita

*Advanced Technology and Science, Systems Innovation Engineering,
Tokushima University, 2-1 Minamijyousanjima-cho,Tokushima 770-8506, Japan
c501547001@tokushima-u.ac.jp, matumoto;mino;kita@is.tokushima-u.ac.jp*

Illustration images used in comics or animation have a style that constitutes an emotional feature. The style is represented by the various elements of the illustration image. There are a few research studies that treat the style of illustration images. In this paper, we tried to model the style by using an image feature, and to classify an illustration image by style. We thought that the color that appeared infrequently would represent the style of the illustration image. Therefore, we proposed the method for creating the color histogram, which emphasizes colors appearing infrequently. We term this "Infrequency histogram; IF-hist." To test the effectiveness of the histogram, we experimented with classifying two styles defined as "For boys" and "For girls" based on the IF-hist. The results of the experiment indicated that, when using the IF-hist, the precision of the classification result of the style "For girls" is 93%. This is 50% higher than when using the existing normal color histogram. Moreover, the precision of the other classification results has improved.

Keywords: Image Classification; Illustration Image; Color Histogram; Style; IF-hist; Sensibility.

1. Introduction

Illustration images are used in comics or animation works. Illustration images typically consist of lines, and their outlines are clearer than those of oil paintings or photographs. Illustration images are often drawn to be caricatures rather than realistic portrayals in comics or animation works. Until just a decade ago, illustration images were drawn in an analog manner. Now, they are often drawn by digital tools on a computer. In addition, the spread of the Internet has become helpful in publishing illustration images drawn by amateur illustrators all over the world. Therefore, we can view a lot of illustration images on the web.

We believe that the illustration image is familiar to many people and is popular worldwide. For example, "Pixiv" is SNS for posting illustration images. According to the announcement of Pixiv in 2014, the number of users registering was over 10 million. The location of registered users is not only Japan but Taiwan, China, the USA, the UK, and more. Because of this, it is thought that demand for services dealing with illustration images will increase.

We can feel an impression when we see an illustration image, with this impression being evoked by various elements of the image. In this paper, we define such an impression as "the style." The fan of an illustration image can distinguish the illustrator by feeling the illustrator ' s style from the image. Moreover, the fan can classify an illustration image in relation to those that are or are not of a similar style. There are a few research studies that treat the style of illustration images, but previous researchers did not propose the automatic analysis method to analyze the elements that represent the style. The purpose of this study is the following.

- To represent the style by using image feature values.
- To construct style-based classifiers for illustration images.

In this study, we modeled the style of illustration images by focusing on the color information of a given image.

2. Previous Research

2.1. *Recognition model that focuses on line information*

Kuriyama[1] created the recognition model based on density of lines instead of line shape. This study is similar to ours in that it classifies the images by constructing models for separation. However, it does not use color information. The majority of the illustration images are colored, and, when people obtain the information by vision, it is largely affected by color information. Because the style might express sensibility, color information should be used as feature.

2.2. *Similarity of touch*

To study the similarity of touch in relation to illustration images, Kadokura[2] used the number of types of colors as a feature. To examine the trend of appearing colors, he used saturation and lightness instead of hue as feature values. His study targeted clip art, which comprises very simple images. However, because illustration images used in comics or animation include expression that is more sensitive, we are not concerned with clip art.

Moreover, Rechard et al.[3] performed an experiment to deduce whether a picture that is thought to be painted by van Gogh was really authored by van Gogh. Their research targeted oil painting, but oil painting and illustration images are created by different techniques. Therefore, it is not clear whether the method that was effective in their study would be effective for our purposes.

3. Proposed Method

In this study, we used color information in order to classify illustration images by style. We created a color histogram by focusing on low frequency color.

3.1. *Color histogram*

In the field of image processing, the histogram represents the distribution of brightness in an image. It is also used as a function of the digital camera and image editing software. A histogram is used for quality identification of an image and adjustment of contrast. A color histogram represents the distribution of color gradation of each RGB channel in a color image. It also represents the appearance frequency of each color. Because the maximum value in a histogram fluctuates according to the pixel count of the target image, the histogram was normalized by pixel count.

3.2. *image classification using a color histogram*

The color histogram is a simple feature value. If we want to classify illustration images by using that feature, it is therefore easy to build the system, and the feature value is easy to handle. Actually, image classification using a color histogram has been the subject of various studies[456].

When we classify images by using a color histogram, we should look out for the following points. Firstly, the color histogram does not contain information about what color gradation appears in which pixel. Even though color histograms are similar to one another, it is unlikely that images would have the same tint. Secondly, because the color histogram is a feature value obtained from color information alone, it is difficult or impossible to judge whether composition and motif are similar; even though the color histograms of the illustration images are similar. Even if images have the same style, they often have different composition and motifs. Therefore, it is difficult to classify the style by composition or motifs in images.

We used the color histogram as a feature that does not rely on motif, composition, and character drawn in illustration images. Because some studies investigated the association between sensibility and color information[78], it was thought that the color histogram is suitable for investigating the affective style or sensibility features. Even if illustration images have the same style, it is not possible to conclude that they always have a similar tint. Therefore, we thought it necessary to propose a new method of creating a color histogram.

3.3. *Color histogram focused on colors appearing infrequently*

To classify illustration images by style, we proposed using color information that does not appear in images. Various kinds of color are employed in an illustration image. Even if illustration images have the same style, it is difficult to identify the color that represents the style, as some common colors appear in those illustration images.

Therefore, we focused on the color information that is not used in an illustration image. We assumed that the absolute color to represent the style does not exist; thus the color to represent the style is determined relatively. When an illustrator draws an illustration image, he or she might think, "This color is more suited than the

other colors to this style" and subsequently choose colors by that thought process. In other words, we inferred that a color that is not suited to representing the style has been avoided. Therefore, we proposed the feature extraction method to focus on colors appearing infrequently, and we used this as a feature value to classify an illustration image by style. We refer to our proposed color histogram focusing on colors appearing infrequently as "Infrequency Histogram; IF-hist." In the following, we call it "IF-hist."

3.4. *Creating the method of IF-hist*

In the following explanation, the RGB color space is used. The color histogram has 256 values for each color channel. First, it was decided how many histogram values remain as original values. In order to focus on infrequency value in a color histogram, IF-hist saves some small values with former value. Moreover, IF-hist changes other histogram values to the maximum value. It is ordered so as to emphasize information regarding color infrequency by great differences in the histogram value between gradations. The second step was as follows. In a normal color histogram, a histogram value is saved based on gradation. IF-hist sorts these histogram values in ascending order. In this step, gradations were ranked according to appearance frequency of a color in an illustration image.

The third step was as follows. Against the histogram that is sorted in ascending order based on appearance frequency, histogram values of gradation that have less of a determined rank were changed to the maximum histogram value. In this step, the information about colors that appear infrequently is not changed. However, the information about other colors is altered and only includes the information that was used in the target image. It does not contain the information about the extent that was used in the image.

Fig.1 and Fig.2 show a sample color histogram. Fig.1 is a normal color histogram. Fig.2 is an IF-hist. These histograms were obtained from the same illustration image. The number of N in the caption of Fig.2 is the number that remained as original values.
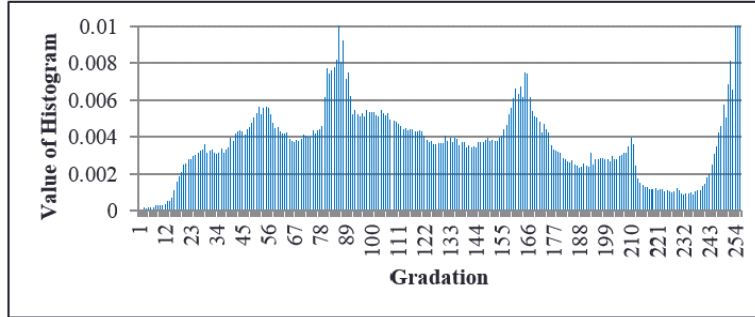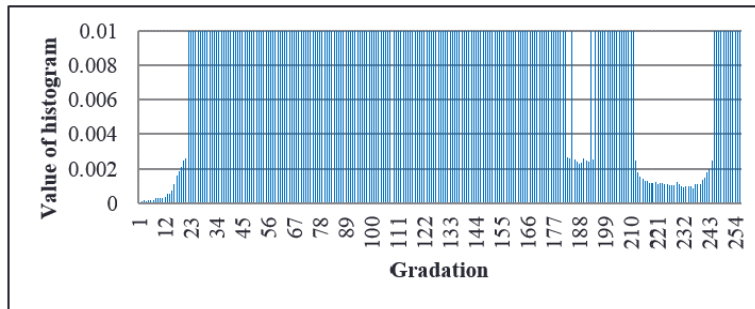
Fig. 1. Sample of normal color histogram.

Fig. 2. Sample of normal IF-hist.

4. Evaluation Experiment

4.1. *Experiment Process*

This section describes the evaluation experiment. We obtained the IF-hist from illustration images. Using the IF-hist as a feature, we classify the illustration image by using Support Vector Machines (SVMs).

In this study, two styles are used. These styles are "For boys" and "For girls." The reason why we chose these styles is that these two categories are determined in a relatively objective way by using the metadata of the images. In our experiments, we selected as a test image the cover illustration of a comic, for which the name and publisher are available. We then determined the styles to be defined as "For boys" or "For girls" by using this information.

4.2. *Experimental Condition*

4.2.1. *Experimental Data*

The experimental data was described in this section. In this experiment, we used cover illustration of comics. These images ware collected by scanning real comics. Table 1 shows the number of the data used in our experiment. We used 281-fold cross-validation (i.e., we used leave-one-out method.) The library which was used in this experiment is lib-svm[9]. The parameter to create a classifier for image classification was default settings.

Table 1. Experimental Data

Cover illustration of the comic for boys	170
Cover illustration of the comic for girls	111
Total	281

4.2.2. *Color histogram used for machine learning*

We compared the following 4 types of color histograms.

- Normal color histogram
- IF-hist (N = 32)
- IF-hist (N = 64)
- IF-hist (N = 128)

The N is the number that remained as the original histogram value. All histograms have 256 histogram values divided into a Red channel, Green channel, and Blue channel. By integrating the histogram of all the channels, we created a 768-dimensional vector from an image. The normal color histogram is used for validation of the effectiveness of the proposed method compared to previous methods.

4.3. *Valuation basis of experiment*

We used recall, precision, and F-measure for evaluation of the experimental results. The definitions for recall, precision, and F-measure are given in Eq(1), Eq(2), and Eq(3).

$$Recall_i = \frac{R_i}{N_i} \tag{1}$$

$$Precision_i = \frac{R_i}{C_i} \tag{2}$$

$$F_i = 2 * \frac{Recall_i * Precision_i}{Recall_i + Precision_i} \tag{3}$$

R_i : The number of classified the style of i correctly.

N_i : Tne number of illustration images which have the style of i.

C_i : The number of illustration images that were classified as having the style of i.

i : The number of the style.

5. Results and Discussions

5.1. *Experimental results*

The experimental result of Macro-average precision is described in Table 2. The experimental results of classifying the styles as "For boys" and "For girls" are described in Fig.3 and Fig.4.
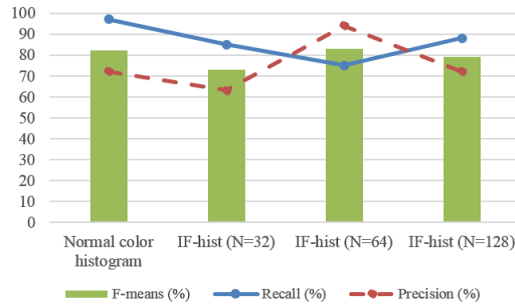
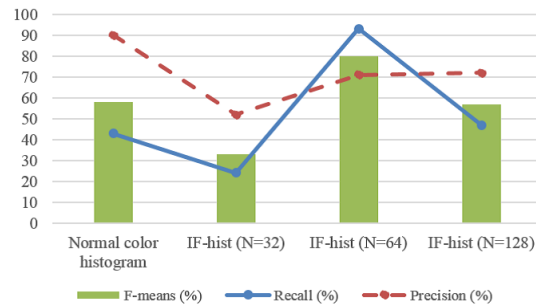

Fig. 3. Sample of normal color histogram.

Fig. 4. Sample of normal color histogram.

Table 2. Experimental Data

Training Data	Normal color histogram	IF-hist (N=32)	IF-hist (N=64)	IF-hist (N=128)
Macro-average Precision(%)	75	61	82	72

In the case of the result of using the normal color histogram, the recall and precision scores of "For boys" were high. On the other hand, the recall of "For girls" was 43%. This was less than half of the recall of "For boys." From this result, it is considered that the conventional method that classified the illustration image was biased to the style of "For boys," because the method cannot extract enough features to classify the style of "For girls."

Next, we will discuss the classification result using IF-hist. When using IF-hist (N = 32, 128), classification performance was lower than when using the normal color histogram. However, where IF-hist (N=64) was used, the recall of "For girls" was 93%, which is 50% higher than was the case when using the normal color histogram. The F-means have also been improved.

From this, we considered that our proposed histogram "IF-hist" is effective to classify an illustration image into the styles "For boys" and "For girls" when we choose the appropriate N value.

5.2. *Discussion*

In this section, we discuss the experimental result of using the IF-hist (N = 64). The classification performance of the style "For girls" was significantly improved by using IF-hist. Therefore, we considered that an IF-hist has been able to obtain a feature that represents the style of "For girls." Fig.5, Fig.6, Fig.7, and Fig.8 show the color histogram and IF-hist that were used in the experiment. The histograms in Fig.5 and Fig.6 were obtained from illustration images that are in the style of "For boys." The histograms in Fig.7 and Fig.8 were obtained from illustration images that are in the style of "For girls." These histograms were obtained from the Blue channel.

Comparing color histograms in these graphs indicates that the shapes of histograms differ significantly. Therefore, it is difficult to find a common characteristic. IF-hists in Fig.7 and Fig.8 show a gradation in which infrequency appears continuous. This feature is not shown in Fig.5 and Fig.6. Such a feature also appeared in other illustration images that have the style of "For girls."

For this reason, we considered that a gradation that appears infrequently is continuous in an illustration image associated with the style of "For girls." Therefore, we thought that that would be a clue to classifying the style of "For girls."
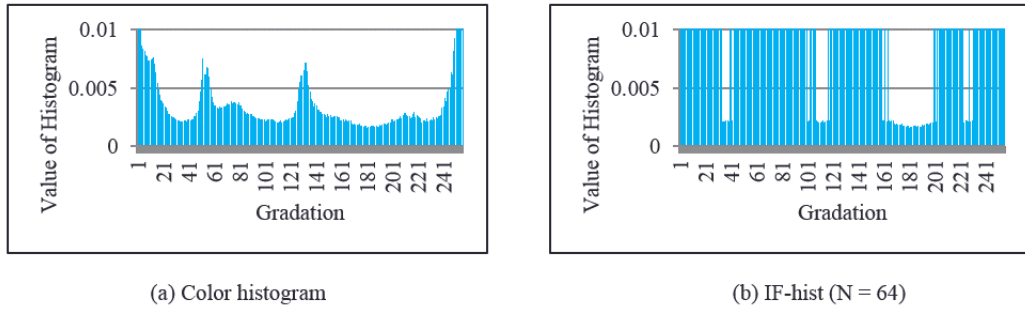
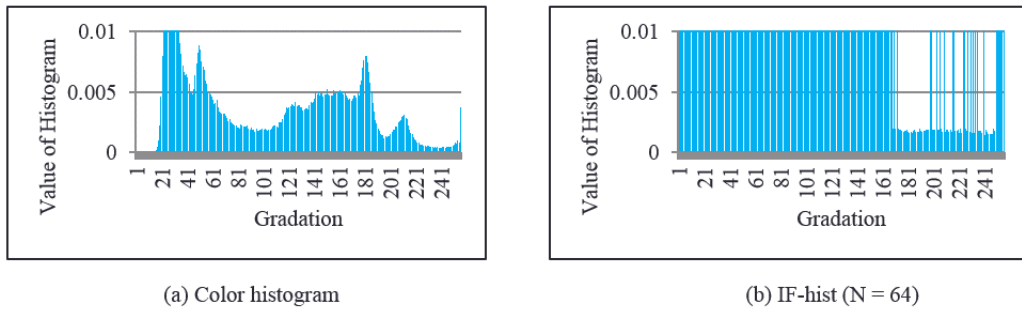Fig. 5. Histograms obtained from an illustration image which have the style for "For boys" (1).

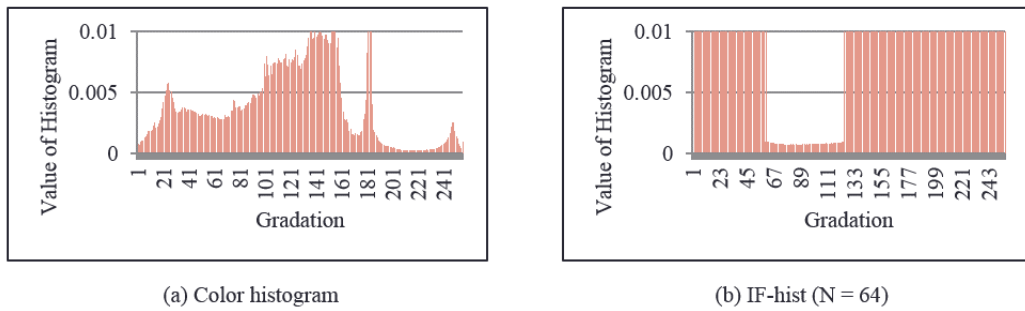Fig. 6. Histograms obtained from an illustration image which have the style for "For boys" (2).

Fig. 7. Histograms obtained from an illustration image which have the style for "For girls" (1).
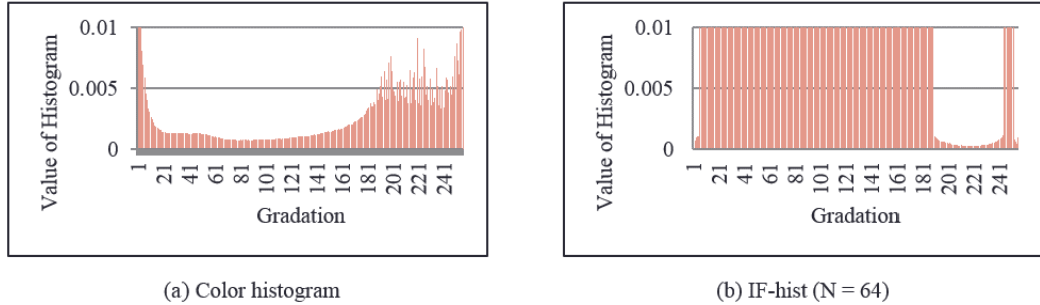
(a) Color histogram

(b) IF-hist (N = 64)

Fig. 8. Histograms obtained from an illustration image which have the style for "For girls" (2).

6. Conclusions

In this study, we classified an illustration image by its style. To do so, we focused on color information; in particular, color that is used infrequently in an illustration image. Moreover, we proposed the "Infrequency Histogram; IF-hist." IF-hist is a color histogram that is ordered so as to emphasize colors that appear infrequently in an image. We experimented with classifying illustration images into two groups of styles defined as "For boys" and "For girls." In the experiment, we used cover illustrations of comics and obtained histograms from those illustration images.

In order to compare the classification performance, the classifiers for machine learning using Support Vector Machine were created from some color histograms. The illustration images were classified into two groups depending on style. As a result of the experiment, the recall of the style "For girls" was 93% when using the IF-hist (N=64). This was 50% higher than the result obtained when using the existing method. The value of the other classification results likewise improved as compared to the existing method.

When comparing a histogram, a gradation that appeared with infrequency was continuous in an illustration image with the style of "For girls." As future studies, we will experiment with the classification of other styles by using this feature. In addition, we used a rank of appearance frequency to obtain the IF-hist in this study. We will consequently try to obtain IF-hist using a histogram with a value that is lower than the threshold. Furthermore, we would like to use a color space other than RGB color space (such as HSV color space) to obtain a color histogram.

References

1. Shigeru Kuriyama. *Cognitive Classification for Styles of illustrations based Recognition model*, IPSJ SIG Technical Report 2013-CG-152(3), pp.1-7, 2013.
2. Kento Kadokura and Yuko Osana. *Image(Artwork) Retrieval based on Similarity of Touch,*, Proc. 75th National Convention of IPSJ 2013(1), pp.603-604, 2013.
3. C.R.Johnson, E.Hendriks, I.J.Berezhno, S.M.Hughes I.Daubechies, E.JiaLi, Postma, and J.Z.Wang *Image Processing for Artist Identification*, Processing for Artist Identification Proc. of IEEE Signal Processing Magazine, Vol. 25, No.4, pp.37-48, 2008.
4. P Haffner and V.N. Vapnik. *Support vector machines for histogram-based image classification*, Neural Networks, IEEE Transactions on (Volume:10 , Issue: 5), pp.1055-1064, 1999.
5. Sergyan, S. *Color histogram features based image classification in content-based image retrieval systems*, Applied Machine Intelligence and Informatics, 2008. SAMI 2008. 6th International Symposium on, pp.221-224, 2008.
6. Greg Pass and Ramin Zabih. *Histogram Refinement for Content-Based Image Retrieval*, Applications of Computer Vision, 1996. WACV '96. , Proceedings 3rd IEEE Workshop on pp.96-102, 1996.
7. Jana Machajdik and Allan Hanbury. *Affective image classification using features inspired by psychology and art theory*, MM '10 Proceedings of the international conference on Multimedia, pp.83-92, 2010.
8. Rie Honda, Yasuhiro Suzuki and Takahumi Oohori. *Correlation between Kansei and Color Histgram in Image*, FIT of IPSJ 4(3), pp.87-88, 2005.
9. Chih-Chung Chang and Chih-Jen Lin. *LIBSVM: A library for support vector machines*, ACM Transactions on Intelligent Systems and Technology Volume 2 Issue 3, 2011.

Akira Fujisawa

He received the B.S. degree and M.S. degree in 2013 and 2015 from Faculty of Engineering, Tokushima University. He is currently a PhD candidate at the Tokushima University. His research interests include Multimedia Information Retrieval, Image Recognition. He is member of JSAI.

Kazuyuki Matsumoto

He received the Ph.D degree in 2008 from Faculty of Engineering, the University of Tokushima. He is currently an Assitant Professor at the university of Tokushima. His research interests include affective computing, Emotion Recognition and Natural Language Processing. He is a member of IPSJ, IEICE, IEEJ.

Minoru Yoshida

He is a lecturer at the Department of Information Science and Intelligent Systems, University of Tokushima. After receiving his BSc, MSc, and PhD degrees from the University of Tokyo in 1998, 2000, and 2003, respectively, he worked as an assistant professor at the Information Technology Center, University of Tokyo. His current research interests include Web Document Analysis and Text Mining for the Documents on the WWW.

Kenji Kita

He received the B.S. degree in mathematics and the PhD degree in electrical engineering, both from Waseda University, Tokyo, Japan, in 1981 and 1992, respectively. From 1983 to 1987, he worked for the Oki Electric Industry Co. Ltd., Tokyo, Japan. From 1987 to 1992, he was a researcher at ATR Interpreting Telephony Research Laboratories, Kyoto, Japan. Since 1992, he has been with Tokushima University, Tokushima, Japan, where he is currently a Professor at Faculty of Engineering. His current research interests include multimedia information retrieval, natural language processing, and speech recognition.