PERCEIVED QUALITY OF WOOD IMAGES INFLUENCED BY THE RATIO OF SKEWNESS TO KURTOSIS OF IMAGE HISTOGRAM

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Keywords: skewness, kurtosis, histogram, wood grain, perceived quality

ABSTRACT

It is known that the shape of luminance histogram of images is related to material perception. We investigated how luminance histogram contributed to improving the perceived quality of wood images by examining various woods and adhesive vinyl sheets with printed wood grain. In the first experiment, we made a visual evaluation of the perceived quality of wood samples. We also measured the color parameters of the samples in order to examine the colorimetrical property of wood samples. In the second experiment, we evaluated the naturalness of wood images, of which skewness and kurtosis were changed, by a paired comparison method. Results suggest that the ratio of skewness to kurtosis of the luminance histogram affects the perceived quality of wood images.

INTRODUCTION

We can easily recognize the quality of a surface such as color, glossiness, surface material, and surface state in daily life. Clarifying the mechanism of perceived quality is an important issue. Motoyoshi et al. examined the relationship between glossiness and the shape of the luminance histogram of the stucco image [1]. They suggested the skewness of luminance histogram affected glossiness perception. Wada et al. conducted a study to estimate the freshness of cabbage from the image statistics [2]. They found a relationship between freshness perception and the features of the luminance distribution of the images. These studies showed that the luminance distribution was an effective factor for the perceived quality of materials.

Wood is one of familiar materials. There are many kinds of products as well as, their imitations such as computer graphics and prints, which represents wood grain without using real wood. Finding factors that affect the appearance of real wood are useful for various applications such as making imitation wood products. Natural wood is a collection of cells which causes peculiar features of wood such as gloss and pattern [3]. Here, we define the perceived quality of wood as a realistic appearance of wood. Considering previous researches, it would be expected that the shape of luminance histogram also affects the perceived quality of wood. The purpose of this work is to reveal the image statistics affecting the perceived quality of wood when wood samples convert to two-dimensional images.

EXPERIMENT 1 : EVALUATION OF REAL WOOD SAMPLES

In this experiment, the realness of natural and imitation wood samples was visually evaluated in order to quantitatively analyze the perceived quality of wood

Experimental environment and wood samples

A wood sample (65 x 65 mm, 9 x 9 degree) with a reference white frame (1 degree width, N9 in Munsell value) was placed in a viewing booth and uniformly illuminated by fluorescent lamps (5200 K, 1000 lx). Background was gray surface (N5). Observers looked at the sample from a distance of 41 cm. They were not able to see anything except the sample and the background.

We prepared 21 samples of natural wood and 14 samples of imitation wood made of adhesive vinyl sheets with printed wood grain.

Procedure

First, an observer looked at a wood sample, and answered whether it was 'real one' or 'imitation'. After the answer, he or she was asked to score a certainty with three levels; 'very confident', 'a fairly confident', and 'less confident'. Test samples which were a mixture of natural wood and adhesive vinyl sheets were presented one by one in a random order but in the same order in the inter-observers. Observers responded once for each sample.

Seventeen observers in their twenties with normal color vision and normal or corrected to normal visual acuity participated. Nobody had the detailed knowledge of wood.

Result and discussion

The average rate of correct answers in observers responding to real or imitation correctly was above chance level, 0.5 (natural wood 0.68, SD = 0.11; imitation wood 0.73, SD = 0.13). The rate of correct answers would rise when the certainty score is high because the score means index indicating whether observers had self-confidence to their answer. Figure 1 shows the relationship between the certainty score and the rating of answer 'real one'. The abscissa shows the average certainty score in observers. Negative number means answer 'imitation'. The ordinate shows the rating of answer 'real one' to all samples. Coefficient of determination (R^2) between the certainty score and the rating is high. Thus, we defined the average certainty score as realness value to show how observers perceive the samples as real wood.

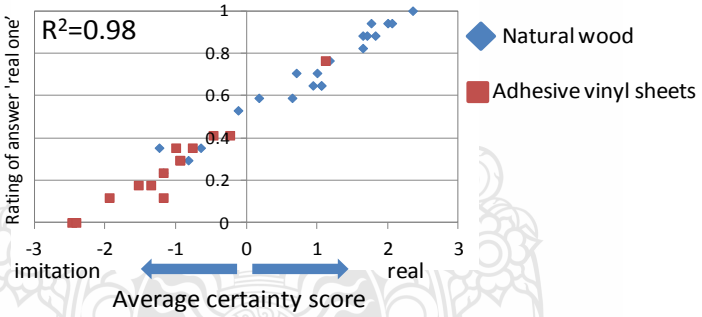

Figure 1. Correlation between the rating of answer 'real one' and the average certainty score

COLORIMETRICAL ANALYSIS OF WOOD SAMPLES

In order to obtain the colorimetrical properties of the wood samples, we measured the CIE 1931 tristimulus values by a 2D color analyzer (KONICA MINOLTA:CA-2000A). Measuring environment was the same as Experiment 1. The resolution of the 2D measurement was 570 x 570 pixels at the area of 57 x 57 mm. Tristimulus values were converted to ATD color space by Eq. (1) and Eq. (2). Then, image statistics was analyzed. In ATD color space, A is the same as luminance, Y. T represents reddish and greenish component, and D represents bluish and yellowish component. For the equal energy white, $X = Y = Z$, T and D are defined to become zero.

$$\begin{pmatrix} L \\ M \\ S \end{pmatrix} = \begin{pmatrix} 0.38971 & 0.68898 & -0.07868 \\ -0.22981 & 1.1834 & 0.04641 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \end{pmatrix} \quad (1)$$

$$\begin{pmatrix} A \\ T \\ D \end{pmatrix} = \begin{pmatrix} 0.3710 & 0.6291 & 0 \\ 1 & -1 & 0 \\ 0.3710 & 0.6291 & -1 \end{pmatrix} \begin{pmatrix} L \\ M \\ S \end{pmatrix} \quad (2)$$

We analyzed relation between the realness values and some image statistics such as the average, the standard deviation (S.D.), the skewness and the kurtosis of luminance. However, none of them had high correlation. Thus, we considered the relation of three parameters, the skewness, the kurtosis, and the realness values as shown in Figure 2. The realness values are presented by different symbols. Each colored ellipsoid indicates the 90% confidence ellipsoid for each block of realness values that were divided into three levels. High realness values concentrate on the center of the plane, but low values distribute widely, suggesting probability of realness value is high in certain ratio of skewness to kurtosis.

In order to clarify the effect of the ratio of skewness to kurtosis on the perceived quality of wood, we evaluate wood images that were modified their skewness and kurtosis in the next section.

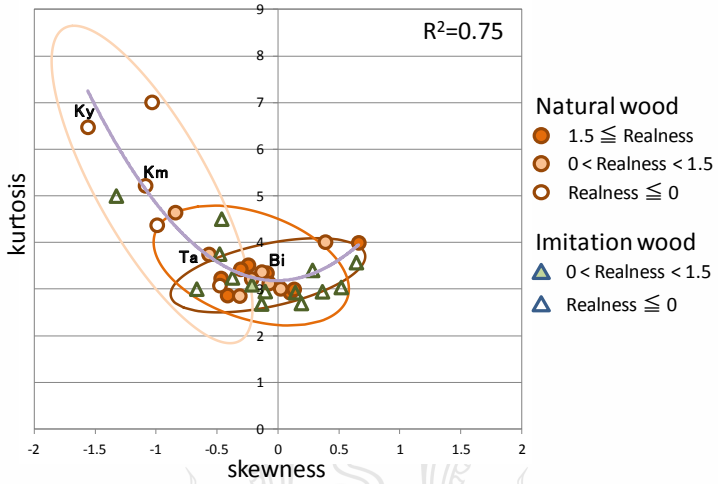

Figure 2. Correlation of skewness, kurtosis and realness values

EXPERIMENT 2 : EVALUATION OF WOOD IMAGES

Experimental environment and stimuli

Wood images created from the 2D measurement data were presented on a 21-inch CRT monitor (Sony GDM-F500) controlled by ViSaGe (Cambridge Research Systems Co. Ltd.) in a darkroom. An observer looked at the monitor with chinrest and viewing distance was about 140 cm. Background luminance on the monitor was about 18 cd/m^2 (corresponding to N5 in Munsell value). The test images were digitally created by manipulating their luminance distribution in a histogram matching technique. The technique needed two images with base and target histogram. We prepared four kinds of wood images, Birch (Bi), Tamo (Ta), Kembas (Km), and Keyaki (Ky) for base and target images that were chosen based on the realness value and the skewness. We divided the realness values into four blocks, and chose each image representing each block with equal interval of skewness on a regression line of the skewness and the kurtosis. The chosen images were

Matched Target 1 (Bi)	Matched Target 2 (Ta)	Matched Target 3 (Km)	Matched Target 4 (Ky)
realness : 2.35	realness : 0.71	realness : −0.12	realness : −1.24
skewness : −0.09	skewness : −0.57	skewness : −1.09	skewness : −1.56
kurtosis : 3.35	kurtosis : 3.75	kurtosis : 5.23	kurtosis : 6.48

Figure 3. Example of the test images (Birch)

denoted by their initials in Figure 2. The shape of the base histogram was modified to match the target's shape, while maintaining the average *A*, *T*, and *D* values, and RMS contrast of the base histograms. Figure 3 shows the example of the test images with parameters.

Procedure

We used the paired comparison method. An image pair from six image pair sets for each base image was presented in random order. An observer was asked to choose an image that was more realistic wood image. There was no time restriction for observing image and making a choice. Then, following to 2 sec break with gray background next image pair was presented. The images presented in a session were 6 pairs for 4 images, 24 pairs total.

Eleven observers in Experiment 1 also participated in this experiment.

Result and discussion

Figure 4 shows the results for each image. The average and SD of all observers were plotted. The abscissa means the ratio of skewness to kurtosis of the test images. The ordinate means the probability of choosing realistic wood images. Regardless of image, the probability is high when the ratio is near zero, and it is low when the ratio is lower. This shows that observers perceived wood image as more realistic when the ratio of skewness to kurtosis of the test image was near zero. Wood images may appear more realistic by making the appropriate ratio of skewness to kurtosis in any wood images.

This result is consistent with the result of evaluation in Experiment 1, suggesting that the ratio of skewness to kurtosis contributes the perceived quality of wood. However, it is necessary to consider the other factors which affect the perceived quality of wood images because there are wood images which have low realness even they have the appropriate ratio of skewness to kurtosis.

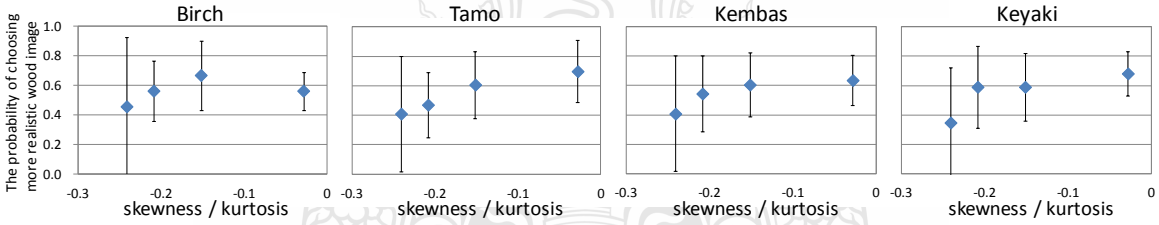

Figure 4. The probability of choosing an image that was more realistic wood image

CONCLUSION

We investigated the perceived quality of wood in relation to the luminance histogram of wood images. We evaluated wood images that modified their skewness and kurtosis of luminance histogram. Our results suggest that luminance distribution of wood, especially the ratio of skewness to kurtosis, affects the perceived quality of wood.

ACKNOWLEDGEMENT

This work was supported the Japan Society for Promotion of Science 23135506.

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