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INVESTIGATION OF SYMMETRIC RELATIONSHIP BETWEEN EVALUATION OF SMOOTHNESS AND ROUGHNESS IN FABRIC SURFACE IMAGES

Takashi MAEHARA[a], Tomoharu ISHIKAWA[b], Yoshiko YANAGIDA[c], Miyoshi AYAMA[b]

[a] *Utsunomiya University, Japan, dc217204@cc.utsunomiya-u.ac.jp*
[b] *Utsunomiya University, Japan, {ishikawa, miyoshi}@is.utsunomiya-u.ac.jp*
[c] *Bunka Gakuen University, Japan, yanagida@bunka.ac.jp*

ABSTRACT

The purpose of this study was to investigate the symmetry relationship between evaluation of smoothness and roughness of fabrics and the physical factors related to the evaluations, using a set of images obtained by photographing the surfaces of eight fabrics. These fabric surface images were created by setting the distance between the fabric and the camera at approximately 1 m and gradually reducing the distance for each of the eight fabrics. Based on these images, we conducted an experiment to evaluate the smoothness and roughness of fabrics on a seven-level unipolar scale. Results showed that the evaluation characteristics of fabric smoothness and roughness with consideration of the shooting distance of the fabric surface images differed for each fabric. Furthermore, analysis of the correlation between evaluation of smoothness and roughness of fabrics indicated that symmetry was not established between evaluation of smoothness and roughness of some fabrics.

Keywords: *Roughness, Smoothness, Visual, Shooting distance, Symmetry*

1 INTRODUCTION

In recent years, Internet shopping has become a popular option for many because of its convenience. In addition, its use is further increasing as a result of the restrictions on urban movement implemented in response to the global COVID-19 pandemic [Ministry of Internal Affairs and Communications, Japan, 2021]. However, previous studies have reported an advantage of vision over physical touch [Heller, 2017; Guest, Catmur, & Lloyd, 2002; Nishimatsu & Sakai, 1987]. Internet shopping can be considered a very useful sales method because its presentation technique leverages this visual advantage. In light of this, an important issue is the

creation of images that facilitate human recognition of fabric textures and the establishment of a presentation method for such images.

In the previous study [Ishikawa et al., 2011], the relationship fabric texture evaluation and mechanical properties was investigated, and it was found that SMD (Mean deviation of surface roughness) [Kawabata, 1980], a mechanical property of the fabric surface, is an important characteristic of the feeling of the fabric texture. In addition, a study to identify evaluation words for fabric appearance and tactility revealed the importance of "smoothness" and "roughness" of fabrics [Ishikawa, Nakamori, Sasaki, Miyatake & Ayama, 2015]. On the other hand, several studies have reported on the symmetry of evaluation using semantically paired evaluation words [Ogino & Noguchi, 1996; Kato, Asahara, Moriyama & Ogiwara, 2021], but there has thus far been no discussion on fabric texture evaluation. In this study, we prepared a set of images of fabric surfaces and conducted experiments to evaluate the smoothness and roughness of fabrics in these images. In this report, symmetry is analyzed in words of oppositeness and correlation.

2 EXPERIMENT

2.1 Experimental Conditions

2.1.1 Creating Images

Eight different fabrics that fashion designers could identify were used (Figure 1). The shooting distance between the camera and the fabrics ranged from 0.2m to 1.0m, and shot in increments of 0.1 m. Nine patterns were used. In total, 72 fabric surface images were created. The camera type, lens, and shooting camera settings are listed in Table 1. The shooting environment included a photography booth (Figure 2) and D65 fluorescent lamps (FLR40S-D-EDL-D65/M, Toshiba, Japan) were placed on the left, right, and top of the booth to ensure uniform brightness throughout.

Table 1. Camera type, Lens and Camera settings

Item	Details
Camera type	Nikon D600
Lens	AF-S Micro NILLOR 60mm
Camera settings	ISO:100, Shutter speed:1/30, Aperture: F10.0

Figure 1. Fabric images

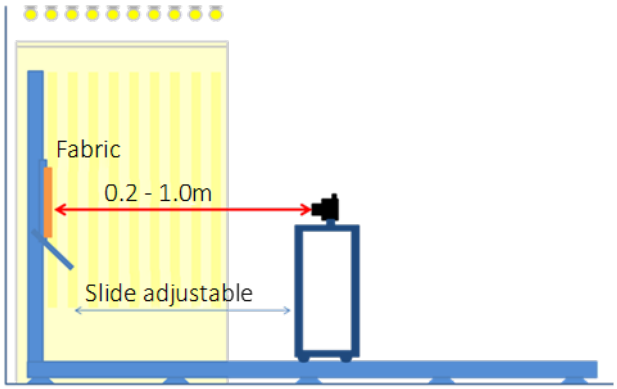

Figure 2. Photography booth for fabric

2.1.2 Evaluation Conditions

Figure 3 illustrates the evaluation conditions. The evaluation conditions consisted of a dark room, with the only light being the brightness emitted from the monitor. The distance from the monitor to the eye was approximately 72 cm. The evaluation scale was a 7-step unipolar scale (0 = no, 2 = slightly, 4 = usually, 6 = very) for roughness and smoothness, respectively. Participants were 10 male engineering students in their 20s.

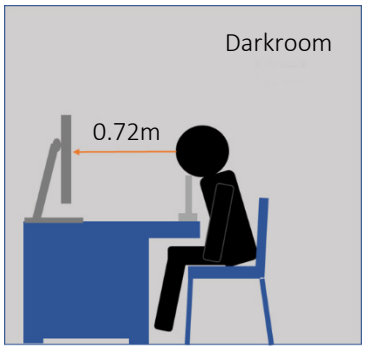

Figure 3. Evaluation conditions

2.2 Result and Discussion of Experiment

Figure 4 presents the relationship between shooting distance and smoothness/roughness evaluation values. As the shooting distance increased, the smoothness evaluation value increased, while the roughness evaluation decreased. Therefore, it is clear that a set of fabric surface images obtained by this imaging method can be used for quantitative assess smoothness/roughness. Further, it is clear that the evaluation characteristics of each fabric vary, although the trends of the evaluation characteristics are similar for each fabric.

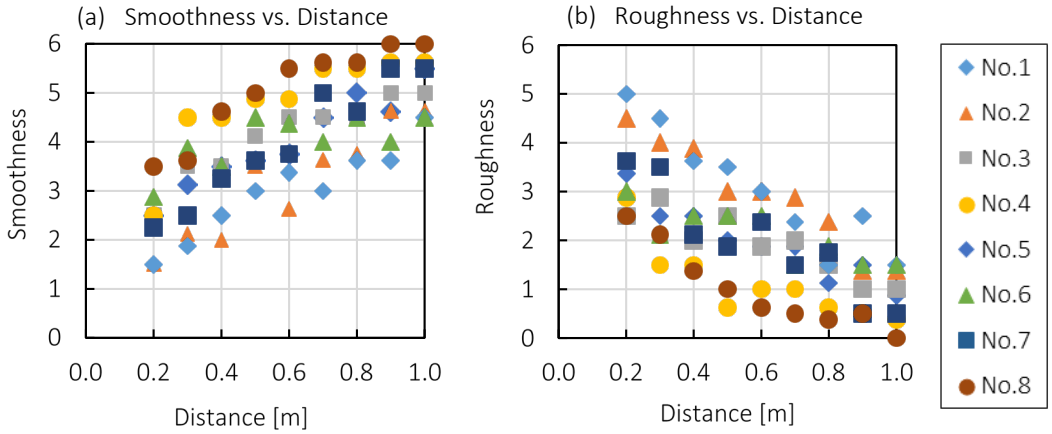

Figure 4. Relationship between shooting distance and evaluation value

Next, the symmetry relationship between evaluation of smoothness and roughness for the same image was examined. For the purposes of this study, symmetry was considered as the sum of the smoothness and roughness evaluations close to 6, and the absolute difference between the sum of the evaluations and 6 was calculated. The symmetry of No. 8 in Figure 5 was as high as approximately 0.9, and the symmetry of No. 5 was as low as approximately 0.72. Based on this, the results indicated that there may or may not be symmetry in the evaluation depending on the fabric type.

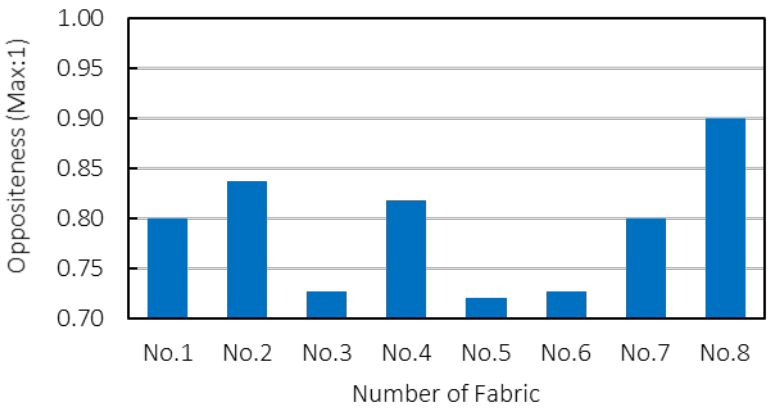

Figure 5. Oppositeness of smoothness and roughness for fabrics

3 ANALYSIS OF RELATIONSHIP BETWEEN SMOOTHNESS AND ROUGHNESS

The correlation coefficients between shooting distance, smoothness, and roughness were analyzed. Fabrics Nos. 1, 2, 3, 5, 7, and 8 which had high correlation coefficients between shooting distance and smoothness evaluation (Figure 6-(a)), tended to have high correlation coefficients between shooting distance and roughness evaluation (Figure 6-(b)). However, fabrics Nos. 4 and 6, which had low correlation coefficients between shooting distance and smoothness evaluation, tended to have low correlation coefficients between shooting distance and roughness evaluation.

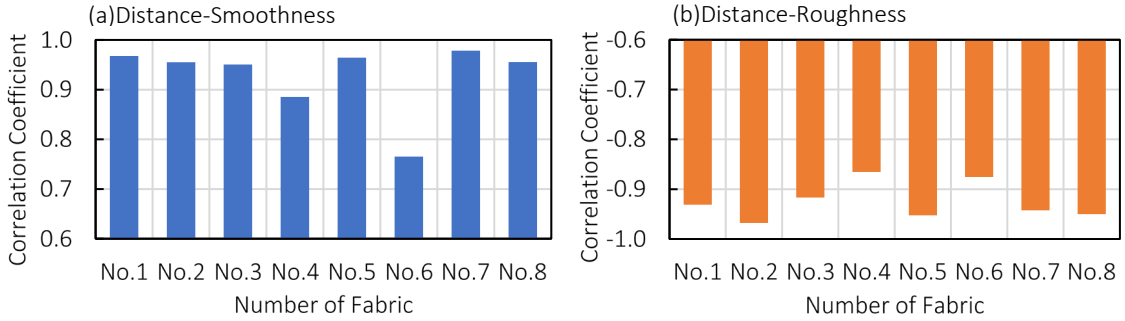

Figure 6. Correlation coefficient between shooting distance and smoothness/roughness evaluation

The correlation coefficients between evaluation of smoothness and roughness (Figure 7) were high for Nos. 1, 2, 4, 5, 7, and 8, suggesting a high correlation between the evaluation words. However, the correlation coefficients were low for fabric Nos. 3 and 6, suggesting a low correlation among the evaluation words. In other words, there were cases in which the correlation was not recognized, depending on the fabric.

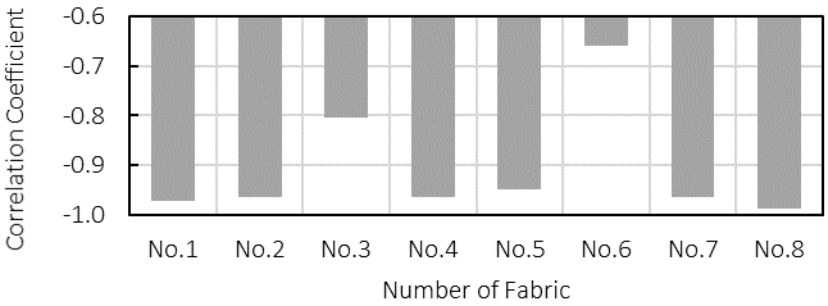

Figure 7. Correlation coefficient between evaluation of smoothness and roughness

Next, we analyzed the relationship between oppositeness (Figure 5) and the correlation between the evaluation words (Figure 7). Among Nos. 3, 5, and 6, which had low oppositeness, Nos. 3 and 6 also had low correlations, whereas No. 5 had low oppositeness but high correlations, suggesting that oppositeness and correlations capture different factors relating to making evaluations.

4 CONCLUSION AND FUTURE WORKS

The purpose of this study was to evaluate the smoothness and roughness of fabrics at seven unipolar levels using a set of images of eight different fabric surfaces and nine shooting distance conditions, and to examine the evaluation characteristics and symmetry between the evaluation words. The results revealed that the evaluation characteristics of smoothness and roughness of the fabric surface image with consideration of the shooting distance differed for each fabric. The fabrics with low correlation coefficients between the distance at which the fabric surface image was taken and the smoothness evaluation were almost the same as in the case of the roughness evaluation of the fabrics. Furthermore, the analysis of the correlation between evaluation of smoothness and roughness of a fabric indicated that symmetry between the smoothness and roughness evaluations could not be established in some fabrics.

It is suggested that future studies examine the differences in the evaluation characteristics of smoothness and roughness of fabrics and the effects of the physical sensation and visual characteristics of fabric surfaces, which are thought to influence the symmetry of smoothness and roughness evaluations.

Based on the above results, our final goal is to contribute to the development of next-generation online shopping sites that present images conforming to the evaluation of smoothness and roughness.

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