Comparison of Visual Impression Given by Texture of Real Surfaces and Synthesized Images

Atsushi Takemoto* Taishi Fujiwara† Kensuke Tobitani Yusuke Tani Noriko Nagata‡

Kwansei Gakuin University

ABSTRACT

We present a method to compare visual impressions given by the textures of real surfaces and 3D synthesized images of synthetic resins to improve the reality of CG images. We analyzed the structures of the visual impressions by conducting subjective evaluation experiments using real textures and generated images of the textures based on measurements of surface characteristics. We clarified the relationship between the visual impressions of the textures and the surface characteristics and showed the possibility of feedback to improve the reality of CG images.

Index Terms: Computing methodologies—Artificial intelligence—Computer vision representations—Appearance and texture representations

1 INTRODUCTION

In the field of computer graphics, many attempts to represent objects more realistically have been made [1, 2, 5]. However, so far, hardly any general method of making an objective and quantitative evaluation of the reality of CG images exists. In previous studies, visual roughness perceptions on dot pattern textures and their CG images were compared [3], and an impression evaluation of "pearl-like" quality was performed using photographs and synthesized CG images of pearls [4]. However, these studies were restrictive in terms of dependence on objects. In this study, we focus on emboss processing on surfaces of synthetic resins, and aim to investigate visual impressions given by real surfaces and generated texture images of synthetic resins. In addition, we propose a method to clarify physical differences by comparing them. Finally, we apply the results to improve the reality of CG images.

2 SUBJECTIVE EVALUATION EXPERIMENTS IN TEXTURES

We conducted subjective evaluation experiments to investigate the visual impressions given by real surfaces and synthesized texture images.

2.1 Collecting evaluation words

Prior to experiments, we collected words for evaluation of visual impression. First, we conducted a free writing experiment. Participants in this experiment observed the real surfaces of synthetic resins and freely wrote out the visual impressions given by them. Then we verified whether the obtained words were suitable for visual impression. As a result, we collected 59 adjectives with high fitness. After that, we verified whether these adjectives could replace each other and calculated the similarity of each word based on the semantic replaceability. Then, using the similarity of words, we performed multi-dimensional scaling and hierarchical clustering using Ward's method. Finally, we collected 19 adjectives that were comprehensive and representative to evaluate visual impression, and we used them for evaluation experiments. These adjectives are actually Japanese words.

*e-mail: a.takemoto@kwansei.ac.jp

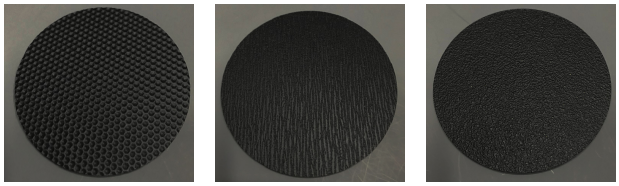
†e-mail: t.fujiwara@kwansei.ac.jp

‡e-mail: nagata@kwansei.ac.jp

2.2 Evaluation of real textures

2.2.1 Method

We used 20 samples of synthetic resins as stimuli. Each was made using various emboss processing, for example, a wrinkle or dot pattern (Fig. 1). The participants in this experiment were 19 Japanese college students in their 20s (17 men, 2 women). They evaluated a 19-adjective scale of approximately 20 stimuli in 5 stages. This experiment was conducted in a darkroom where the lighting environment was controlled.



(a) Sample 5. (b) Sample 13. (c) Sample 18.

Figure 1: Examples of synthetic resin samples.

2.2.2 Results and discussion

We performed factor analysis to rate the data using the maximum likelihood method and the Promax rotation. Table 1a shows the results of factor analysis. We extracted 3 factors. We interpreted each factor as follows: Factor 1 is "freshness" because "dry" and "aged" have high negative factor loading; Factor 2 is "roughness" because "slick" and "smooth" have high negative factor loading; and Factor 3 is "preference" because "uncool" and "unlikable" have negative factor loading. We regarded the adjectives that did not have factor loading of 0.5 or more for any factor do not belong to any factor.

2.3 Evaluation of synthesized texture images

2.3.1 Method

We used 20 synthesized texture images as stimuli (Fig. 2). They were each generated based on measurements of BRDF (bidirectional reflectance distribution function) and height maps of 20 samples of synthetic resins. To generate images, we used Autodesk MAYA, and for the lighting conditions at the time of rendering, we set the same environment as the lighting environment of the previous experiment described in section 2.2. The participants in this experiment were 10 Japanese college students in their 20s (9 men, 1 woman). They evaluated a 19-adjective scale of approximately 20 stimuli in 5 stages. Then, we used the same adjectives in the experiment described in section 2.2 for evaluation. This evaluation experiment was conducted in a darkroom. For presentation of the stimuli, the display monitor was used at a resolution of 1920×1200.

(a) Sample 5. (b) Sample 13. (c) Sample 18.

Figure 2: Examples of synthesized texture images.

2.3.2 Results and discussion

We performed factor analysis to rate the data using the maximum likelihood method and the Promax rotation. Table 1b shows the results of the factor analysis. We extracted 4 factors. We interpreted each factor as follows: Factor 1 is "innovativeness" because "futuristic" and "progressive" have high positive factor loading; Factor 2 is "smoothness" because "smooth" and "slick" have high positive factor loading; Factor 3 is "profoundness" because "firm" and "heavy" have high positive factor loading; and Factor 4 is "unevenness" because "warty" and "uneven" have high positive factor loading.

Table 1: Results of factor analysis.

(a) Real textures.

	Factor 1	Factor 2	Factor 3
dry	-1.003	-.057	.122
aged	-.994	-.161	-.010
regular	.925	.562	-.050
youthful	.919	-.043	.090
futuristic	.902	.090	.166
sporty	.851	-.135	.044
progressive	.833	-.027	.235
sophisticated	.816	-.042	.303
rough	-.693	.593	.109
beautiful	.524	-.378	.404
heavy	-.440	.158	.129
slick	.044	-1.017	-.104
smooth	-.018	-.969	-.007
uneven	.119	.947	-.070
jagged	-.223	.905	.486
warty	.294	.703	-.316
uncool	-.056	.391	-.639
unlikable	-.040	.437	-.599
firm	.196	.219	.400

(b) Synthesized texture images.

	Factor 1	Factor 2	Factor 3	Factor 4
futuristic	1.034	-.210	-.115	.031
progressive	.977	-.352	.103	-.005
aged	-.965	-.013	.055	.042
regular	.919	.082	-.099	.130
sophisticated	.859	-.111	.217	-.148
youthful	.849	.077	.059	.041
rough	-.785	-.339	-.026	-.048
dry	-.748	-.334	-.003	-.151
sporty	.742	.243	.009	.195
beautiful	.636	-.022	.494	-.129
smooth	-.139	.963	.110	-.321
slick	.095	.890	.093	-.242
jagged	-.006	-.795	.144	-.448
firm	.097	.122	.855	.144
heavy	-.506	.018	.792	.292
uncool	-.137	.101	-.771	.098
unlikable	-.111	-.107	.667	.087
warty	.339	-.129	-.073	.938
uneven	-.192	-.156	.185	.931

3 Comparison of Visual Impressions

3.1 Two-Way ANOVA

We performed a two-way ANOVA to investigate the difference of the visual impressions, with factor condition (real and synthesized images) and stimuli (texture). The analysis was performed with the data of 7 participants who took part in both evaluation experiments. From the results of the analysis, there were no significant differences in the conditions. However, for the specific adjectives "beautiful," "dry," "jagged," "rough," "slick," "smooth," "unlikable," and "warty," there were significant differences in interaction between condition and stimuli at the 5 percent level.

3.2 Multiple comparison

To clarify in which stimuli significant differences occurred for specific adjectives, we performed a multiple comparison using the Bonferroni method. Table 2 shows the results of the multiple comparison. In the table, the stimuli for which there were significant differences are colored. The stimuli colored in red show that the evaluation score of the real texture was higher than that of the synthesized image. The stimuli colored in blue show that the evaluation score of the synthesized texture image was higher than that of the real texture.

3.3 Discussion

Compared with the results of the factor analysis for the real textures and the synthesized texture images, Factor 2 in the real textures separated into Factor 2 and Factor 4 in the synthesized texture images. The results of two-way ANOVA indicated significantly different interactions in "jagged," "slick," "smooth," and "warty." We infer that the result is due to the difference in visual impressions in the real textures and the synthesized images. Picking out "jagged," "slick," "smooth," and "warty" in Factor 2, we recolored based on the results of the multiple comparison (Table 3). In this process, "jagged" and "warty" were replaced with "not jagged" and "not warty." The stimuli colored in red show increasing the visual impression of "smoothness" in the synthesized images. On the other hand, the stimuli colored in blue show decreasing it in the synthesized images. For these reasons, we interpreted that the visual impression of smoothness in synthesized images increases in coarse and deep textures, such as in sample 5; however, it decreases in fine and shallow textures, such as in sample 13. These results suggest the possibility of improving the reality of CG images considering physical characteristics.

Table 2: Results of multiple comparison.

adjectives\samples	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
beautiful																				
dry																				
jagged																				
rough																				
slick																				
smooth																				
unlikable																				
warty																				

Table 3: Results of recoloring.

adjectives\samples	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
not jagged					△	△				▼					▼					△
slick				▼	△					▼			▼					▼		
smooth	△							▼	△				▼							
not warty				▼													▼	▼		

4 Conclusion

We investigated the difference in visual impressions regarding the texture of synthetic resins of real surfaces and 3D synthesized images. Based on the results, we clarified the relationship between the visual impressions of the textures and their surface characteristics. This suggests the possibility of feedback to improve the reality of CG images.

Acknowledgments

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