Evaluation of Visual Features of Textile Designs Using Genetic Algorithm

Ken'ichi Ohta*, Mitsuya Saeki**, Chikako Yamada***, Toyonori Nishimatsu****, Members, TMSJ

* Himeji Institute of Technology, Himeji, Japan  
** Technical Research Center of Hyogo Pref., Nishiwaki, Japan  
*** Ikenobo Junior College, Kyoto, Japan  
**** Shinsyu University, Ueda, Japan

Based on Journal of the Textile Machinery Society of Japan, Vol.36, No.4, P99-102 (1997-4)

Abstract

Designs that have been stored in early days are often used as a reference when textile designs are created. To effectively use these resources, an well-organized design database must be constructed and a useful searching method must be studied. As to design searching method, searching methods that deal with human subjective information is requested. As a technique for these searching methods, one method to characterize visual feature of textile designs is proposed. In this study, a correspondence was examined between the subjectivity like "strong impact" for textile designs and spatial frequencies that are objective visual features for them. In this examination, genetic algorithm was introduced in order to increase the efficiency of processing time.

It was presumed that the subjective impressions of "strong impact" were related to lower components of spatial frequencies of textile design images. In this result, the textile designs that impress human when human compare designs are similar to the textile designs that are made up of lower spatial frequency components. As to design searches from subjective impressions of "strong impact," lower spatial frequency components that are objective visual features are available for one of subjective searching item.

1. Introduction

When searching a textile design database, it is important to be able to use the visual features of textile design in meeting the demands of a designer's subjective reference to a "certain image".

As stated in the first report, the spatial frequencies that effect objective estimation have not yet been examined. For this reason, this study will deal with the subjective impression of "strong impact" as a subjective factor of textile design for comparison, and investigate its relationship to spatial frequencies, regarded as one kind of quantified objective visual feature's. Large-scale calculation management regarding color image transactions is required, so we will introduce Genetic Algorithm (AG) in order to efficiently compare the subjective evaluation with the objective evaluation.

2. Experimental Methods

2.1 The Subjective Evaluation of Textile Design

Using ten pieces of checked yarn-dyed fabric design cloths (25 cm × 25 cm) in the textile designs test, we did a paired comparison physical test based on the subjective impression of "having strong impact." For this subjective evaluation, we adopted the results reported in Part 2 ~. Refer to Part 2 for details about the contents of test and evaluation and the method of examinations. The paired comparison scale gained from the paired comparison test is given in Table 1. From now on, we will treat the paired comparison scale as the subjective evaluation scale of textile design.

2.2 The Objective Evaluation of Textile Design

We use spatial frequencies, which are one of the quantified objective visual features, for objective evaluation of textile design. Because these measure the periodicity of a repeated pattern in the surface pattern of a textile, it is thought that spatial characteristic are revealed in the spatial frequency. Generally speaking, visual feature which man recognizes can be shown with the characteristics of low-pass filters.
Accordingly, it is believed that some visual features are generated at low frequency components of spatial frequency, the low-pass transaction is done in the spatial territory. As for the details on spatial frequencies and low-pass transactions, see Part 1. In this study, we will consider the evaluation of the low-pass image gained from this operation.

As stated above, the visual features of human beings can be analogous to low-pass filter characteristics, we cross-correlate between the low-pass images and the original images with each textile design in order to examine the quantity of information shared by low frequency components on the textile surface patterns. This shows the level of correspondence to the low-pass images and the original images. The textile surface patterns are those used in Part 2 and were input as 512 X 512 sized images using a color scanner. The correlation of the image A(m,n) and the image B(m,n) can be found by the following equation. In this case, we define the correlation as the objective evaluation scale.

Next, we correlate the subjective evaluation scale and the objective evaluation scale. This time, if we can gain a high correlation, we consider the subjectivity as having "strong impact" with close relation to frequencies including the circle of low-pass radius r in the territory of spatial frequencies.

2.3 Introduction of Genetic Algorithm (GA)

We showed how to relate the subjective evaluation scale with the objective evaluation scale above. Next we must replicate the low-pass image of all low-pass radius r against the image of each textile design. We will also calculate the correlation coefficient. In this report, the number of textile design image tested is 10, the values of the low-pass radius r are 1, 2, ..., 255, and each element of L*a*b* is made the target. So we replicate the low-pass image to 255 X 10 X 3 and calculate the correlation coefficient between each low-pass image and the original image. Increasing the size or number of images greatly increases the time needed for processing. To solve this problem, we introduce GA for efficient processing. GA is a kind of search algorithm aimed at a process the evolution of living things. In GA, each searching point is regarded as a living individual with a gene. Such individuals gather and form groups of individuals. The individual groups have repeated generational changes and become groups well adapted to environment and to find the answers required. This report chooses Simple Genetic Algorithm (SAG), which is the most basic.

Each individual has a gene and is called the gene model. The characteristics of the individual are called "expressions of individuality." We set the number of individuals at 15 and the expression of individuality as the value of low-pass radius r (r=1, 2, ..., 255). And as the value of low-pass radius r ranges 1 ≤ r ≤ 2-1, a gene is set as a fixed length of 8 bit binary number. Next, carry out the following operation.

First, change the image of each textile design into the territory of the spatial frequencies territory. Next, the form multiplies of the individual whose expression is the low-pass radius, and makes a group of living things. Carry out the following operation for each individual.

(1) Filter the spatial frequency of each textile design to show the low-pass radius of each individual textile design image and gain the low-pass images of each image.

(2) Look for the correlation coefficient between the low-pass image from (1) and the original image, and define it as the measure of objective evaluation.

(3) Look for the correlation coefficient between the subject evaluation and the object evaluation, and define it as the degree of adaptability of the individual. If the adaptability degrees of all individuals are filled and the average degree of adaptability of the living things reaches the target value already determined (0.90 in this study), finish the GA operation. If not, apply the following operation (4)-(7) to the group of living things.

(4) Select the individual with the highest degree of adaptability, and form the new group of living thing (selection). Selection is the operation of choosing the individual making up the next generation group based on its adaptability. The individual of highest adaptability is selected for the next generation by this operation. In this study, the number of individuals in the new group of living things is the same as the number of individuals in the original group of living things.

(5) Carry out a crossing of the individuals of new living things, according to the crossing rate. By selecting individuals to form the next generational group, crossing selects a pair of individuals at random and partially changes the position of these gene models at random. The aim is to search the points closest of this searching point.

(6) Next, mutate the individual of living things according to mutation rate. This operation changes the randomly ranged genes of the randomly selected individuals into opposition genes. The aim of this operation is to search the points farthest from this searching point. Set the crossing rate at 20 % and the mutation rate at 20 %.

(7) Define the group of living things consisting of new individuals from the operation as the next generation.
Table 1  Paired comparison scale using Bradley's method

| LABEL | SCALE |
|-------|-------|
| A     | 0.002 |
| B     | 0.004 |
| C     | 0.017 |
| D     | 0.032 |
| E     | 0.043 |
| F     | 0.084 |
| G     | 0.159 |
| H     | 0.147 |
| I     | 0.190 |
| J     | 0.323 |

Fig. 1 Flow chart of Genetic Algorithm

Fig. 2 Result of GA (Cross-Correlation between subjective scale of "pop out feeling" and radius of low-pass filter)
The operations are shown in Figure 1. For low-pass radii, which are already chosen, keep the correlation coefficient between the low-pass image and the original image at that time. When the low-pass radius is chosen again, retrieve the correlation coefficient, that is, the objective evaluation scale from the table. By this operation, we can save a great deal of time reproducing low-pass images and calculating the correlation, and we can reduce the transaction time when present groups of living things are chosen for the individual of next generation by the low-pass radii of their expression.

3. Results and Observations

In cases when we got the objective evaluation scale from an image with a component in L*a*b* colors, the average adoption degree of a group of living things showed the highest value at the end of GA. This is shown in Figure 2. The curved lines plot the value of correlation coefficient between the subjective evaluation and the objective evaluation. The distribution of segments meeting the curved lines perpendicularly show the individual distribution gained from GA. In case, the individuals are centered around the same value r; these are shown to be overlapped. We procured these curved lines in all our searches to assure valid GA treatment. In comparison with all our searches, searches done with GA allowed us to complete our searches with 20% of processing.

As seen in Figure 2(b), the individuals are distributed across a small territory of low-pass radii. It is thought that the subjective evaluation is related to the objective evaluation in this territory. As the expression of individuality represents low-pass radii, the subjective impression of "strong impact" appears to be closely related to a* element in L*a*b* colors, that is, or the low components of spatial frequency of image whose density level changes color from red to green.

What we find from these results is that in comparative judgement of textile designs, what humans find to be of "strong impact" are not subtle changes in color and form, but broad changes in color and form, especially color changes from red to green.

4. Conclusion

First, we carried out a paired comparison test based on the subjective impression of textile designs having "strong impact" and we gained the subjective evaluation scale. Next, from the fact that the visual characteristics of human being are characterized to low-pass filter features, we examined the cross-correlation between the original image of a textile surface image and the low-pass image, and defined the results as the objective evaluation scale. Examining the correspondence to the subjective evaluation, we introduced GA considering the efficiency for carrying out the calculation. As a result, the subjective evaluation of having "strong impact" corresponded to the* component of L*a*b* colors, the low-pass radius of spatial frequencies which showed information of changing color from red to green.

Though the objective method of evaluation sufficiently stated the subjective impression of having "strong impact," we still have to investigate both objective features, which will be a clue to explaining the subjective, and their mutual effects.

REFERENCES

1) K.Ohta, T.Ishii, A.Nakata, Sen-i Kikai Gakkaishi, 47, 5, pp.51-57(1994)
2) K.ohta, K.Sakaue, H.Kosako, Denshi Joho Tsushin Gakkai Ronbunshi, J74-D II , 11, pp.1491-1497(1991)
3) H.Sakata, H.Isono, Television, 31, 1, pp.29-35(1977)
4) H.Kitano, Sangyo Tosyo, pp.3-60(1993)
5) T.Higuchi, H.Kitano, Joho Syori, 34, 7, pp.871-883 (1993)
6) K.Wada, Suuri Kagaku, 328, pp.47-51(1990)
7) K.Ohta, M.SaeKI, C.Yamada, T.Ishii, Sen-i Kikai Gakkaishi, 50, 3, pp.58-65(1997)
8) K.Ohta, K.Sakaue, H.Kosako, A.Takaoka, Denshi Joho Tsushin Gakkai Ronbunshi, J74-D II , 11, pp.1520-1527(1991)
9) Tyler C.W., Chang J.J., Proc. Soc. photo. Opt. Instrum. eng., 74, pp.216-222(1976)