Exploring Texture Pattern Features and Relations to Kansei with 2D FFT - Wallpapers and Dashboard Leather Grain Patterns

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Abstract

Purpose – Ablity of texture pattern recognition of human is very high and precise. Although details of texture significantly affect to Kansei, grasping texture features in quantitative methods have been difficult. We have analyzed wallpaper and car dashboard leather grain patterns with 2-dimensional FFT (Fast Fourier Transfer). Relations between spectrum features and Kansei evaluation are also analyzed.

Methodology/Approach – On Wallpaper study, sample rooms with various wall paper were made with architectural 3-dimensional CAD software. Twenty- five different wallpaper samples were used. Fifty-four Kansei word pairs were used as 5-point SD questionnaire. Sample pictures were presented with color calibrated display.

With PCA, we have analyzed Kansei space. The 1st principal component was named as "Activity". The 2nd pc was "refined-ness". Then we have analyzed texture of 3 samples with 2D FFT, those have almost same color but differs on texture.

On car dashboard leather grain patterns, 24 samples of different pattern those have same color were evaluated. Using close-up camera picture, leather grain patterns were analyzed with 2D FFT.

Findings – On wallpaper study, the samples 20,17 and 11 have almost same grayish beige color. On sample 20, 2D FFT result clearly shows the dominant pattern of check and its higher harmonic components. In sample 17, the result suggest the oblique components, In sample 11, there are wide renge surge of oblique components suggests various frequencies of triangular texture. Even within the triangles, as lower frequency components increase, "activity" decreases and tends toward "heavy" Kansei.

On leather grain pattern study, variations of grain size, variations of grain shape, line directions and intensity were captured from 2D spectrum. Critical frequency features for Kansei were also found.
Originality/Value of paper – Modern pattern analytic techniques have been not utilized for Kansei engineering. We presented very useful and promising technique for quantificate various detailed features.

Keywords *texture analysis, 2-dimensional FFT, multivariate analysis*

Paper type *Research paper*

1. INTRODUCTION

In Kansei engineering, we have been treated design elements variations as categorical variables (nominal scale). Typical coding are such like long / tall / short / cubic or round / square corners. Categorically coded design elements are assigned as Xs, Kansei evaluation value on a Kansei word is assigned as Y, then weights on Xs have been solved with Quantification Theory Type I, a variant of multiple regression analysis. This way of analysis is useful in the practical applications those have compounds of various types of design elements.

On the other hand, categorical coding loses the design details in the analysis. Many design elements can be expressed in analog continuous figures (interval scale) with proper measurement.

In this research, we have analyzed relations between texture patterns and Kansei. With the multivariate analysis based approach, we analyzed relations between wallpaper texture and Kansei evaluation. Then, frequency domain of the texture patterns was analyzed with 2-dimensional FFT (Fast Fourier Transfer). We have considered the aggregation with common multivariate analyses and pattern analysis technique to exploring relations between Kansei and design more in detail.

2. 2D FFT

There are several approaches for analyzing 2D patterns from the aspect of special frequency. We have analyzed these samples with 2D FFT. Two-dimensional FFT is used as a method of analyzing special frequency in a shape of spectrum. And in signal processing field, it has been used for frequency filtering method, especially for removing higher or lower frequency noises. To removing noises, calculate the picture's 2D FFT, then removing unwanted frequency region, finally by computing inverse 2D FFT, noises are removed. In this study, we have used 2D FFT as a spectrum analyzer of texture pattern and texture orientation.

Computation of 2D FFT has two stages. At first, each line (row) of original picture is substituted by its 1D FFT spectrum, and then 1D FFT is prerformed on each column [1]. At each row, when lower cycles have more power than higher cycles, then left side of the spectrum has higher value, on the result of "1st step: FFT on rows". In this research, all original samples have 255 x 255 pixel size, then lowest frequency is the 1 cycle (corresponds to 255 x 255 check) and the highest is 128 cycles (2 x 2 check) (shown in Figure 2). In the example which shown in figure 1, the zone from 1 cycle to around 50 cycles has higher power.

In the 2nd step, FFT was performed on each column on the array of row FFT results. Its outcome means analysis of the perturbation (on row) of each cycle (of row FFT).

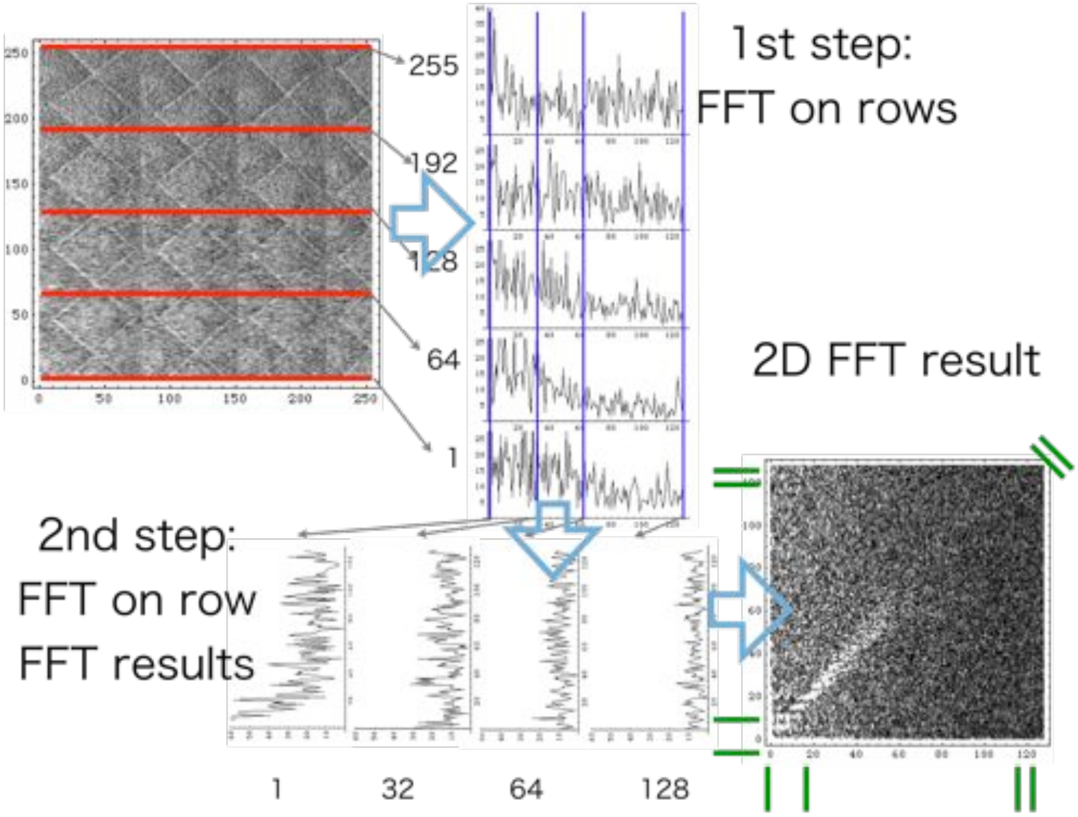

Figure 1. Scheme of computing 2D FFT

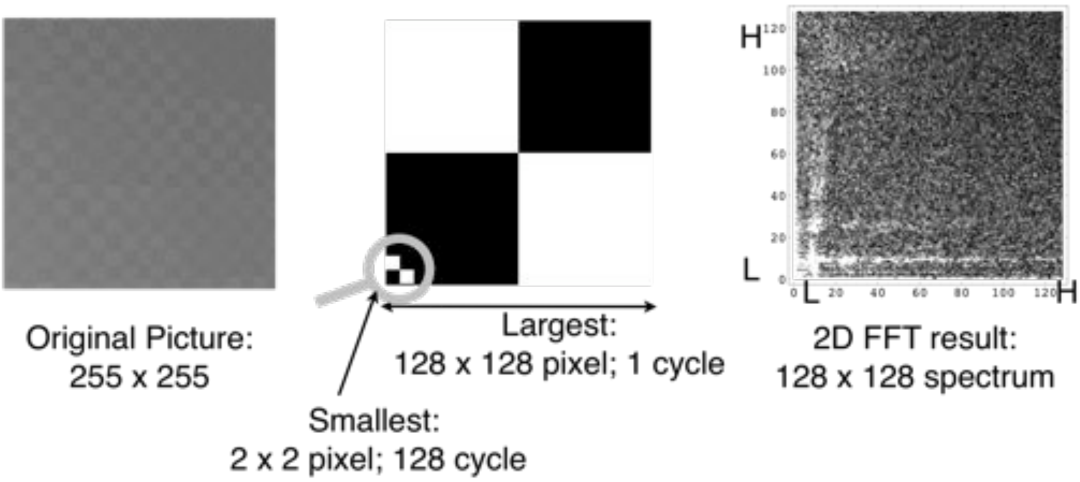

Figure 2. Original picture and corresponding cycle

In the example of figure 1, 2nd step FFT at column 1 shows the perturbation of 1 cycle, the very row frequency. In common texture, low frequency component has low frequency perturbation. On 32 cycles, there are surges from about 22 to 38 cycles. These correspond 11 pixels (255/22) to around 7 pixels (255/38) texture pattern, parts of various frequency of fabric texture.

In a result of figure 1 example, diagonal surges are apparent in the 2D FFT result. These correspond to the various frequencies of oblique texture pattern. In figure 2, several horizontal and vertical surge lines correspond to one dark or light block, check, and their harmonics.

3. KANSEI EVALUATION EXPERIMENT OF WALLPAPER

3.1 Evaluation Experiment

We have made 25 sample rooms with different wallpaper patterns with architectural 3-dimensional CAD software (Vectorworks ver.12). Twenty-five commercially-produced wallpaper samples were scanned and used for texture mapping on the wall.

Subjects were 10 males and 12 females, whose ages are between 20 to 23. Fifty-four Kansei word pairs were used as 5-point SD questionnaire. Sample pictures were presented in random order with color-calibrated display.

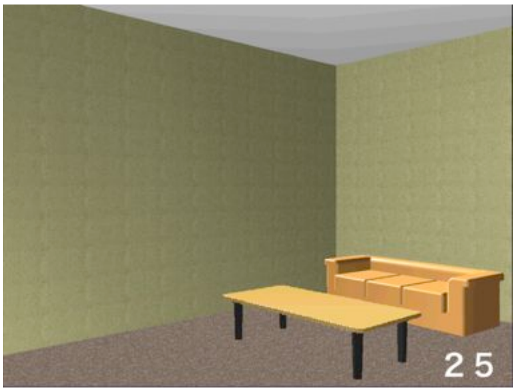

Figure 3. Evaluation sample

3.2 Kansei Analysis with PCA and QT1

With PCA, we have analyzed Kansei space. First and second principal components were considered because of the larger eigenvalues.

In the 1st principal component, "bright", "lively" and "childish" have larger positive loading, "dark", "adult" and "heavy" have larger negative loading. The 1st principal component was named as "Activity".

For the 1st phase analysis, relations between design elements were analyzed with Quantification Theory type I analysis (categorical coding of the texture). On the right hand side of figure 1 (upper graph), we found the relations such as, "bright" is picture pattern or check, "childish" and “feminine” are picture pattern. On the left side, "adult" is stripe and warm color, "masculine" is stripe.

In the 2nd principal component, "refined", "simple", "plain" and "decent" have larger positive loading. "Coarse", "unique" and "glitter" have larger negative loading. The 2nd PC was named as "refinedness". On the upper side of figure 4 (bottom graph), "Decent" is stripe and warm color, "refined" is stripe, "chic" is solid color. On the bottom side, "brilliant" and "individual" are picture pattern.

In general, "activity" positive words are check or picture pattern and in cold color. "Refinedness" positive words are plain or stripe. Moreover, many of them are in warm color.

Figure 5 shows the design suggestions based on above results. For “active” and “healthy” Kansei, cold color and check paper is appropriate. For “ease” room, warm color and stripe paper is preferable. For “chic” room, warm color but plain, unpatterned paper is desirable.

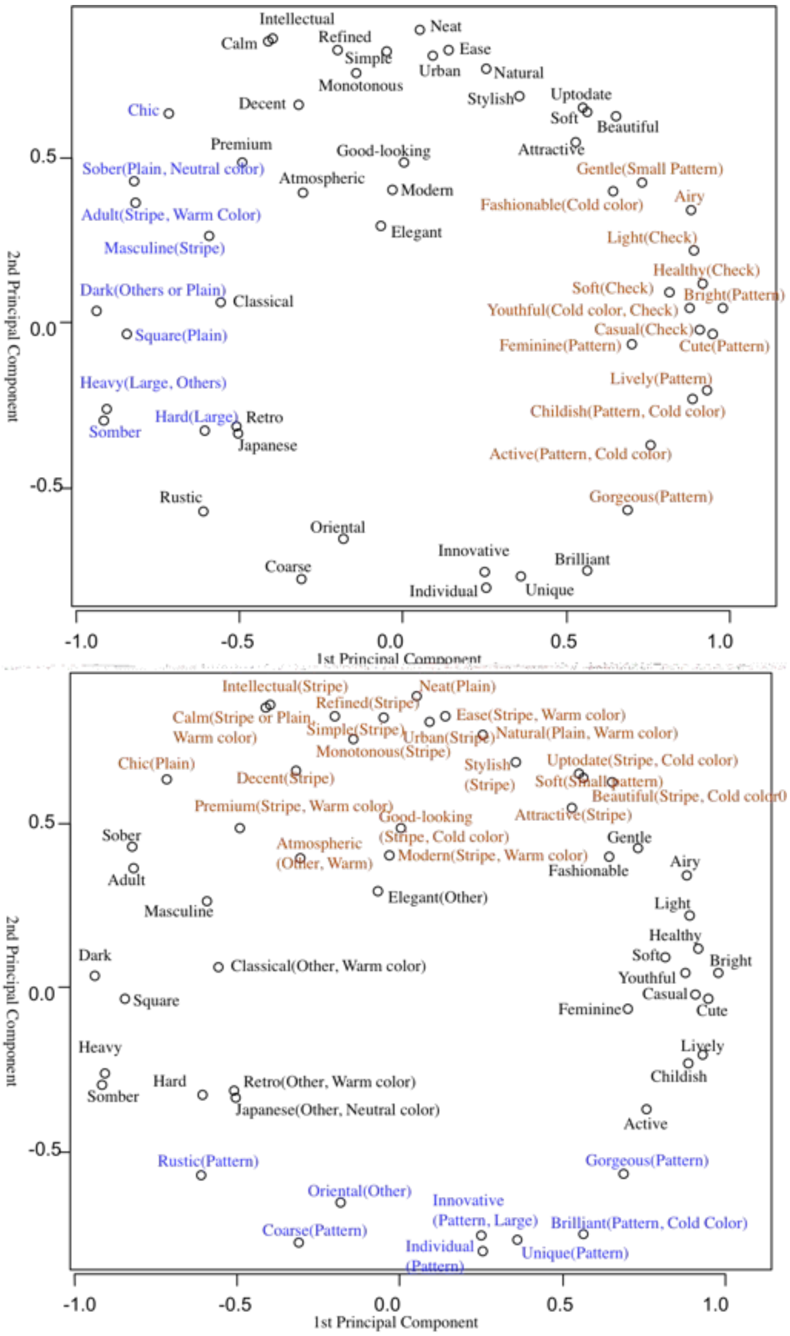

Figure 4. Principal component loadings of Kansei words and corresponding design features (upper: along 1st PC, bottom: along 2nd PC)

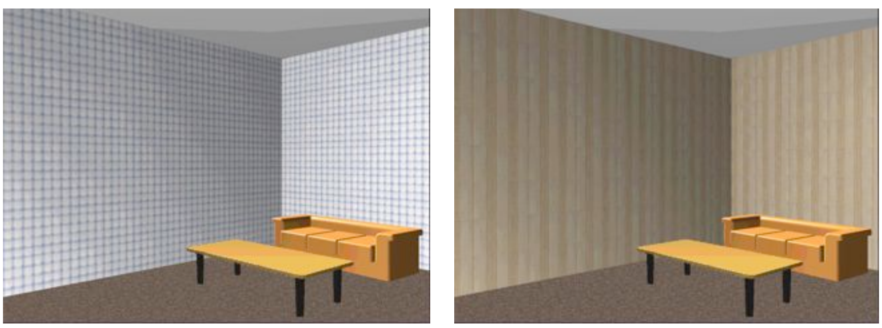

Figure 5. Design suggestions for “active” room (left) and “refined” room (right)

4. WALLPAPER TEXTURE ANALYSIS WITH 2D FFT AND RELATIONS BETWEEN KANSEI

Then we have analyzed texture of 3 samples. The samples 20,17 and 11 have almost same greyish beige color. Although they differ only on texture, their corresponding Kansei is rather different as seen in Fig.6. Sample 20 has square check and evaluated high on "adult" and "calm". 17 has smaller triangle texture, vertical stripe and is "adult", "sober" and "dark". 11 has larger triangle texture and more "heavy".

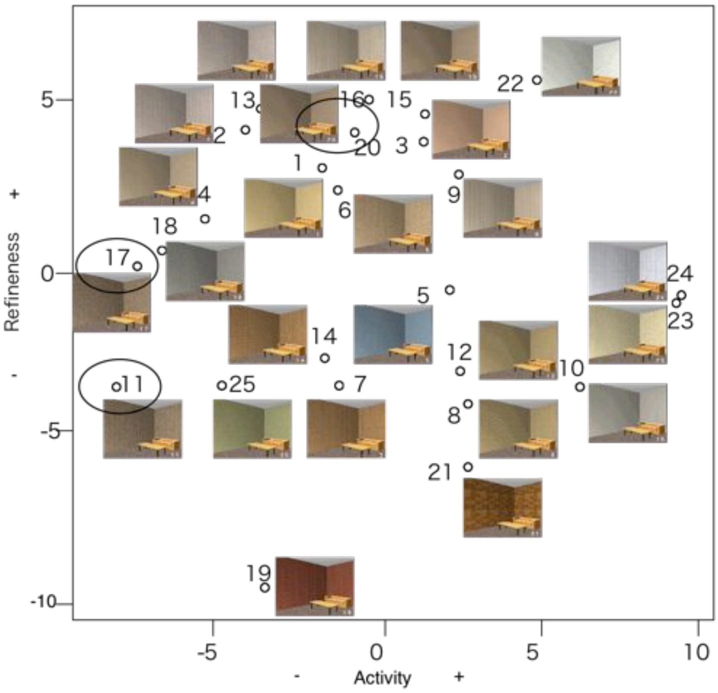

Figure 6. PC score plot of samples

We have analyzed these samples with 2D FFT. The sample picture sizes 255 x 255 pixels. 2DFFT shows horizontal frequency distribution along direction of x axis. Vertical frequency distribution was shown along direction of y axis. Oblique components are shown on orthogonal orientation. Left down corner shows the 1 cycle. FFT computation program was written in Mathematica, based on Prof. Andrew Dougherty's code [2].

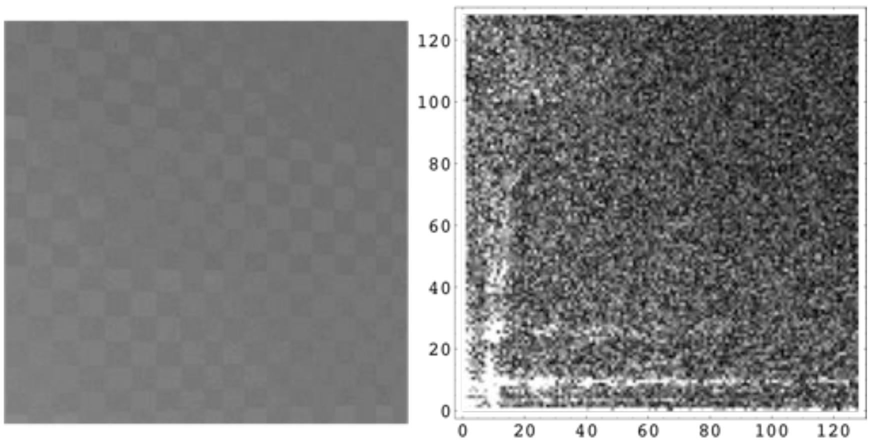

Figure 7. Sample 20 (left) FFT result (right)

On sample 20 (Fig.7), white dots are lined around 9 cycles on both horizontal (y axis) and vertical (x axis). These correspond to 255/9=28 pixel. Since size of a check of 4 blocks is near 28 pixel, the white lines show this check and its higher harmonic components.

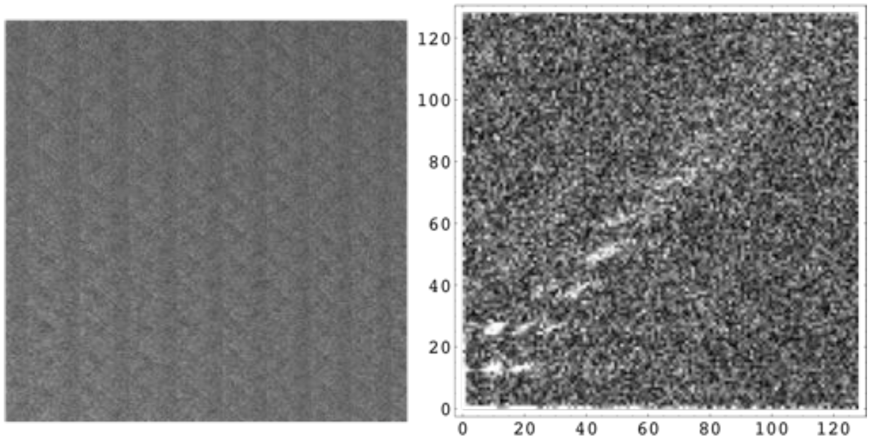

Figure 8. Sample 17 (left) FFT result (right)

In sample 17 (Fig.8), orthogonal white dots suggest the oblique components, There are peaks along 9 to 11 and 18 cycles. The former corresponds the large vertical stripe (30 pixel) and latter corresponds to the height of the triangle texture (14 pixel).

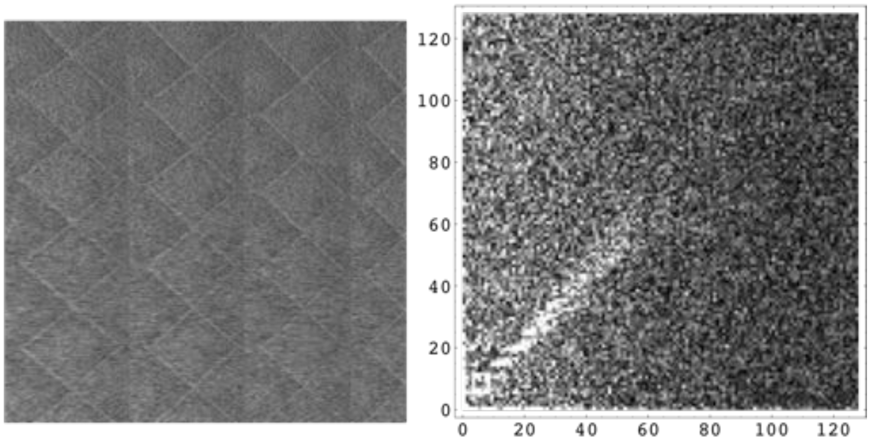

Figure 9. Sample 11 (left) FFT result (right)

In sample 11 (Fig.9), there are oblique components stronger than the sample 17, especially on lower to middle frequencies. On the x axis, there are peaks on 4 and 8 cycles. The former is large vertical stripe (70 pixel) and the latter is the height of the triangle (30 pixel). On the y axis, there is a peak around 20 cycle and is corresponds to the size of the triangle base (58 pixel).

The triangles have many frequency components than square checks. Even within the triangles, as lower frequency components increase, "activity" decreases and tends toward "heavy" Kansei.

5. ANALYSIS OF DASHBOARD LEATHER GRAIN PATTERNS WITH 2D FFT AND RELATIONS BETWEEN KANSEI

5.1 Evaluation Experiment of Leather Grain Pattern

Twenty-four leather grain pattern samples those used in the evaluation were made on plastic film with different fabrication conditions. From 4 basic patterns, variations were made with 5 different heat pressing conditions.

Kansei evaluation was done with 20 participants. Ten participants were female and other 10 were male, all of them were students.

5.2 2D FFT analysis of Leather Grain Pattern

All leather grain patterns were taken with digital single-lens reflex camera. Same as wallpaper case, 255 x 255 gray scale data were used for analysis.

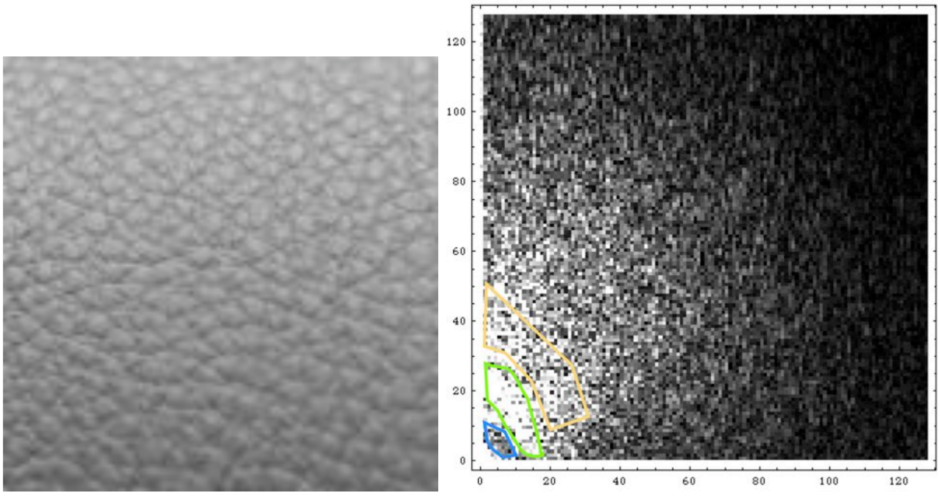

Figure 10. One of master pattern sample (left) and FFT result (right)

Figure 10 shows the one of the master pattern. The result shows the 3 different round arch areas. The 1st arch (darker area) locates the most lower frequency region in the 2D FFT spectrum, from 5 to 10 cycles of horizontal and vertical axes. This arch means lack of lower frequency. The 2nd arch (brighter area) locates the outside of the 1st arch. This arch is from 10 to 20 cycles at the horizontal axis and from 10 to 30 cycles at the vertical axis. This arch shows the dominant peak of leather grains those have round or rhombic shape. The 3rd arch which locates outside of the 2nd arch also shows the anisotropic nature of the pattern. Leather grain pattern of this sample is little longer along with the horizontal direction than vertical direction.

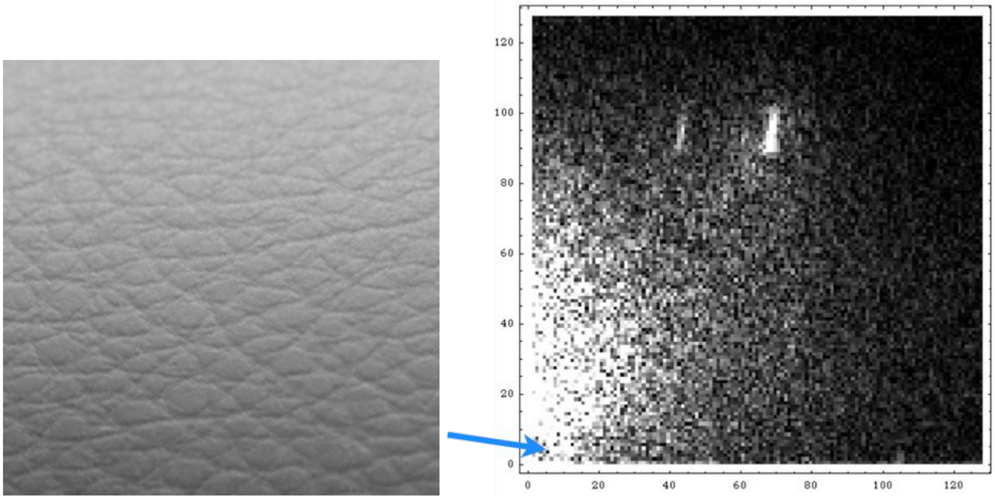

Figure 11. Variant pattern sample (left) and FFT result (right)

Figure 11 shows the one of the variant pattern and its analyzing result. The pattern was made with more stretching than the master. 2D FFT spectrum shows lower frequency surge in lower left corner. Two isolated peaks on the upper side corresponds small granular textures caused with the stretching process.

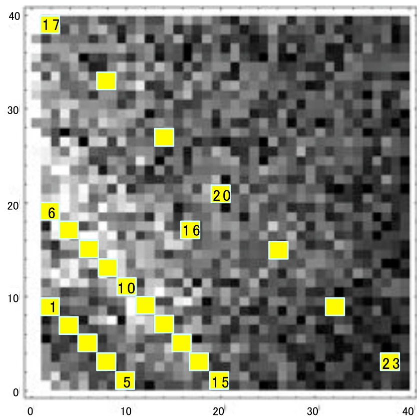

Figure 12. Re-sampling points on the 2D FFT spectrum

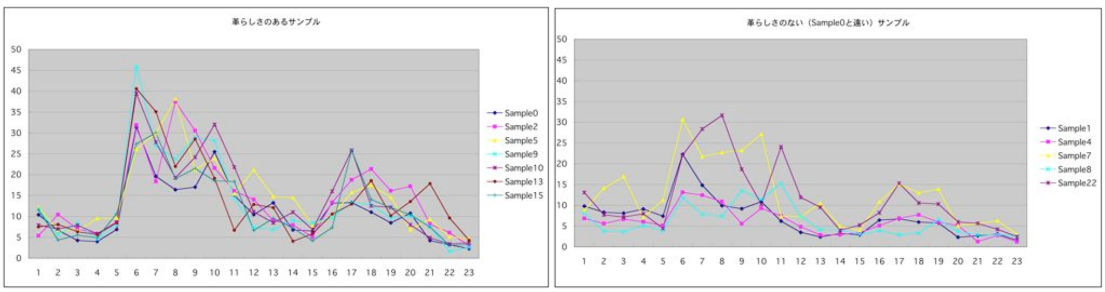

Figure 13. Power chart of re-sampled points value. Left: Highly evaluated samples of "Authentic" and "Premium", Right: Slightly evaluated samples.

We have re-sampled value from the 2D FFT spectrum for exploring the relations between Kansei evaluations. We have compared power of these re-sampled points between samples have highly evaluated on "Authentic" and "Premium" and slightly evaluated samples. The differences between two kinds of samples are apparently shown in Figure 13. Highly evaluated samples have surge on point 6 to 8 and gradually power falls. Slightly evaluated ones have not large surge and not show decrease along the line. Also, highly evaluated samples have a surge on point 17 and decay along the line. Slightly evaluated have not such feature.

6. CONCLUSION

In this paper, we have presented a methodology that combines the common procedures of Kansei engineering and a signal processing technique.

Common Kansei engineering procedure is useful at finding relations between salient design features and Kansei evaluation. In wallpaper case, the salient features are colors and patterns like stripes, check and unpatterned. These features are foreseen to have decisive effect on Kansei evaluation.

Pattern analytic, signal-processing methods seems excellent on detailed design effect, many of those are unforeseen. Sample 20,17 and 11 have just same color and texture only is different.

Dealing with detailed design is difficult in common KE methods. In this leather grain case, all samples have exactly same color. Incorporating all of details into design element table and solving the equations to get weights on them are almost impossible. Exploring details with signal processing methods and comparing between samples are promising way to understanding delicate design features and Kansei.

REFERENCES

1.Sonka, M., Hlavac, V. & Boyle, R., Image Processing, Analysis and Machine Vision, Champann & Hall, 1993.

2. Prof. Dougherty Physics page, Lafayette College, http://ww2.lafayette.edu/~doughera/index.html