A Colour Support System for Townscape Based on *Kansei* and Colour Harmony Models

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Abstract – **A townscape has been a main factor in urban-development problems in Japan. In the townscape, keeping harmony with environment is a common goal. But useful and meaningful goals are expressing individuality and impression of the town in the townscape. In this paper, we propose the colour planning support system to improve the townscape. The system finds propositional colour combinations based on three elements, town image, colour harmony, and cost. The targets of this model are mostly townscapes in residential areas that already exist. In this paper, we introduce the construction of a *Kansei* evaluation model to quantify the impression. First, we conducted computer-based evaluational experiments for 20 subjects using the SD method to clarify the relationship between town image and street colours. We chose 16 adjective words related to town image and prepared 100 colour picture samples for the evaluation. After the experiments, we constructed the model using a neural network for each word. We chose 62 experimental results for the training data of the neural network and 20 results for the testing data. Each colour in the data was selected to have unique hue, brightness or saturation attributes. After the construction, we tested the model for accuracy. We input the testing data into the constructed model and calculated errors between the output from the model and the experimental results. Testing of the model showed that the model worked well for more than 80% of the samples. The model demonstrated influences of colours on the town image.**

I Introduction

Recently, the problem of how to live in a comfortable environment has become more important, and the townscape is a main factor in urban-development problems in Japan. Dealing with the townscape, keeping harmony with the environment is a common goal. But expressing individuality and the town's image in the townscape are also useful and meaningful goals. In addition to the historical background of the town, form and material of the buildings in the town are also elements. In these elements, the colour scheme of the buildings is one of the most influential factor. When we consider colours of buildings, each nearby colours in the row is important. Proper evaluation of colour must consider the whole street, not only individual building. Although several colour plans for townscapes have been carried out previously, most plans have been based on anecdotal reports or experience and conducted individually.

In this paper, we propose a colour planning support system for townscape. The proposed system finds the best colour coordination for a street by considering the importance of three elements: town image, colour harmony, and the cost to change colours. In this paper, *town image* means the impression of the townscape, the emotional response when viewing the townscape. Handling the town image requires quantification of the response. We also introduce the construction of an emotional model linking *town image* and *street colours* to quantify the response.

II CIELAB Colour Space

CIELAB is a colour space adopted by CIE in 1976. CIELAB indicates these values with three axes: L^*, a^*, and b^*. L^* is a central vertical axis that represents lightness. Two horizontal axes, a^* and b^*, represent hue and saturation respectively. On the a^* axis, positive values indicate amounts of red and negative values indicate green. Similarly, positive values indicate yellow and negative values indicate blue on the b^* axis. This colour system features an uniform colour space. In the uniform colour space, equivalent numerical distances represent equal visually perceived colour differences. In this study, we will focus attention on the psychological response differences and colour differences. We use CIELAB to indicate colours of the townscape.

III System Overview

The input to the colour support system are the current townscape colours and ideal town images. The system outputs several propositional colour combina-

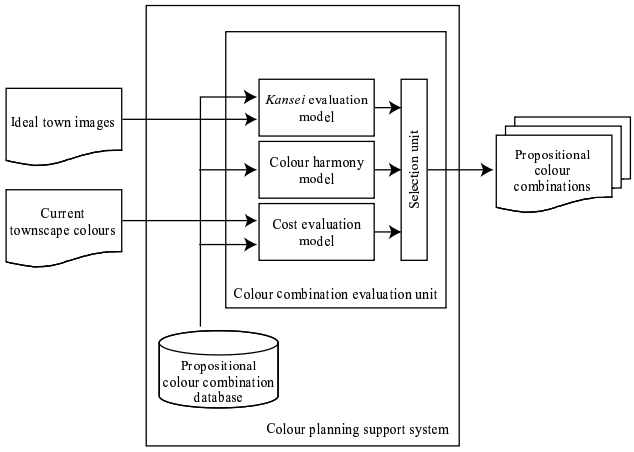


Fig. 1 Block diagram of the colour support system.

tions for the townscape, as shown in Fig. 1. In the system, a colour combination will be selected from the *Propositional Colour Combinations Database*. The selected combination is evaluated in the *Colour Combination Evaluation Unit*.

A Propositional Colour Combinations Database

A large number of colour combinations are stored in the *Propositional Colour Combinations Database* in advance. The combinations are designed from available colours and their combinations.

B Colour Combination Evaluation Unit

The *Colour Combination Evaluation Unit* evaluates the colour combinations selected from the database. The unit picks some propositional colour combinations up for the output of the system based on scores of the following three models.

First, town images of the colour combination selected from the database are judged to be appropriate for the ideal town images or not. The unit calcuates differences between the ideal town images and the psychological responses for the selected colour combination. The combination having smaller differences is evaluated as the appropriate combination. This process requires quantification of the responce. We modeled a relationship between *town image* and *street colours* as a *Kansei* evaluation model.

Next, the selected colour combination is evaluated from the approach of colour harmony. Various studies of colour harmony have been reported in the past. Moon and Spencer [1][2][3] proposed a colour harmony equations. We will construct a colour harmony model for the townscape based on their colour harmony equations.

The targets of this system will be mostly townscapes that already exist. It is practically impossible to change all the colours of a townscape, even if the best townscape design is known. In many cases, a portion of the colours may be changed. At this point, the problem of creating the biggest effect of improvement at the lowest cost becomes important. The cost evaluation model caluculates the cost to change current townscape colours into selected colour combination.

Table 1 Pairs of adjective words related to townscape.

adjective No.	adjective words	
1	cold	warm
2	unrefined	refined
3	cheap	luxurious
4	graceless	graceful
5	restless	calm
6	unfriendly	friendly
7	uncomfortable	comfortable
8	artificial	natural
9	typical	individualistic
10	conservative	progressive
11	quiet	lively
12	dirty	clean
13	old-fashioned	modern
14	awkward	elegant
15	western	eastern
16	rural	urban

IV *Kansei* Evaluation Model

We constructed a *Kansei* evaluation model with neural network from the approach of *Kansei* engineering [4]. This technique translates psychological responses to a target into perceptual design elements. The input to the model is street colours and the output is town image.

A Collection of Adjective Words

Using adjectives allows expression of psychological responses about a target (e.g., happy, hard, slow...). In our study, we use adjective words to express the town image. First, we collected approximately 470 words related to the town image from dictionaries and former studies. After the collection, we combined similar words and made pairs with opposite meaning words. At last, we selected 16 pairs of adjective words for the evaluation experiments, as shown in Table 1.

B Townscape Sample

We prepared pictures of residential area as samples for the evaluation. We made 100 colour picture samples with painting a same picture in order to make the other conditions all the same. The buildings in the picture samples are common style and without special decorations. The picture shows the front side of buildings.

Fig. 2 Screen appearance of the experiments.

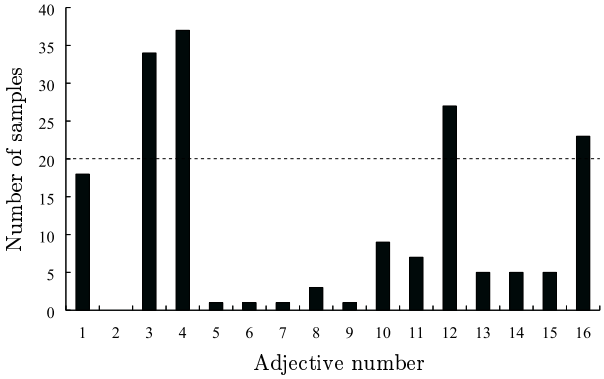


Fig. 3 The number of samples evaluated as the center of SD scale by more than 50% of the subjects.

C Evaluation Experiment of Town Image

We conducted computer-based evaluation experiments for 20 subjects, including 16 males and 4 females, using the SD (semantic differential) method [5] to investigate the relationship between *town image* and *street colours*. The experiments were conducted on a CRT display. Fig. 2 shows the screen appearance of the experiments. The picture sample is placed on the upper part of the screen and 16 pairs of the adjective words are placed on the lower part. There are 5 buttons between the adjective words. The background of the picture sample is light gray.

In the experiments, the subjects select a suitable response on the SD scales, from 1 to 5, for every pair of adjective words. The subjects evaluate all of 100 picture samples. The samples are shown at random to reduce influence from the order of the presentation, and the subjects take a thorough break every 20 samples.

D Selection of Adjectives

After the experiments, we selected appropriate words for the model construction based on the results of the above experiments. Evaluation in the center of the SD scale implies that the adjective words evaluated as neutral. The adjective words that have many neutral evaluations may be irrelevant for expressing town images. Fig. 3 shows the number of samples evaluated as the center of the SD scale by more than 50% of the subjects. Over 50% of the subjects evaluated adjectives No. 3, 4, 12, and 16 as neutral for more than 20 picture samples. Thus, we excluded these 4 adjective words.

Variance of evaluation scores is also a factor to be considered. We checked the variance for each sample but every pair of adjectives showed low variance. We did not exclude any adjective words in this process. Ultimately, we selected 12 adjective words to construct the *Kansei* model.

E Construction of Kansei Evaluation Model

We constructed the model using a neural network for each pair of adjectives. We chose 62 experimental results as the training data of the neural network and 20 results as the testing data. Each colour in the data was selected to have unique hue, brightness or saturation attributes. We selected data of various, dissimilar colour combinations.

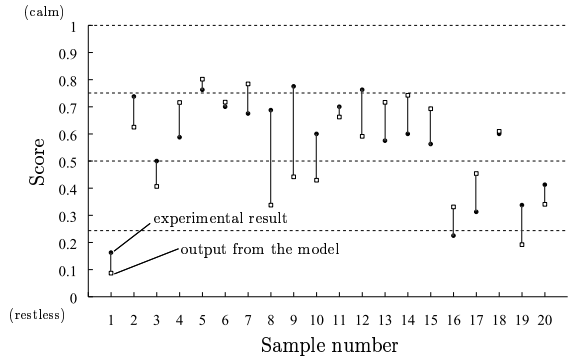
The input items to the neural network are wall colour, roof colour, and window frame colour of the buildings in the picture sample. Every colour is indicated in CIELAB. Three values, L^*, a^*, and b^* are used for the wall colour and roof colour, and only L^* is used for the window frame colour because the usage of the colour is limited. Since there are 3 buildings in the picture sample, the input data becomes 21 values. The output from the neural network is the SD scale as town image . Every value was normalized between 0 and 1. We used the back propagation as a learning algorithm.

V Results

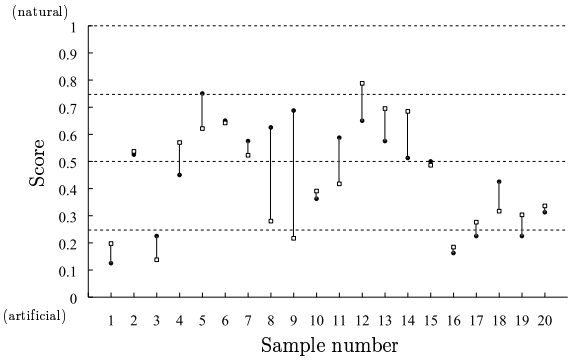
After the construction, we tested the performance of the model. We input the 20 testing data, shown in Table 2, into the constructed model and calculate errors between the outputs from the model and the average of the experimental results. Examples of the testing results are shown in Fig. 4. The broken lines in the figure correspond to the SD scales. Testing of the model shows that the error was within 0.25 for over 80% of the samples. This result is adequate for our emotional model.

In Fig. 4(a), the model shows the impression *restless* for the samples No. 1, 3, 16, 17, 19, and 20. These 6 samples have high brightness colours and/or high saturation colours such as light red, bright yellow, or light violet for a wall colour. In contrast, the samples No. 2, 4 to 15, and 18, evaluated as *calm*, do not have such colours. In this way, high brightness colours and high saturation colours influenced town images in the other adjective words as well.

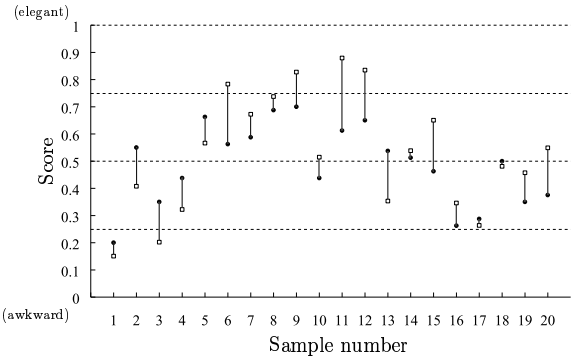
In Fig. 4(b), the samples No. 1, 3, and 16 to 20 were evaluated as *artificial* by the model. Most of these



(a) No.5 restless - calm



(b) No.8 artificial - natural



(c) No.14 awkward - elegant

Fig. 4 Examples of the testing results.

samples have high brightness colours and/or high saturation colours, but the sample No. 18 does not have such colours. There are similar colours as the sample evaluated as *natural* in the sample No. 18 except dark blue. Therefore, the dark blue seems to influence the town image. When dark blue is used with low brightness colours and/or low saturation colours, dark blue makes the image not only *calm* but also *artificial*.

VI Conclusion

In this paper, we proposed a colour planning support system for townscapes. The system finds propositional colour combinations based on the evaluation of three models, the *Kansei* evaluation model, the colour harmony model, and the cost evaluation model. Also, we introduced the construction of the *Kansei* evaluation model. Testing of the model showed that the model worked well for over 80% of the samples. The model demonstrated influences of colours on the town image.

As our future research, we will construct the other models to complete of the proposed system.

Table 2 Wall colours of the testing samples in CIELAB.

sample No.	building1 $\{L^*, a^*, b^*\}$	building2 $\{L^*, a^*, b^*\}$	building3 $\{L^*, a^*, b^*\}$
1	**{78, 13, 5}**	**{83, -7, 46}**	**{85, -8, -6}**
2	{83, 0, 0}	{77, 0, 0}	{80, 0, 0}
3	{80, 0, 0}	{77, 0, 0}	{80, 0, 0}
4	**{85, 6, 12}**	{67, 1, 15}	**{80, 8, 28}**
5	{48, 12, 29}	{50, 1, 17}	{50, 15, 28}
6	{96, -1, 1}	{95, -1, 8}	{91, 1, 1}
7	{48,12, 29}	{46, 0, 0}	{50, 15, 28}
8	{48, 12, 29}	{77, 0, 0}	{50, 15, 28}
9	{48, 12, 29}	{67, 1, 15}	{50, 15, 28}
10	{80, 0, 0}	{95, -1, 8}	{80, 0, 0}
11	{48, 12, 29}	{95, -1, 8}	{50, 15, 28}
12	{83, 0, 0}	{95, -1, 8}	{80, 0, 18}
13	{80, 0, 0}	{95, -1, 8}	{50, 15, 28}
14	{48, 12, 29}	{95, -1, 8}	{80, 0, 18}
15	{48, 12, 29}	{67, -5, 42}	{50, 15, 28}
16	**{78, 13, 5}**	{95, -1, 8}	**{87, 1, 50}**
17	**{78, 13, 5}**	**{68, 6, -6}**	{62, 0, 0}
18	{50, 0, 12}	{67, 1, 15}	**{28, 0, -22}**
19	**{78, 13, 5}**	{95, -1, 8}	{80, 0, 0}
20	**{76, -10, 20}**	{95, -1, 8}	{62, 0, 0}

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