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Construction of an Objective Image Evaluation Model of Pencil Still Images using Linear Regression

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Abstract: This paper describes an objective evaluation model for pencil still drawing images. The evaluation model consists of factor F_i which is defined as to cover the features value of the basic pencil still drawing image. F_i is also defined by considering a feature of subjective evaluation for the drawn pencil still drawing image. Our model approximate the features of the drawing image accurately and define the correlation between F_i as small as possible.

It is possible to clarify that the constructed evaluation model approximates the subjective evaluation experiment result of the drawing image

Keywords: *Pencil still drawing; Subjective evaluation; Objective evaluation; Evaluation model;Linear regression;*

I. INTRODUCTION

Drawing is a basic element of art education, and is emphasized for acquiring the basic skills needed for rendering images. Through drawing, students can be expected to master the skills of accurately capturing/ depicting shapes with a sense of perspective and solidity (methods of shading). Therefore, it is not possible to go through art education without drawing, and it is desirable for improving the skills of beginners to repeat the cycle of drawing → evaluation.

In evaluating drawings, the evaluator expresses features of the work using various evaluative terms. These evaluative terms are words expressing the impressions of the evaluator, and this does not mean that the evaluator has a theory regarding those impressions, or clear evaluative criteria. However, research is being done in the area of sensibility information processing, and when a person comes to some conclusion, they produce that result based on some system. Therefore, there should be some evaluation system when evaluating drawings. In research on evaluation of drawings, there have been few studies adopting the impressions received from works as a form of information, and treating them as an evaluation system.

The purpose of this research is not to evaluate only how motif shapes are captured, but rather to develop a model for drawing evaluation similar to the human systems for evaluative sensation and sensibility information processing.

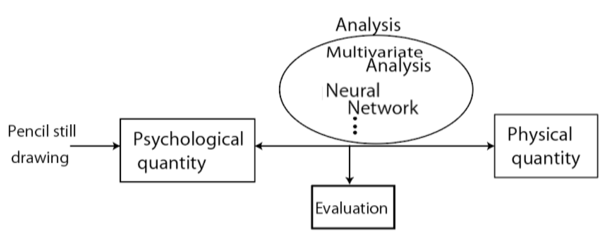

Fig. 1: The research approach

As a first step toward developing this evaluation method, we proposed as method for evaluating pencil still drawing image at art college.

II. PENCILSTILL DRAWING IMAGE

According to the book "Basics of Drawing for Going to Art College" (in Japanese)[1], the basic elements of drawing are as follows:

- What is the form? (Shape)
- What is the light/dark status? (Light/dark)
- What material (substance) is it made of? (Material)
- What sort of space is present? (Space)

Shape can be refined further into mass and texture, and structure into proportion and movement. Also, light/dark can be refined into tone, material into texture and sense of color, and space into cavity of the motif, space present in a gap or interval, and space which exists to envelop the motif.

In [1], there is the following description of motifs:

- Single motif (those taking a single basic form as structure, those taking two basic forms as structure, those with combined structure of three or more forms)
- Multiple motifs
- Concept of space

In the case of a single motif, a key point is to analyze what basic forms the motif is composed of. In the case of a motif composed of multiple basic forms, it is said to be important to ascertain the shape of each motif and their axis, and draw so the axis is in the center, and to ascertain, by breaking down a complex structure, that it is a combination of basic forms.

For multiple motifs, it is necessary to consider not only the positional relationships and shapes of motifs, but also the space surrounding them. Space cannot be directly apprehended, but it is possible to regard space as depth, using the context of individual motifs as cues, and in terms of the concept of space, a certain recognition of space is possible from information such as the spacing of motifs, and the texture and height of individual motifs.

III. APPROACH FROM SUBJECTIVE EVALUATION

In general, evaluation of drawing is done not by comparing with the motif, but by examining the drawing alone. The evaluator evaluates the drawing objectively, but the possibility cannot be denied that the evaluation may involve impressions as well as technical aspects. Therefore, in this research, the technique of viewing and evaluating drawings is defined as an approach from subjective evaluation, and first of all, the evaluation axes are clarified.

Sensory stimulation, stimulation obtained through impressions, and information obtained when a drawing is viewed based on previous experience are tentatively defined as subjectivity, and then an evaluation scale for evaluating drawings is examined. Evaluative terms used when evaluating drawings, and words used in criticism, are gathered, with careful attention to ensure no omissions, and after analyzing that terminology, the evaluative terms used in the research are defined.

Many books have been published on pencil drawing, but in most of them the content mainly concerns techniques for drawing featuring a single motif, and many books focus on evaluation for that technique. The interrelations of multiple motifs are set aside, and there are many terms for evaluating even a single motif. In this research, evaluative terms for evaluating drawings were first extracted from books [2][3] serving as reference for drawing pencil still drawings, regardless of the individual drawings techniques, and then those items were classified using the KJ method. As a result, it was possible to classify evaluative terms from the technical side. Also, in subjective evaluation, in which a person evaluates a drawing image, it has been found that individual evaluators do not have different evaluation axes, and in fact have evaluation axes backed up by similar techniques [4].

For the evaluation axes in this research, the plan was to incorporate not only the technical side but also the impression side, but on the impression side there are many items for which it is not possible predict whether they are affected by the technical side, and it is desirable to establish evaluation axes which do not distinguish between the technical and impression sides. After all, many of the subjective impressions of drawings can be regarded as expressed through drawing technique. The evaluation axes in this research were defined relating to four items (composition, shape, light/dark-color-texture, and space/solidity) and the feature quantities extracted from drawings were defined individually.

A subjective evaluation experiment was carried out regarding these four items. For this evaluation, 20 practical skills instructors from the university were randomly divided into 7-person groups, and each instructor carried out a five-level evaluation of composition, shape, light/dark-color-texture, and space/solidity, and the results were averaged. Taking the number of evaluators to be n, and the evaluation value of each evaluator to be A_i, the subjective evaluation value (MOS) was calculated using Equation (1).

$$\mathrm{MOS}^{i} = \frac{1}{\mathrm{N}}\sum_{\mathrm{n}=1}^{\mathrm{N}} \mathrm{A}_{\mathrm{n}}^{i} \quad (1)$$

N: number of observer

i: index of drawing image

The maximum standard deviation was 0.31 for evaluation results of the 20 instructors who evaluated 100 drawing images, and no variation was evident in evaluator competency with respect to evaluation. If an evaluation equation highly correlated with the results of this subjective evaluation experiment can be defined, then it may be possible use computers to carry out evaluation of pencil still drawings.

IV. OBJECTIVE EVALUATION MODEL

In this research, the F_i are defined to cover the basic features of drawings. With regard to these F_i, to objectively evaluate a pencil still drawing image, the features of the drawing image are functionally approximated, taking coordinates (m, n) or luminance L as the feature quantity. *i* is defined to accurately approximate the feature quantities of the drawing image, and to ensure the correlation between F_i is as small as possible. If, basically, none of the used feature quantities is missing, then the realized method of evaluation has high general applicability to evaluation of a wide range of drawing images.

In drawings, it is important to express the accurate shape, size balance, and the sense of texture of the motifs. Therefore, the following F_1 to F_4 were defined as basic feature quantities.

F_1: Overall balance
F_2: Light/dark and gradation
F_3: Size of motif relative to image as a whole
F_4: Valance of size of individual motifs

The relationships between a drawing image and F_1 to F_4 are as shown in Fig. 2.

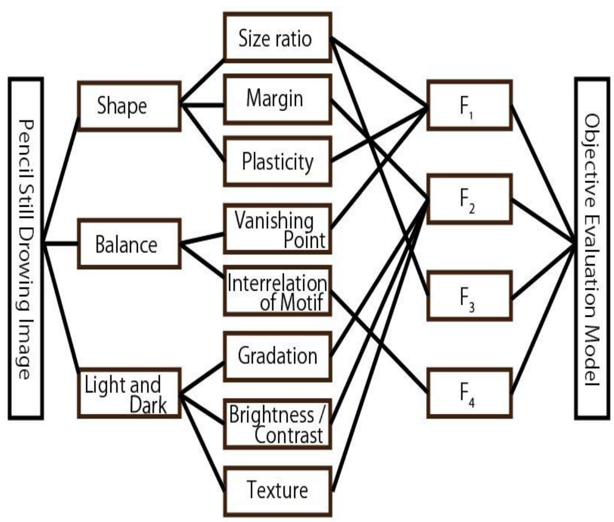

Fig. 2: Relationships between drawing image and evaluation model

F_1 to F_4 which estimate feature quantities are given by Equations (2) to (5).

$$l = (m_j, 900) - (m_i, 900)$$

$$F_1 = \delta_l (2)$$

The coordinate values m_i andm_j are the coordinate values of the intersection point of a straight line subtracting the motif and a straight line assuming the eye's height.

$$F_2 = \frac{\mathrm{Cov}\,(L_{img}\ ,\ L_{ref})}{(\sigma L_{img})\times(\sigma L_{ref})} \quad (3)$$

F_2 expresses the correlation by expressing the luminance values of the original image and the evaluation image as 255 dimensional vectors.

$$F_3 = \frac{1}{N}\sum_{n=1}^{N}\frac{(W_{ref}\times H_{ref}) - (W_{img}\times H_{img})}{W_{img}\times H_{img}} \quad (4)$$

W and H shown here are the width and height of the inscribed quadrangle of the motif and N is the number of motifs.

$$\Delta S = (W_{ref}\times\ H_{ref}) - \ (W_{img}\ \times\ H_{img})$$

$$F_4 = \delta_S \quad (5)$$

W and H shown here are the width and height of the inscribed quadrangle of the motif.ΔS is difference of image.

For the evaluation value, multiple regression analysis is carried out between the F_i and the subjective evaluation value. The partial regression coefficient is found, and the evaluation value Q_i is obtained as the linear sum of the F_i.

$$Q_i = b_0 + \sum b_j\, F_j^i \quad (6)$$

Figure3 shows a motif image used for evaluation.

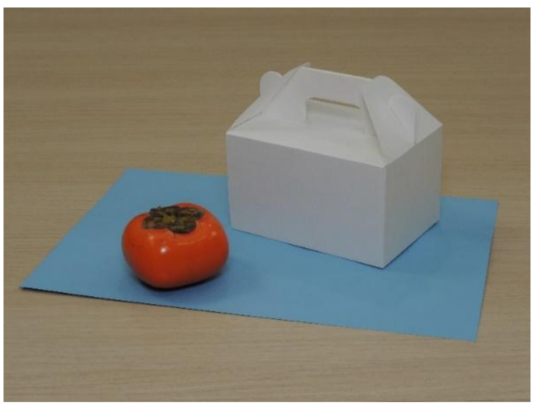

Fig. 3: Image combining motifs (one example)

The motifs were a persimmon and a paper box, and the person executing the drawing image placed the motifs freely within the angle of view. Examples of drawing images used to develop the evaluation model are shown in Figs. 4,5 and 6.

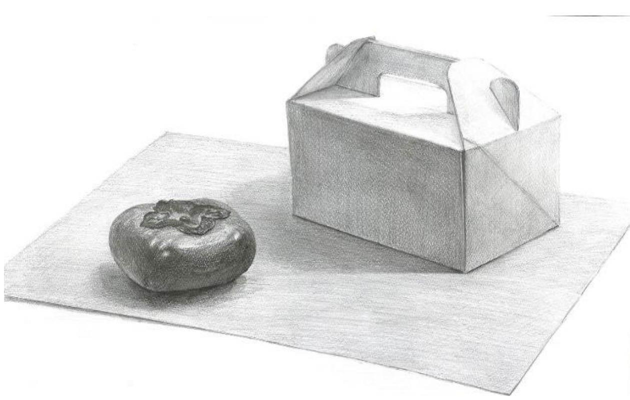

Fig. 4: Example of drawing image by artist (teacher)

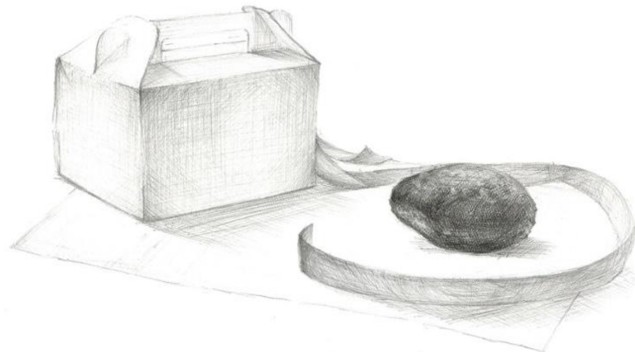

Fig. 5: Example of drawing image by student

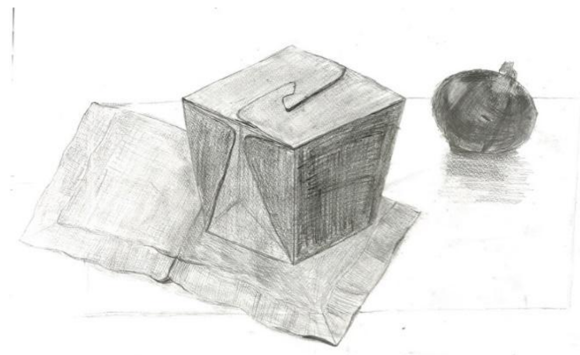

Fig. 6: Example of drawing image by student

F_i were calculated from 35 drawing images, and the subjective evaluation value was estimated using Equation (6). Equation (7) shows the results of conducting multiple regression analysis of the partial regression coefficients based on feature quantities, with Equation (6) and MOS.

$$\hat{y} = 3.19 - 5.5\mathrm{E}\ 03F_1 + 2.23F_2 +\ 1.8\mathrm{E\text{-}}02F_3 -\ 4.5\mathrm{E\text{-}}06F_4 \quad (7)$$

Figure 7 shows the relationship between the defined image feature quantities and MOS.

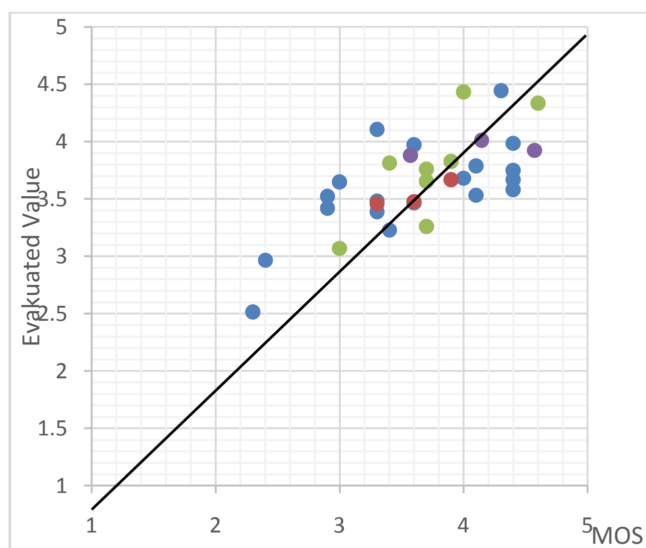

Fig. 7: Relationship MOS and Evaluated Value

In the subjective evaluation experiment, five stages of 1 to 5 stages are used, but since it is a sample image was drawing at the art college, the image of Evaluation 1 does not exist. For this reason.

To quantitatively express the degree of approximation between the evaluation value Q and MOS, the multiple correlation coefficient between the evaluation value and MOS is calculated using Equation (8)

$$R = \frac{\delta_Q}{\delta_{MOS}} \quad (8)$$

Here, σ_Q and σ_{MOS} indicate standard deviation of the evaluation value Q and MOS in this case. R using this

technique is 0.71, and it is evident that the evaluation model approximates the results of the subjective evaluation experiment for drawing images.

CONCLUSIONS

An evaluation model was developed for the purpose of objectively evaluating drawing images. F_i were defined to cover basic drawing features. With regard to these F_i, to objectively evaluate a pencil still drawing image, the features of the drawing image were functionally approximated, taking coordinates (*m*, *n*) or luminance *L* as the feature quantity. $_i$ was defined to accurately approximate the feature quantities of the drawing image, and to ensure the correlation between F_i was as small as possible.

Definition was done so that F_1 approximates overall balance, F_2 light/dark and gradation, F_3 size of motif relative to image as a whole, and F_4 the valance of size of individual motifs. It was shown that the developed evaluation model approximates results of the subjective evaluation experiment for drawing images.

Future works

The F_i indicating image features were defined to cover the features of drawing images, but it is very likely that the multiple correlation coefficients with the results of the subjective evaluation experiment can be improved further. Another issue for the future will be improving the general applicability of the evaluation model by evaluating images drawn using other motifs.

There are many types of motifs for drawing images, and general applicability is essential. Going forward, the authors will examine F_i which express the features of drawing images, and ways to address the diversity of motifs.

Acknowledgement

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