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A Technique for Error Awareness in Pencil Drawing

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Abstract: Training in realistic drawing is a basic technique of art education. Even though a novice artist may feel something is wrong in his or her sketch, the novice often cannot explain what the errors are. It is typical for a drawing teacher to try to advise a student about errors during drawing training by using analogical explanation. Analogical explanation provides the learner with an image of a solid that reflects his or her errors. However, the significance or merit of this kind of explanation is not well understood, even though the importance of learning by error is well known in practical education conditions. This paper describes a technique for error awareness in pencil drawing. The technique involves the creation of a three-dimensional model that reflects the learner's errors as acquired from a scanned digital image of the learner's pencil drawing.

Keywords: Learning by errors, error awareness, error-based simulation, pencil drawing

Introduction

Realistic drawing, that is, drawing things as they are seen, is fundamental to art education. Students must train not only their hands but also their eyes [4]. Repeated training in pencil drawing is a typical pedagogical technique. To master realistic drawing requires a great deal of discipline.

During such training, most novices cannot recognize the errors in their sketches, even though they may sense that something is wrong. They often cannot improve their sketches and are not able to explain which parts of the drawing are in error. A drawing tutor will not only correct a drawing, but will also explain the reasons why a student's drawing needs correction. This kind of tutor's advice can be thought of as a "scaffold" [3] for the learner to deeply understand the source of the error.

We interviewed a drawing instructor and found that a tutor's advice regarding errors can be categorized into the following 3 classes [2]. (A) Explanation of the location of an error in a sketch. This type of explanation points out the learner's errors in a sketch. (B) Explanation about how to correct a drawing. This type of explanation shows a learner how to correct a sketch. (C) Analogical explanation of the errors in a sketch; for example, "The dish in your drawing looks like a rugby ball." This type of explanation gives the learner a solid image reflecting their errors.

Novices often fail to improve upon their errors through if only type (A) and (B) advice is offered because they do not understand their errors. In such cases, a tutor's type (C) advice is regarded to be more effective [1]. Figure 1 shows the mechanism of analogical

explanation (type (C) advice). Differences between the novice's sketch and the tutor's sketch are unclear to the learner. However, differences between the subject of a drawing and an erroneous object that reflects the leaner's errors are obvious to the learner. To generate an analogical explanation, just preparing a correct answer is not sufficient; the explanation needs to be generated from the learner's errors. This mechanism is the same as the Error Visualization of Hirashima.

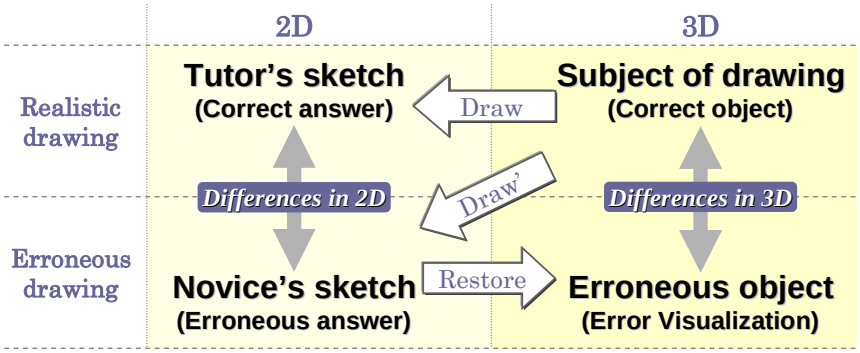

Fig. 1 A tutor's analogical advice provides a learner with an erroneous solid object image that reflects the learner's errors.

This paper describes an attempt to visualize errors by using a three-dimensional model of a novice's two-dimensional pencil drawing. In pencil drawing, plates, mugs, apples, and flowers are typical drawing subjects. These are called motifs because they include geometries that students need to learn, and they are easy to prepare. Our error visualization already contains standard 3D models of typical motifs that are used to generate erroneous 3D models. An erroneous 3D model is generated by a scale transformation of the standard 3D model.

For example, Figure 2 shows the motif, novice's sketch, and error visualization. The dish was drawn as if the novice had looked down upon it from a higher position. The error visualization shows the dish floating and inclined as if the novice were seeing it from the side.

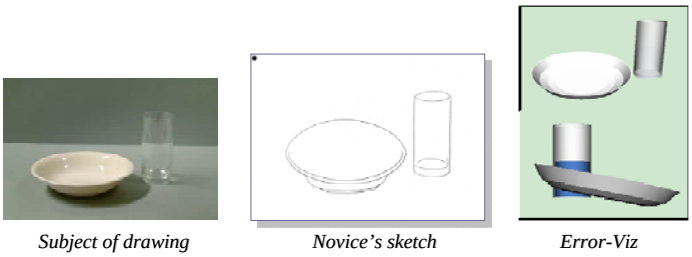

Fig. 2 Error visualization from a novice's sketch.

We developed an application called Error-Viz for use in realistic pencil drawing training. To use Error-Viz, a tutor chooses the motif from among standard 3D models. Then the tutor inputs the size of the drawing's subject and a parameter indicating the viewpoint of the student. Error-Viz makes a 3D model and a 2D image of the motif. After the novice completes the drawing, it is scanned or photographed. Error-Viz obtains feature parameters from the novice's sketch and makes an erroneous 3D model.

1. Errors in Realistic Drawing

In order to document a learner's errors, we observed a pencil drawing class for a period of 5 days [2]. The tutor of the class provided 677 suggestions regarding their sketches to 19 students. The following were the 8 most frequently cited errors:

(**E1**) **Too high drawing position of a dish:** In comparison with the glass, the oval shape of the top of a dish is drawn too wide for the learner's viewpoint.
(**E2**) **Wrong dish size:** A dish is drawn too large compared with the size of a glass.
(**E3**) **Wrong glass width:** A glass is drawn too thick compared with the width of a dish.
(**E4**) **Wrong relationship between cross sections of a glass:** The cross sections at different heights of a glass should be different.
(**E5**) **Wrong glass width:** A glass is drawn with an imbalanced width. It should be uniform.
(**E6**) **Wrong breadth of the brim of a dish:** The breadth of a dish brim is drawn unnaturally.
(**E7**) **Wrong inclination of a glass:** A glass drawn is inclining.
(**E8**) **Wrong dish depth:** The depth of a dish is drawn unnaturally compared with the width of the dish.

2. Technique of Error Visualization

This section describes the procedure of error visualization; an overview is shown in Figure 3.

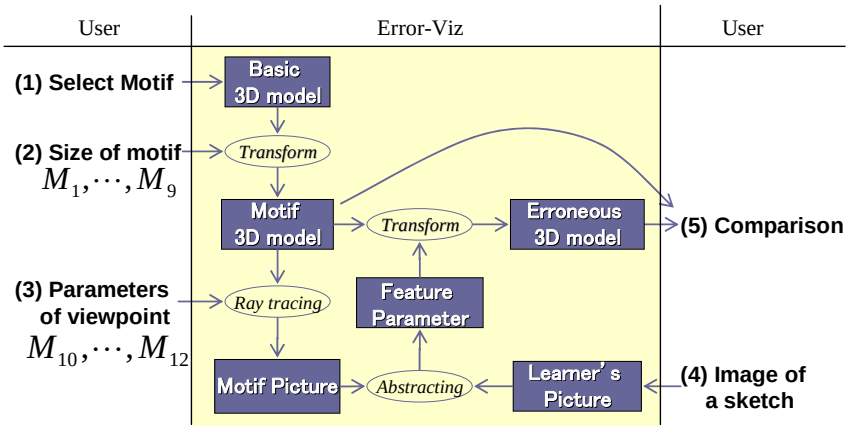

Fig. 3 Overview of error visualization.

2.1 Constructing the 3D Model and Picture of the Motif

The basic models are distinguished by some feature parameters independent of scale. To transform a basic model into a 3D model of the motif the tutor selected, the tutor measures the parameters $M_1,M_2,\cdots,M_{12}$ of the motif, where $M_1,\cdots,M_6$ are for the dish 3D model (Fig.4); M_7 and M_8 are the diameter and height of the glass, respectively; and $M_9,\cdots,M_{12}$ are the distances between a learner and the objects in the motif (Fig.5).

If position vector **S** is the basic model and matrix **R** is the scale-transformation with parameters $M_1,M_2,\cdots,M_{12}$, the motif 3D model **P** is

$$\mathbf{P} = k_{3D}\,\mathbf{R}\,\mathbf{S},$$

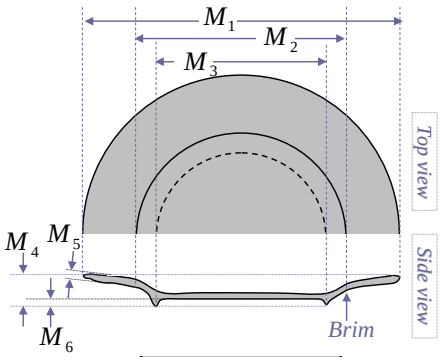

Fig. 4 Parameters of the dish 3D model.

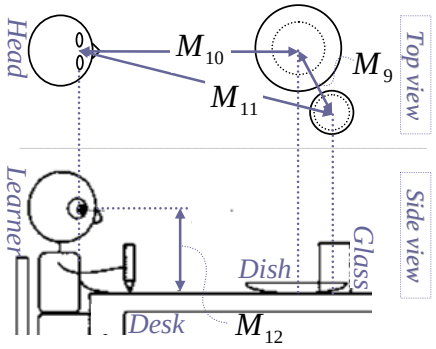

Fig. 5 Distances between a learner and objects in the motif.

where k_{3D} is a ratio used to convert the size of the motif to the 3D model. The tutor controls k_{3D} to adjust the size of the model appearing in a display.

A ray-tracing application generates a picture of the motif-model **P** as viewed from the learner's perspective.

2.2 Feature Parameters

The typical errors (E1)-(E8) are distinguished by some feature parameters. To convert the motif-model into the learner's erroneous model, the feature parameters are obtained by analyzing pictures of the motif and the learner's sketch. For example, a dish and glass motif requires feature parameters $F_1, F_2, \cdots, F_{15}$ as shown in Figure 6.

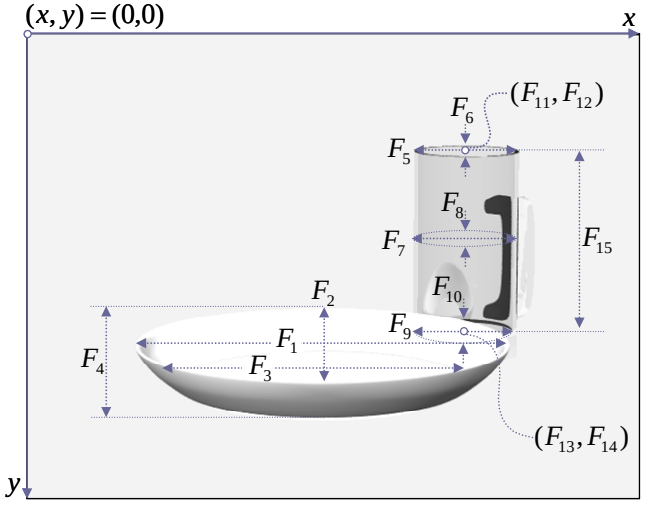

Fig. 6 Feature parameters of a picture of the subject of a drawing.

2.3 Extracting Feature Parameters

Feature parameters are obtained by thinning and binalization of a picture. The feature parameters $F_1, F_2, \cdots, F_{15}$ are analyzed from a picture of the motif. The feature parameters $F_1', F_2', \cdots, F_{15}'$ are analyzed from a picture of the learner's sketch.

2.4 Constructing the Erroneous 3D model

The erroneous 3D model is constructed by reflecting the feature parameters F' onto the motif model $\mathbf{P}$. To reflect an error, a scaling transformation for $\mathbf{P}$ is defined for each error. This section illustrates the construction of an erroneous 3D model regarding (E1).

Let us define the position-vector $\mathbf{P}_d$ for the dish. To simplify the following explanation, $\mathbf{P}_d$ has its own local origin. The vertical axis is the y axis, the learner's viewpoint is on the yz plane, and the x axis runs across an object.

(**E1**) **Too high drawing position of a dish.** So that the motif corresponds to the learner's sketch of the oval form around the top of the dish, $\mathbf{P}_d$ is rotated about the x axis by θ, which expresses the difference of the ratio of width to height:

$$\mathbf{P}'_d = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix} \mathbf{P}_d, \text{where} \theta = \arcsin\left(\frac{F'_2}{F'_1}\right) - \arcsin\left(\frac{F_2}{F_1}\right).$$

Viewed from the side, the dish appears to be floating and inclined.

Figure 7 shows examples of displays from Error-Viz illustrating errors (E1)–(E8).

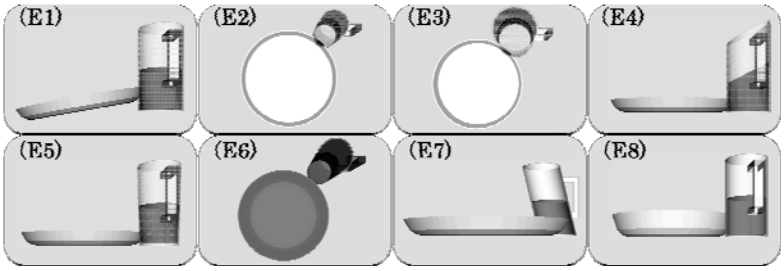

Fig. 7 Display examples of error visualization for the 8 kinds of errors.

3. Conclusion

Most novices cannot recognize the errors in their sketches, even though they may sense that something is wrong. A scaffold to understand the errors is important for learning from error. Differences between the subject of a drawing and an erroneous object that reflects the leaner's errors are obvious to the learner. This paper describes a technique to generate a 3D model from the learner's erroneous pencil drawing.

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