

# Tutoring System for Pencil Drawing Discipline

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**Abstract:** This paper describes a sketch tutoring system for beginners. Drawing an image that one actually sees is basic training for drawing education. To start learning, learners must accept that their own sketch contains errors. Our goal is to reveal an effective support method for a learner's error awareness. We have developed a sketch tutoring system that displays errors with a 3D model from a learner's erroneous sketch. We intend to generate erroneous 3D model from a learner's sketch and to decide the effective appearance of the 3D model to isolate the errors intuitively. This paper specifically addresses advice about shadow in a sketch. We held a preliminary experiment to evaluate the system. The results indicate the effectiveness of the proposed method.

## 1. Introduction

Mistakes during problem solving present a learner important opportunity to acquire new knowledge and skills. Hirashima insists that learners need to be aware of errors alone for learning from mistakes (Hirashima et al., 1997, 1998). He also argued that tutor's effective scaffolding is required for such error awareness. Error Visualization (Horiguchi et al., 1999, 2002) shows erroneous simulation as such feedback from a computer. Our research goal is to reveal effective support for a learner's error awareness in pencil-drawing discipline. This paper describes development of a sketch tutoring system for beginners.

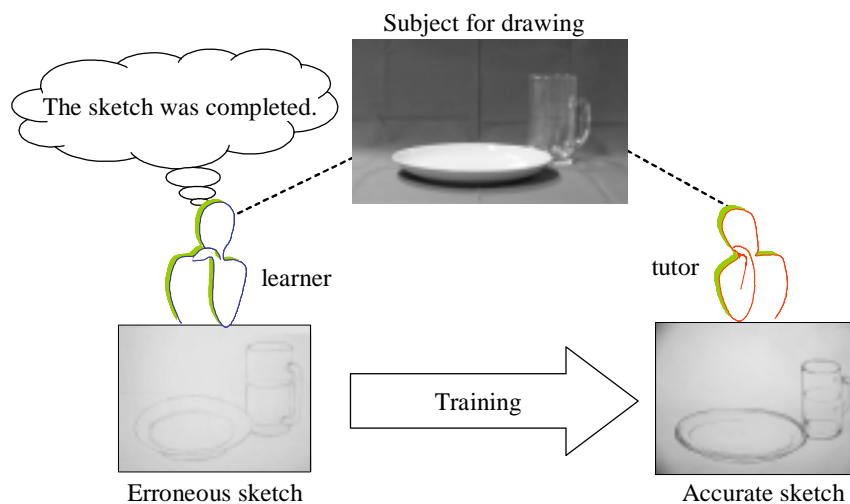
Drawing what one sees is an important theme for drawing discipline (De Reyna R., 1996). In such discipline, a learner's sketch contains many errors that can be contrasted against a subject for drawing. A goal of that discipline is that learners acquire ability to diagnose their own sketch alone. Through investigation of actual drawing discipline, we observed that a tutor repeatedly points out errors in learners' sketches. However, learners persisted in their belief in the quality of their sketch and did not easily accept the existence of errors. To make learners understand their own errors, the tutor often used analogy. For example, an ashtray, a hat and a tureen were used as analogies when the tutor indicated errors in drawn plate. Pointing out the analogy with a hat, the tutor expected that the learner would realize that the depth of the drawn plate was too deep and that the brim was too wide.

We assumed that watching drawn objects from many angles facilitates a learner's awareness of errors in a sketch. This paper describes a method to display errors in a learner's sketch with a 3D model. This study specifically addresses: (1) generation of an erroneous 3D model from a learner's sketch, and (2) determination of effective appearance of the 3D model to show the errors easily. We developed a sketch tutoring system that shows a learner's errors of shape and arrangement in a sketch (Takagi et al., 2003, Kajimoto et al., 2002). This paper focuses on method of advising about shadows. Section 2 describes drawing discipline. Section 3 proposes a method to generate advice about shadows in a sketch. Section 4 describes a preliminary experiment for evaluation of our system.

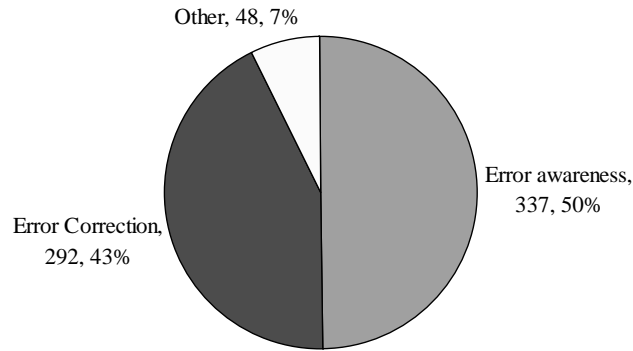
## 2. Drawing discipline

To reveal necessity of error awareness in drawing discipline, we investigated a drawing class at a lifelong learning school in Japan. The tutor used a plate and a beer mug as drawing subjects. This drawing discipline trains learners to draw what they see. In such training, a tutor selects drawing subjects that contain geometric shapes such as circles, ovals, square, and so on. A plate and a beer mug contain many ovals and are handy for our preparation. (Fig. 1) shows an example of the subject for drawing discipline.

The class had 19 learners and was held for 5 weeks. We recorded the tutor's and the learners' conversations and learners' sketches to investigate the tutor's advices against the learners' errors. Recorded advice was categorized into the following three groups: error awareness, error correction, and other. Error awareness comprised advice to appraise learners of the existence of errors. Error correction included advice regarding methods to improve errors. Other advice included the tutor's praise, general drawing explanations, and so on. The total number of recorded advice instances was 677.



**Figure 1:** Drawing Discipline



**Figure 2:** The tutor's advices in 5 weeks

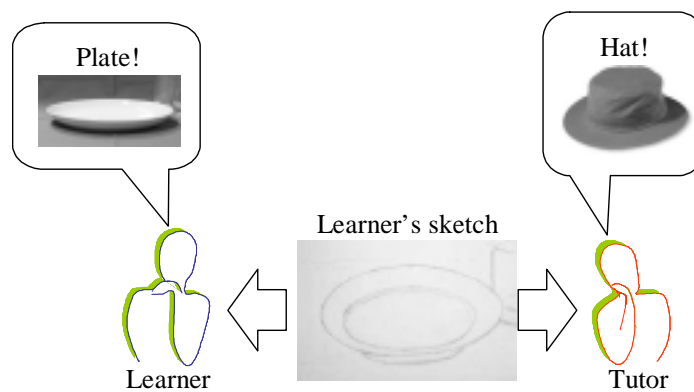
(Fig. 2) shows the result of the categorization. The result indicates that the tutor spends much time on error awareness and that the learners did not easily accept errors indicated by the advice. The result indicated that learners require assistance to find their errors.

### 3. Sketch Tutoring System

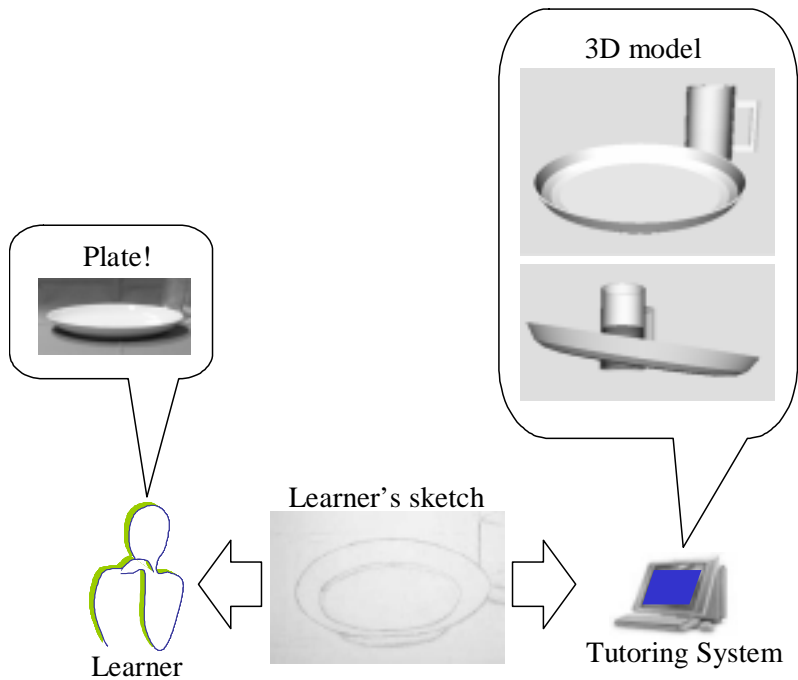
#### 3.1 Method of appearing errors

The tutoring system needs to break a learner's belief that a self-produced sketch is accurate when compared to subjects for drawing. In actual drawing discipline, a tutor frequently used analogies with other objects (Fig. 3). We think that the analogies provide learners a trigger to criticize their sketches. Our tutoring system shows errors with a 3D model. A 3D model of a learner's erroneous sketch offers different viewpoints with a sketch. An adequate viewpoint facilitates a learner's understanding of the errors.

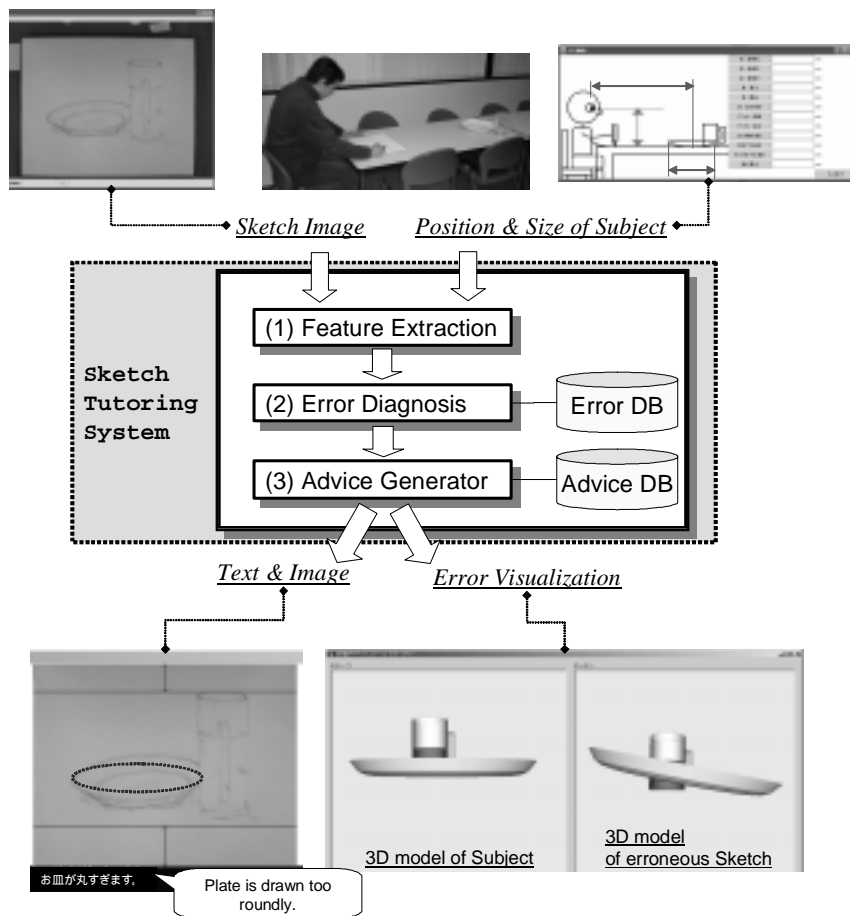
(Fig. 4) shows an example of some errors that appeared. The plate shape in the learner's sketch is too round. Therefore the tutoring system shows the erroneous 3D model and a view from side of the plate. We expect that learners can thereby notice the errors of their sketches from the inclined plate.



**Figure 3:** A learner's belief and a tutor's advice



**Figure 4:** An example of advice from the sketch tutoring system



**Figure 5:** Overview of the sketch tutoring system

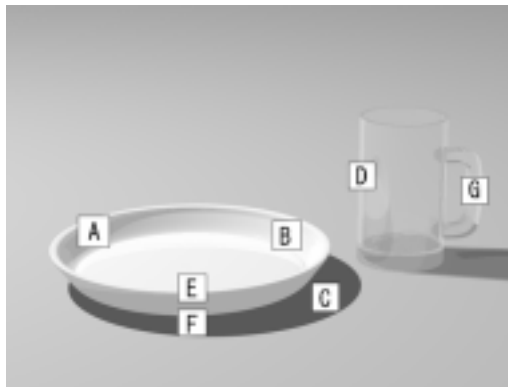
### 3.2 System Overview

(Fig. 5) shows an overview of the sketch tutoring system. The system consists of the following three subsystems: (1) feature extraction, (2) error diagnosis, and (3) advice generation. First, a learner inputs 12 values to the system regarding the position and size of a subject for drawing. Those include information such as plate diameter, plate height, mug diameter, mug height, distance between a learner and subject, and so on. Then the learner takes a picture of the sketch with a digital camera and inputs an image file to the system. Subsequently, the system extracts the pencil-drawn area using texture analysis and gradient-based edge detection. The pencil-drawn area is thinned to obtain a single-pixel-wide center line. The line is utilized as the skeleton data of the sketch for specification of the each target part, such as a plate rim. After specifying the parts, some parameter values are computed for sketch evaluation. The details of the subsystems (1) and (2) regarding the sketch shape and arrangement have already been reported (Takagi et al., 2003, Kajimoto et al., 2002). This paper describes advice for shadows.

### 3.3 Advice for shadow errors

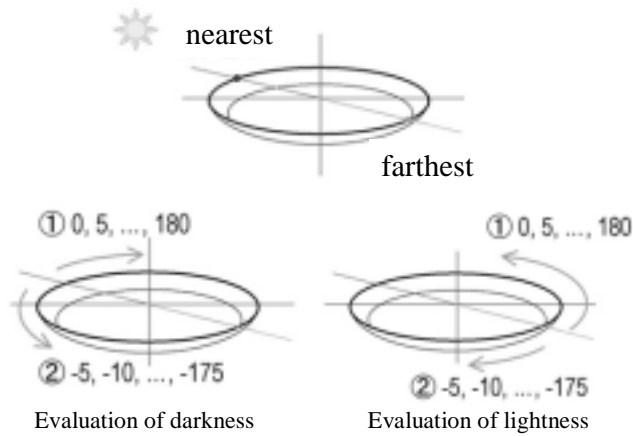
Through investigation of the drawing class described in Section 2, we selected seven regions from the learners' frequent errors made in shadow drawing. (Fig. 6) shows these seven areas.

- A) The dark shadow at the inside of the plate.
- B) The light shadow at the inside of the plate.
- C) The shadow of the plate.
- D) The light shadow of the beer mug.
- E) The shadow of the edge of the plate.
- F) The reflected light under the plate.
- G) The light shadow of the handle of the beer mug.



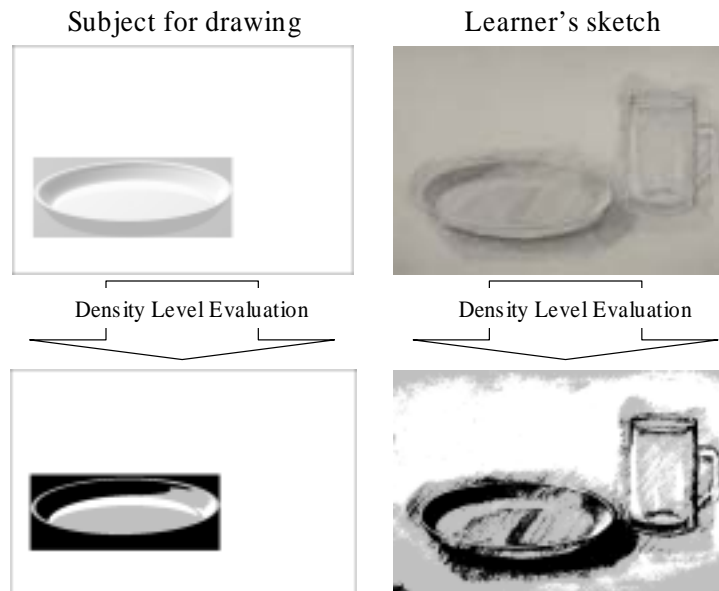
**Figure 6:** The most frequent errors concerning the shadow

Areas (A), (B) and (E) are expressed as a sector of an oval. Area (A) is evaluated from the nearest point from the light source to the angle of  $180^\circ$  by  $5^\circ$  increments. Area (B) is evaluated from the farthest point to the angle of  $180^\circ$  by  $5^\circ$  increments. Area (E) is evaluated from the nearest point to the angle of  $355^\circ$  by  $5^\circ$  increments.



**Figure 7:** Evaluation of region-(A),(B),(C),(E),(F) areas

To extract image features from the sketch and the generated image of drawing subject by the inputted 12 parameters in Section 3.2, the system evaluates three density levels of shadow about the seven regions. The density is represented as the percentage of the number of black pixels in the total number of pixels of the region. The first level is from 0% to 33%. The second level is from 33% to 66%. The third level is from 66% to 100%. (Fig. 8) shows an example of the evaluation.

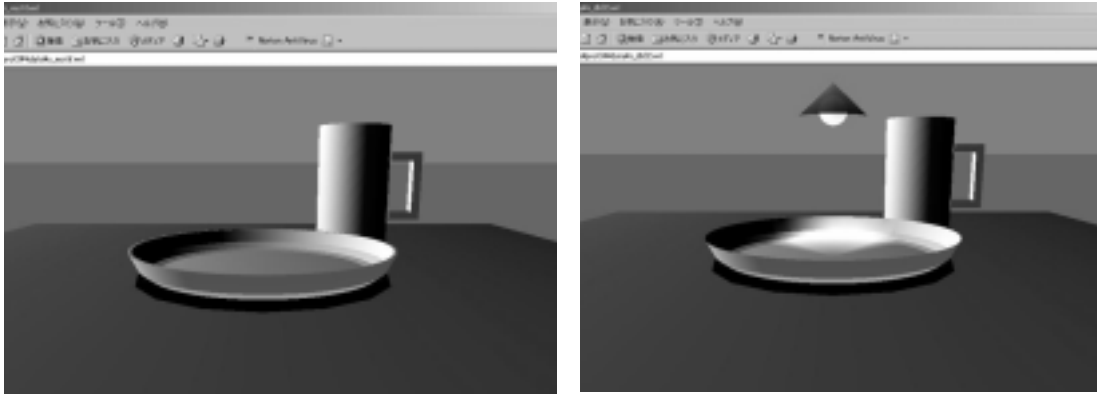


**Figure 8:** Image Evaluation

The system compares the density level of the subject for drawing  $d_s$  and the learner's sketch  $d_L$ . The differences  $d_s - d_L$  is within the range from -2 to 2. The regions which have the greatest absolute value of  $|d_s - d_L|$  (not zero) are selected as region-contained errors. The system determines a viewpoint of the 3D model for each error. (Tab. 1) shows the appearance for errors. (Fig. 9) shows a 3D model that the system generated from erroneous sketches of the region (B) in (Tab. 1). In this 3D model, the system depicts errors by adding a spotlight to illuminate areas in (B).

**Table 1:** Appearance of the 3D model

<i>region</i>	<i>appearance</i>
A) The dark shadow at the inside of the plate.	Make the region darker
B) The light shadow at the inside of the plate.	Make the region lighter
C) The shadow of the plate.	Eliminate or extend the shadow
D) The light shadow of the beer mug.	Make the region darker
E) The shadow of the edge of the plate.	Make the plate thinner
F) The reflected light under the plate.	Make the region no reflected light
G) The light shadow of the handle of the beer mug.	Make the handle thinner or darker



(a) subjects for drawing

(b) a learner's erroneous sketch

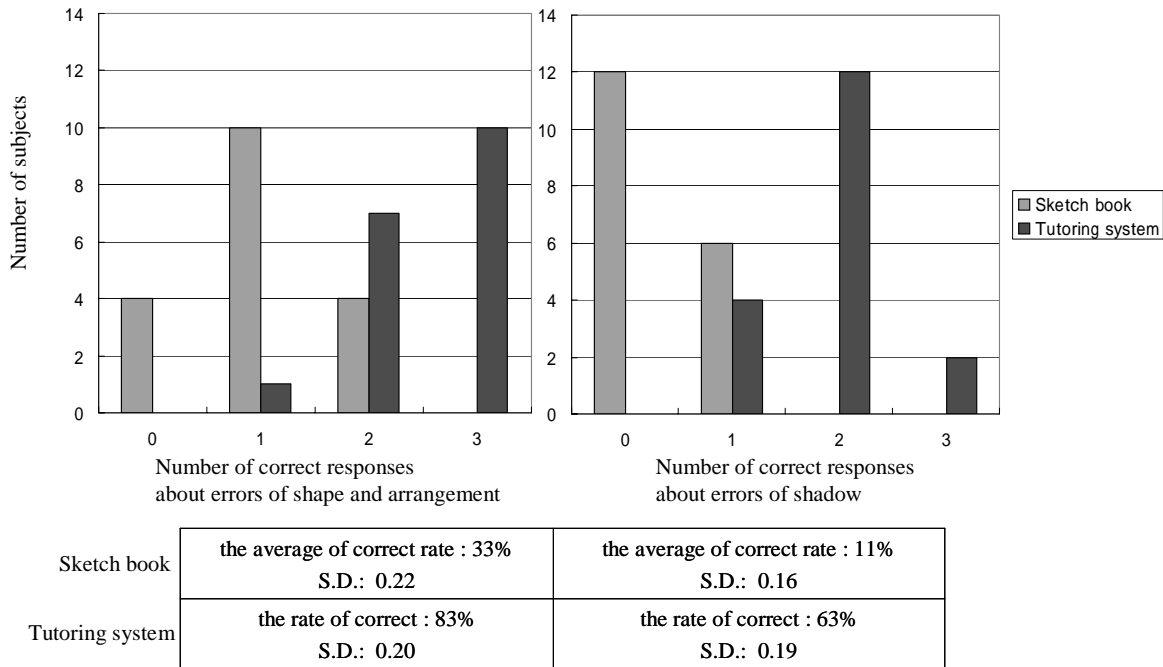
**Figure 9:** Example of appearance of 3D model for region-(B)

#### 4. Preliminary Experiment

To test if the tutoring system could actually enhance learner's awareness of errors, we held a preliminary experiment. This experiment compares differences in error awareness conditions with the tutoring system and without it. We prepared two drawings that include three errors of shape and arrangement and that include three errors of shadow. These drawing were shown on a sketch book and a computer screen by the tutoring system. Subjects of this experiment are university students who learn pencil drawing.

First, we asked 18 learners to point out all errors in one drawing on a sketch book. Then we asked them to point out all errors in another drawing on computer screen that was generated by the tutoring system. We investigate the correct number in responses.

(Fig. 10) shows the results of investigation. Most subjects pointed out more errors with the tutoring system than with the sketch book. The result indicates the effectiveness of the tutoring system.



**Figure 10:** Results of the preliminary experiment

## 5. Conclusions

This paper describes development of sketch tutoring system for supporting learner’s awareness of errors about shadow. The system provides an erroneous 3D model from a learner’s sketch. A preliminary experiment for evaluation of the proposed system confirms its effectiveness. Our future study will address extension of subjects for drawing and generation of advice about coloration. In addition, we are planning to conduct more experiments to evaluate the effectiveness of our system.

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