S. L. Wong et al. (Eds.) (2010). Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education.

AR-Supported Sketch Learning Environment by Drawing from Learner-Selectable Viewpoint

Kazuya SHIROUCHI[a], Masato SOGA[b], Hirokazu TAKI[b]

[a] Graduate School of Systems Engineering, Wakayama University
[b] Faculty of Systems Engineering, Wakayama University

Abstract: We constructed a sketch learning Environment. Instead of a real bowl and a real glass, virtual objects represented as 3D CG objects in a computer are used as motifs and are displayed in real space using augmented reality techniques. Consequently learners are able to compose freely. We conducted an evaluation experiment. The experimental results obtained from an experimental group and a control group were compared, revealing that the learning effect was more pronounced in the experimental group.

Keywords: Sketch, augmented reality, learning environment

1. Introduction

Numerous tools and software, ranging from software used for case studies to commercial software, have been produced to support drawing of pictures and diagrams on a virtual plane in computers. Bill Baxter and others, for instance, have developed a system to draw pictures on a virtual canvas by operating a paintbrush in virtual space. It uses a force display device, a Phantom, as the interface and operates a stylus pen as the paintbrush [1]. The system can be positioned at the highest point in conventional painting tools. However, the system provides only tools sufficient for drawing pictures within a virtual space and does not present information to support learning to draw.

Before we started our study, no system had been reported as supporting the learning of sketching or drawing by providing information about the correctness of a sketch or picture. Our group has been producing learning support environments for about 10 years to fill the role of supporting a drawing teacher when beginners are learning to sketch or draw.

To date, we have proposed and constructed various learning support environments for sketching and drawing [2–7]. They are designed and constructed based on cognitive scientific considerations when learners draw a sketch.

In the process, with the intention of offering advice during drawing, we developed an area information display system as a supportive environment for recognition [4,5]. It is a system with drawings produced by fixing a drawing paper on a graphics tablet (intuos2; Wacom), and using a pen with an attached pencil lead on the tip of an associated stylus pen. This produces a system that enables detection of the pen tip position on the drawing paper. When motifs, a bowl and a glass, are arranged in a designated position and a viewpoint is also fixed in a predetermined position, it will be determined what should be depicted in which area on the drawing paper. By making correspondence between information about a drawing to be drawn and a learner's drawing, it offers audio advice on what should be drawn at the position of the learner's pen tip. Results of an evaluation experiment about the system verified the effectiveness of the advice in learning drawing with a predetermined viewpoint.

In this system, a real bowl and a real glass are used as motifs for a drawing. In addition, a learner's viewpoint is also predetermined for drawing. Therefore, a learner needs to adjust the height and position of the chair according to the learner's own physical status, such as height and sitting height. This procedure is necessary to assign a drawing to be drawn uniquely and to take correspondence with a learner's drawing because the vision of motifs is not determined unless the viewpoint is determined.

This study was undertaken to design and develop a new system enabling setting of a viewpoint freely, not by which a learner adjusts to the system, but by which the system adjusts to a learner.

Instead of a real bowl and a real glass, virtual objects represented as three-dimensional computer graphics (3-D CG) objects in a computer are used as motifs and are displayed in real space using augmented reality (AR) techniques. A learner sketches those virtual motifs. The learner can then determine a viewpoint freely and set part of the field of vision as a composition using a drawing scale that is virtually defined. The system can instantly acquire shape data of the motifs for a determined composition and output audio advice based on the data. A learner can study with a composition set independently while receiving advice from the system.

Although we conducted an evaluation experiment for the trial system using only a glass motif, now a bowl motif has been implemented in addition to the glass motif. It has become possible to learn sketching using both motifs simultaneously.

2. System configuration and principle

2.1 Configuration of the system

The constructed learning support environment comprises a computer main body, an immersive head-mounted display (HMD), a handy video camcorder, and a graphics tablet. The CG models of a glass and a drawing scale are displayed in virtual space. The drawing scale is a tool to determine a composition. The small video camcorder is fixed on the HMD. This enables realization of a video see-through AR. Left picture of figure 1 portrays the way the learning support environment is used.

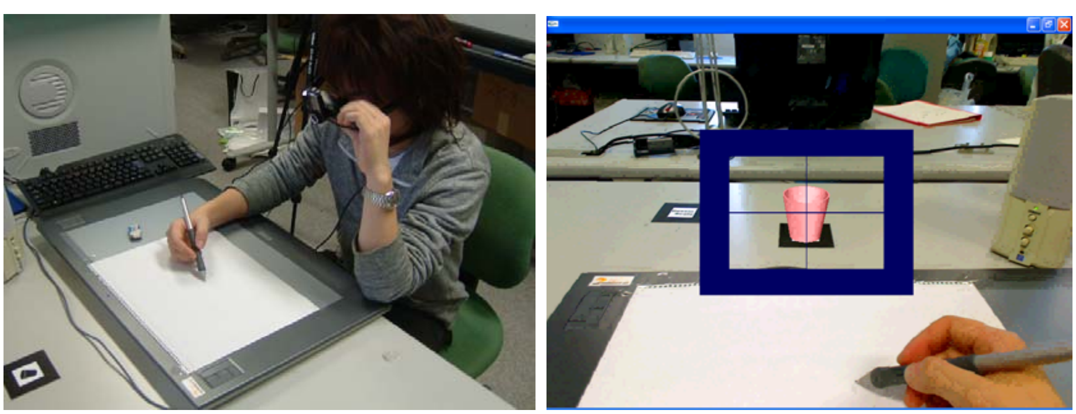

Figure 1 Using the learning support environment.

(Left: A scene of using the learning support environment, Right: Image presented to a learner by AR.)

2.2 Use of AR

Using the ARToolKit, make correspondence between the shape of a marker and a glass created by CG in advance. Then, put the marker on the desk. When capturing the marker using a video see-through method, a learner can see the image as through the glass were set on the desk (Right, Fig. 1).

Because ARToolKit calculates and displays an attitude of motifs from the vision of the marker, when a learner's head moves while wearing the camera, the vision of the motifs changes in conjunction with the vision of the marker.

2.3 Acquisition principle of the outline seen from a viewpoint

The CG models to be used as motifs are assigned feature points with short intervals on the line which could be the outline. The 3-D coordinate values are stored and managed in the PC as data. A learner decides the position of a viewpoint by moving the head. Determination of a viewpoint is conducted by typing keys on the keyboard under the conditions of maintaining the determined viewpoint. The system calculates the positions of each feature point through the drawing scale from the viewpoint with transparent transformation and renders the shape of the motif into a 2-D image.

2.4 Corresponding with a sketch on a drawing paper

For the present study, we used a graphics tablet (Intuos3; Wacom). This is a device to acquire the position of tip of the associated stylus using an electromagnetic induction method. After attaching a pencil lead on the tip of this associated stylus, a learner draws a drawing on a paper fixed to the graphics tablet. Because it is an electromagnetic induction method, the pen tip position is detectable even through the drawing paper. This makes it possible to make correspondence between the 2-D shape of the motif acquired as explained in the previous section and a learner's drawing on the graphics tablet (Fig. 2).

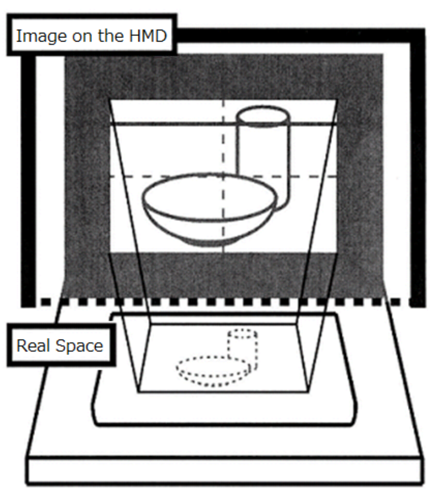

Figure 2 Image presented to a learner by AR.

2.5 Presenting a method of advice

When a learner puts the pen on the drawing paper, audio advice is given on what should be drawn there according to the position. In advance, correspondence is made to all feature points of the 3-D CG models with advisory sentences; they are input into the system. Those advisory sentences are presented by reading them out with text-to-speech software when making correspondence between the 2-D shape and the pen tip position, as described in the previous section.

3. Evaluation experiment

We conducted an evaluation experiment to examine how much of an effect on learning would be achieved using the system. We use a simple glass as a motif. Subjects were 10 students who had learned drawing in a class. They were divided into the following two groups of five each: a group using no system (control group), and a group using it (experimental group).

3.1 Procedures

First, we asked subjects to draw a sketch using a real glass and a drawing scale. At that time, images of the determined compositions were taken using a digital camera.
Next, we asked subjects to practice sketching several times. With the assistance of the learning support environment, the experimental group was asked to sketch a virtual glass using a virtual drawing scale in the system. Instead of using the learning support environment, the control group was given a document about the composition setting with a drawing scale and asked to practice using a real glass and a drawing scale with reading. Because the control group uses no learning support environment, when a drawing that is drawn deviates from a real motif in terms of shape, they cannot obtain advice to point it out.
Finally, we asked both groups to draw a sketch using a real glass and a drawing scale. In the same manner as the first sketch, we shot determined compositions using a digital camera. The shape of a glass used in the final sketch differed from that in the first sketch.

3.2 Results

In a picture created by superimposing a photograph of the composition shot with a digital camera and a sketch that was drawn, we found the degree of coincidence of the edges, base widths, heights, and positions of the glasses by ratio. When the value is 100%, they are perfectly consistent; as the value becomes less than 100%, a sketch that is drawn differs from a photograph of the composition to a greater extent.
Table 1 shows comparison values of the lengths between a photograph of the composition and a sketch drawn before and after practicing in the control group (Subjects A–E) and in the experimental group (Subjects F–J). The values in the columns of “Before” present the ratios of the lengths between a sketch drawn before practicing and a photograph of the composition. The values in the columns of “After” present the ratios of the lengths between a sketch drawn after practicing and a photograph of the composition. When a comparison value becomes larger after practicing than before practicing, the sketch comes to resemble a photograph of the composition more closely. Compared to the control group, the values rose more frequently in the experimental group.

Table 1 Comparison of ratios of the lengths before and after practicing in the control group and the experimental group [%]

Control group		Edge	Base Width	Height	Position (Long)	Position (Wide)	Experimental group		Edge	Base Width	Height	Position (Long)	Position (Wide)
A	Before	82.7	92.3	100	95.9	94.7	F	Before	86.7	90	88.2	58.8	96.9
	After	98.3	90.9	91.6	98.2	100		After	83.3	100	95.2	85	97.3
B	Before	97.1	88.9	94.1	91.2	96.7	G	Before	96.4	90.9	90.5	87.4	90.8
	After	86.7	87.5	94.7	95.6	96.7		After	94.5	100	94.1	95	94.5
C	Before	50	100	88.9	96.3	96.7	H	Before	80	100	100	82.9	85
	After	71.4	90	70.4	91.6	94.3		After	100	100	100	98.7	98.3
D	Before	70	100	88.9	94.2	98.9	I	Before	63.3	100	92	88	95.6
	After	83.3	80	86.7	92.2	94.4		After	85.6	100	84.1	97.1	97.3
E	Before	100	77.8	92.9	86.2	96	J	Before	62.5	76.9	81.8	85.6	81.4
	After	55.4	100	100	89.5	98.5		After	85.8	100	100	82	97.1

4. Conclusions

As described in this paper, we proposed a sketch learning support environment that uses CG models as motifs and displays a superposition visualization of them on the desk using AR techniques. It allows learners to determine a viewpoint freely. After constructing a trial system, we conducted an evaluation experiment. The experimental results obtained from an experimental group and a control group were compared, revealing that the learning effect was more pronounced in the experimental group.

In the future, taking further advantage of a high degree of freedom for viewpoint setting, we plan to implement supportive functions for composition learning, and to increase usable motifs.

References

[1] Baxter, W., Scheib, V., Lin, C. M., & Manocha, D. (2001). DAB: Interactive Haptic Painting with 3D Virtual Brushes, Proc. of the 28th Annual Conference on Computer Graphics and Interactive Techniques, 461-468.

[2] Soga, M., Taki, H., Matsuda, N., Takagi, S., & Yoshimoto, F. (2005). Skill Learning Support and a Framework for the Learning Support Environment (in Japanese), *Journal of Japanese Society for Artificial Intelligence, 20*(5), 533-540.

[3] Takagi, S., Matsuda, N., Soga, M., Taki, H., Shima, T., & Yoshimoto, F. (2003). An Educational Tool for Basic Techniques in Beginner’s Pencil Drawing, *Proc. of Computer Graphics International 2003*, 288-293.

[4] Soga, M., Matsuda, N., & Taki, H. (2008). A Sketch Learning Support Environment that Gives Area-dependent Advice during Drawing the Sketch (in Japanese), *Transactions of the Japanese Society for Artificial Intelligence*, *23*(3), 96-104.

[5] Iwaki, T., Tsuji, T., Maeno, H., Soga, M., Matsuda, N., Takagi, S., Taki, H., & Yoshimoto, F. (2005). A Sketch Learning Support System with Automatic Diagnosis and Advice, Int. Conf. of Computers in Education 2005 (ICCE2005), 977-979.

[6] Soga, M., Maeno, H., Koga, T., Wada, T., Matsuda, N., Takagi, S., Taki, H., & Yoshimoto, F. (2007). Development of the sketch skill learning support system with real time diagnosis and advice showing learner’s arm motion animation (in Japanese), *Transactions of Japanese Society for Information and Systems in Education*, *24*(4), 311-322.

[7] Soga, M., Kuriyama, S., & Taki, H. (2009). Sketch Learning Environment with Diagnosis and Drawing Guidance from Rough Form to Detailed Contour Form, Lecture Notes in Computer Science, Volume 5940/2009, Transactions on Edutainment, Volume III, pp. 129-140, Springer Berlin / Heidelberg.