Browsing Methods for Multiple Online Handwritten Note Animations

Yuuki Maeda[1(✉)] and Motoki Miura[2]

[1] Department of Applied Science for Integrated System Engineering, Kyushu Institute of Technology, 1-1 Sensui, Tobata, Kitakyushu, Fukuoka 804-8550, Japan
maeda@ist.mns.kyutech.ac.jp

[2] Faculty of Basic Sciences, Kyushu Institute of Technology, 1-1 Sensui, Tobata, Kitakyushu, Fukuoka 804-8550, Japan
miuramo@mns.kyutech.ac.jp
http://istlab.mns.kyutech.ac.jp/~maeda/

Abstract. We proposed a student note-sharing system to facilitate collaborative and interactive learning in conventional classrooms. Student notes can already be immediately shared by the students and teacher, using a projection screen. However, the resolution is currently insufficient to allow each student note to be shown in detail, which lessens the learning benefits. To address this issue, we proposed two browsing methods that allow simultaneous viewing of multiple online handwritten note animations. In both methods, the zoom rates were determined automatically. Experiments were conducted on the readability of texts, the visibility of figures, and the intuitiveness of animations. The results demonstrated that the animations produced by the ConstantZoom method were more intuitive than those produced by the VariableZoom method.

Keywords: Multiple handwritten notes · Digital pen system · Simultaneous note animations

1 Introduction

Popularization of digital devices such as tablets and smartphones is changing lifestyles. Users can collect information from online resources and exchange ideas and thoughts through their devices. There is an accelerating movement to use digital devices for learning and teaching in classrooms, allowing teachers to collect student responses, and share them with other students [1].

Tablets and smartphones are versatile tools. However, their usability depends on the interface with the application. These devices may also require drastic changes in our approach to learning and teaching. Such changes may place extra burdens on students, who must learn the usage of each application.

To minimize this burden, Miura et al. have proposed AirTransNote, a student note-sharing system that facilitates collaborative and interactive learning in

T. Yoshino et al. (Eds.): CollabTech 2016, CCIS 647, pp. 212–219, 2016.
DOI: 10.1007/978-981-10-2618-8_17

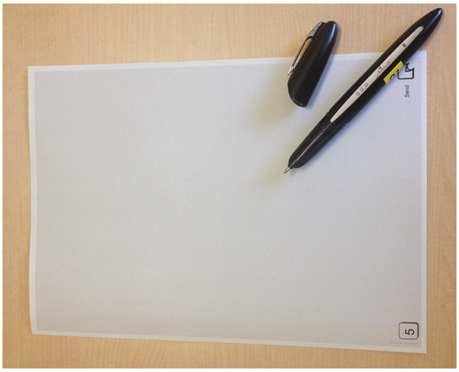

Fig. 1. Anoto-based pen and the special paper

conventional classrooms [2]. AirTransNote uses digital pens (Anoto) and paper (shown in Fig. 1) to collect ideas and responses from students. Since these notes are transmitted wirelessly, the teacher can immediately share them with the rest of the class using a projection screen. This can enhance group learning. As students are familiar with the use of pen and paper, the interface is intuitive, lessening the burden on the students. Prieto et al. [3] reviewed similar augmented paper systems in educational applications.

One of the primary effects of note sharing during a lecture is the enhancement of interaction between students [4]. The browsing method used for the collected notes is therefore crucial. A system can be introduced in which a personal tablet allows each student to browse the notes of other students. However, in this study, we focus on the use of a projection screen as a shared display.

The existing AirTransNote system provides two view modes for note browsing: a thumbnail view and a focused view. The thumbnail view (Fig. 2 left) displays all the student sheets at reduced size, allowing the teacher to assess the progress of each student from the volume of writing. However, teachers find it difficult to comprehend the details of each note due to the low resolution. The focused view (Fig. 2 right) enlarges an area selected by the teacher from the thumbnail view. The focused view is helpful for checking student answers at a glance and has an appropriate resolution for allowing notes to be understood. The OpenNOTE system of DNP [5] provides similar view modes. However, to improve the focused view, teachers are required to decide in advance the areas to be focused on. Because the location of the focused area is the same across all student sheets, if the teacher wishes to focus on real-time handwriting using free format sheets, the focus region must be moved to track the latest notes.

To improve the effectiveness of sharing real-time student handwriting, we introduced an alternative method of browsing that tracks the latest student notes using the AirTransNote system.

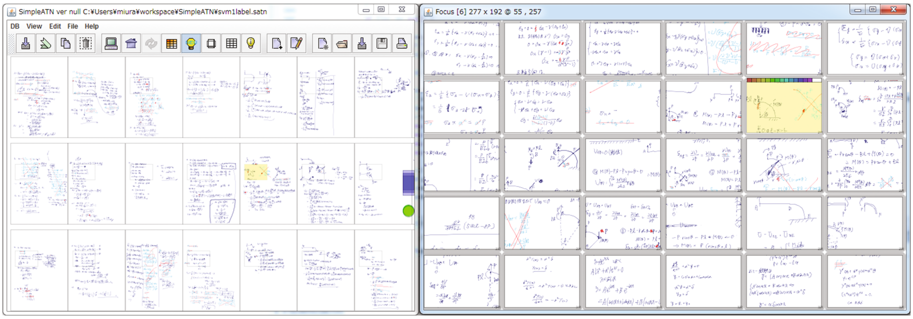

Fig. 2. Conventional view modes in AirTransNote: Thumbnail view (left) and Focused view (right). When the teacher hovers the mouse pointer over the focused view, both views are highlighted.

1.1 Design Criteria

We set the following criteria for the design of an alternative view mode for tracking the latest student notes.

- The view mode displays multiple student notes at an appropriate zoom rate.
- To track the handwriting activities of each student, the view mode focuses on the latest notes.
- Both the teacher and students can read the note content without controlling the zoom rate or position. Panning and zooming are determined automatically.
- To improve awareness of handwriting, the view mode displays handwritten notes with pens.
- The view mode allows both texts and figures to be read.

2 Alternative Browsing Methods

To meet these criteria, we considered two alternative browsing methods: constant zoom and variable zoom.

In this section, we describe our method of calculating zoom areas and zoom rates.

2.1 Format of Digital Pen Data

Before explaining how the zoom areas and zoom rates are calculated, we introduce the basic format of digital pen data. Digital pen data comprises multiple strokes, in which each stroke represents a line generated by the continuous movement of the pen-tip on the paper. The stroke data comprises (1) the coordinates of the pen-tip (x,y), sampled at a frequency of 75 times per second, and (2) the start time of the stroke. The size of the bounding box of the stroke is calculated as shown in Fig. 3. The height of the bounding box is used to estimate the size of the characters used in texts or formulae. It can also be used to determine whether the writing is text, formulae, or figures. In our initial designs, we used the height of the bounding box to determine zoom rates.

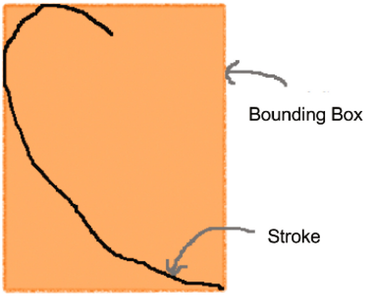

Fig. 3. Bounding box of a stroke

2.2 Constant Zoom

To determine the appropriate zoom rate for each note, the following parameters were considered: (1) the size of the browsing area, (2) the resolution of the display, and (3) the size of the written characters. The first parameter is based on the number of browsing areas, the aspect ratio of the area, and the layout of the browsing areas. The second parameter is determined by the specification of the projector. The third parameter varies from student to student. We therefore estimated the size of the characters by averaging the height of the bounding boxes of the previous strokes. From preliminary experiments, we determined the zoom rate by the following formula:

$$ZoomRate = \frac{27.58}{3 \times AvgHeight_{BoundingBox}} \tag{1}$$

Here, the zoom rate is based on a display resolution of 700 pixels in width and 990 pixels in height for a whole A4-sized sheet. This display resolution allows most of the note to be recognized on the screen. The base line height of the pixels is 27.58, corresponding to 5 mm on the display. This value was based on the guidelines of Japan's Ministry of Health, Labour and Welfare[1]. The denominator is based on the average line height of the main handwritten text in the pixel unit. In our experiment, as described in Sect. 3, a heuristic method was used to determine the denominator part, by introducing a magnification parameter of three that converted the average height of the bounding box to the line height

[1] http://www.mhlw.go.jp/houdou/2002/04/h0405-4.html.

based on target note data. Strictly, the denominator part should be determined by analyzing the height of the main texts in each note.

Figure 4 shows a screenshot of the ConstantZoom view. Each browsing area displays a corresponding student note with the calculated zoom rate and handwriting animations. The pen is moving in the browsing area, and the position of the focused area is automatically updated (panned) based on the latest handwriting position. In ConstantZoom, the zoom rate of each browsing area is almost fixed if the number of large height strokes is smaller than the number of strokes that are generated when writing texts or formulae.

Fig. 4. Screenshot of the ConstantZoom view. The number and layout of the browsing areas were held constant in the experiment.

2.3 VariableZoom

The ConstantZoom method is suitable for notes that consist of texts and formulae. However, a handwritten note often contains figures and graphs. Generally, when the figures and graphs are larger than the texts and formulae, they cannot be displayed using the ConstantZoom method.

To allow display of both texts/formulae and figures/graphs, we introduced the Variable-Zoom method. The VariableZoom method determines the zoom rate by analyzing the average height of the last fifteen strokes. This allows the whole figure and graph to be displayed by zooming out.

3 Experiments

Experiments were conducted to investigate the usability of the proposed browsing method and to explore its characteristics.

Handwritten notes were collected from forty undergraduate students in a lecture on material mechanics. The students were asked to answer questions in the course of the lecture using Anoto digital pens and paper. The notes contained both formulae and figures, at a different ratio for each student. The timestamp data of several of the student notes were defective, and our analysis was confined to notes for which the timestamp data were correct. Notes with few or limited drawings were also eliminated. A total of 22 student notes were used in the analysis.

Eight further participants (all male, ages from 20 to 24) were asked to browse the selected notes on a PC, with a view similar to that shown in Fig. 4. Each participant browsed the notes alone and one by one. The display of the PC was 348 mm in width and 197 mm in height, with a resolution of 1920 × 1080 pixels. The size of each browsing area was 64 mm in width and 32 mm in height, with a resolution of 353 × 175 pixels. An LCD display was used in place of the projection screen to reduce the effect of brightness.

To avoid participants becoming confused when browsing multiple notes simultaneously, we asked them to focus on one specified browsing area. Four student notes with similar average stroke heights and containing both formulae and figures were selected. Figure 5 shows one of the notes used in the experiment. Each participant browsed the notes four times, using the ConstantZoom and VariableZoom methods. The order of presentation was counterbalanced by area and method.

After four browsing sessions, participants were asked to evaluate the online handwriting note animations from three viewpoints: (1) readability of texts, (2) visibility of figures, and (3) intuitiveness of representation/animation. A 5-point Likert scale (1: worst; 5: best) was used.

3.1 Results and Discussion

Figure 6 shows the actual zoom rates for an example note (Fig. 5). The "ConstantZoom" and "VariableZoom" represent the zoom rates of the ConstantZoom and VariableZoom, respectively. This confirmed that the transition of zoom rates was more moderate when using ConstantZoom.

Figure 7 gives the results of the questionnaire. A Mann-Whitney U-test was conducted, with a 5 % significance cutoff. Table 1 shows the results. In terms of readability of texts and visibility of figures, there was no significant difference between the ConstantZoom and the VariableZoom methods. However, the intuitiveness of animation of the ConstantZoom method was rated significantly higher than that of VariableZoom. The participants found frequent and rapid changes in the zoom rate unintuitive, which reduced their evaluations of the browsing method. However, some participants reported that the zoom change helped a mode change to be recognized. Several participants also noted that the readability of the text was significantly affected by the neatness of the handwriting.

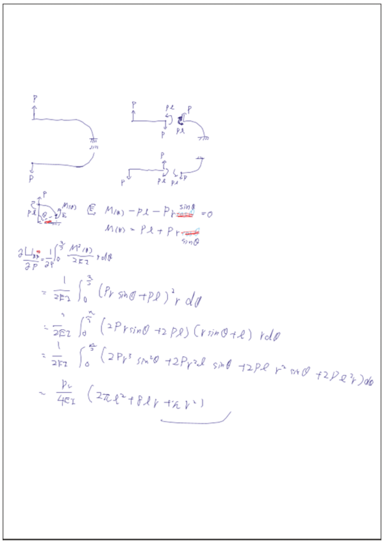

Fig. 5. Example note

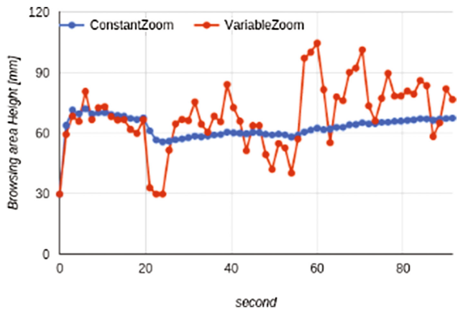

Fig. 6. Actual zoom rates of ConstantZoom/VariableZoom methods for the example note

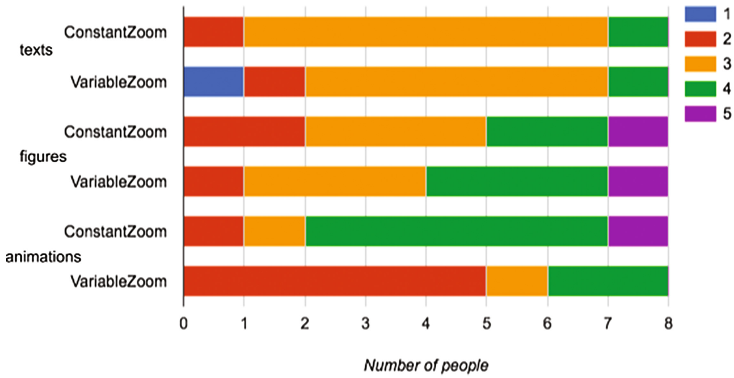

Fig. 7. The results of the questionnaire

Table 1. Mann-Whitney U-test for the result of the questionnaire (significance level was 5 %)

	U	p
texts	28	0.61
figures	13.5	0.58
animations	11.5	0.03

4 Conclusions and Future Work

In this paper, we proposed two browsing methods for simultaneous viewing of multiple online handwritten note animations. In the ConstantZoom method, the zoom rate was determined by averaging the previous handwriting strokes. VariableZoom used a similar approach, except that only the last 15 strokes were used to determine the zoom rate. Experiments were conducted to evaluate the readability of texts, the visibility of figures, and the intuitiveness of animations. The results showed that there were no significant differences in the readability of texts or the visibility of figures. However, the ConstantZoom method was superior to VariableZoom in terms of the intuitiveness of animations.

In future work, we will evaluate a refined VariableZoom method in which the zoom rate is changed more smoothly. We will also try to improve the ease of distinguishing texts and figures by appropriate zooming. Our browsing methods can be used to enhance classroom communication and interactions between students and with teachers by improving the interpretability of handwritten notes.

Acknowledgements. The part of this research was supported by the fund of JSPS KAKENHI Grant-in-Aid for Scientific Research (C): Grant Number 15K00485 and the fund of Telecommunication Advancement Foundation.

References

1. Enriquez, A.G.: Enhancing student performance using tablet computers. Coll. Teach. **58**(3), 77–84 (2010)
2. Miura, M., Sugihara, T., Kunifuji, S.: Improvement of digital pen learning system for daily use in classrooms. Educ. Technol. Res. **34**, 49–57 (2011)
3. Prieto, L.P., Wen, Y., Caballero, D., Dillenbourg, P.: Review of augmented paper systems in education: an orchestration perspective. Educ. Technol. Soc. **17**(4), 169–185 (2014)
4. Sugihara, T., Miura, M., Kunifuji, S.: Practicing on stage: increasing transparency and interaction in class activity with digital pen system. In: König, A., Dengel, A., Hinkelmann, K., Kise, K., Howlett, R.J., Jain, L.C. (eds.) KES 2011. Lecture Notes in Artificial Intelligence (LNAI), vol. 6884, pp. 457–464. Springer, Heidelberg (2010). doi:10.1007/978-3-642-15384-6_49
5. DNP: OpenNOTE. http://www.dnp.co.jp/works/detail/10111269_18925.html (2016/2/12 accessed)