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Michele Della Ventura, *editor*

2020

Proceedings of the International Conference on New Music Concepts Inspired Education and New Computer Science Generation

Vol. 7

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Michele Della Ventura
Editor

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Preface

This volume of proceedings from the conference provides an opportunity for readers to engage with a selection of refereed papers that were presented during the International Conference on New Music Concepts, Inspired Education and New Computer Science Generation. The reader will sample here reports of research on topics ranging from a diverse set of disciplines, including mathematical models in music, computer science, learning and conceptual change; teaching strategies, e-learning and innovative learning, neuroscience, engineering and machine learning.

This conference intended to provide a platform for those researchers in music, education, computer science and educational technology to share experiences of effectively applying cutting-edge technologies to learning and to further spark brightening prospects. It is hoped that the findings of each work presented at the conference have enlightened relevant researchers or education practitioners to create more effective learning environments.
This year we received 57 papers from 19 countries worldwide. After a rigorous review process, 24 paper were accepted for presentation or poster display at the conference, yelling an acceptance rate of 42%. All the submissions were reviewed on the basis of their significance, novelty, technical quality, and practical impact.

The Conferece featured three keynote speakers: Prof. **Giuditta Alessandrini** (Università degli Studi Roma TRE, Italy), Prof. **Renee Timmers** (The University of Sheffield, UK) and Prof. **Axel Roebel** (IRCAM Paris, France).
I would like to thank the Organizing Committee for their efforts and time spent to ensure the success of the conference. I would also like to express my gratitude to the program Committee members for their timely and helpful reviews. Last but not least, I would like to thank all the authors for they contribution in maintaining a high-quality conference and I hope in your continued support in playing a significant role in the Innovative Technologies and Learning community in the future.

March 2020

Michele Della Ventura

Conference Chair

Michele Della Ventura, Accademia Musicale Studio Musica, Treviso, Italy

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Hand Occlusion Management Method for Tabletop Work Support Systems Using a Projector

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Abstract. Work support systems using projectors realize greater work accuracy than systems that use head-mounted displays because such system can directly add digital information to an existing object. However, projection information may be hidden by the user's hand (hand occlusion) and content may be difficult to recognize. Thus, we propose methods to manage hand occlusion that occurs when tracing a line, with a focus on visual and auditory feedback. The proposed method was evaluated quantitatively and qualitatively in a user study, and the effectiveness of combining visual and auditory feedback was recognized.

Keywords. Hand occlusion, work support, visual and auditory feedbacks

1 Introduction

Recently, various work support systems have been developed. In the industrial field, such systems are used for inspection [1], picking [2], and assembly work [3]. In daily work, such systems are used for cooking [4], calligraphy [5], and playing musical instruments [6]. Work support systems are known to improve the quality of work and reduce workload. Many work support systems employ projectors [7-10] because digital information can be directly superimposed onto different objects; thus, the work content can be understood intuitively. In addition, projectors are used because they eliminate the need to attach equipment to the worker's body. Relative to work efficiency, head-mounted display-based support systems are worse than those that use projectors [11]. However, systems that projectors suffer from occlusion that occurs between an object and the digital information, as well as hand occlusion, which occurs between an operator's hand and the digital information. For occlusion occurring between an object and the digital information, a method to project information while avoiding objects has been proposed previously [12, 13]. No hand occlusion management method has been proposed even though hand occlusion is known to affect digital information recognition and work efficiency [14, 15].

In light of this background, we propose hand occlusion management methods that use visual and auditory feedback. This paper presents the results of applying the proposed system to line tracing tasks assuming calligraphy and cake decoration.

2 Related work

Javaed et al. proposed occlusion management methods between a desktop display and objects placed on the display [16]. In that study, a method to notify that something is hidden, a method to notify hidden information, and a method to move hidden information were proposed. It was confirmed that another occlusion emerged even with occlusion management unless the tabletop state was not taken into account. In addition, Cotting et al. proposed as an occlusion management method that avoids objects and does not generate occlusion [12]. They proposed a system that employs Gabor filters to detect desk space where digital information can be projected. Although the projection area is small, this system can be realized at low cost. Riemann et al. proposed a hand that projects information by avoiding objects on a table [13]. In this method, an infrared camera is used to grasp the object on the table, and the area where information can be presented is determined by weighting according to the color, brightness, and height of the object. The only way to copy and convey hidden information to another user is through visual assistance. In addition, when digital information is presented in consideration of a tabletop object, the effect of superimposition, which is a characteristic of projection type AR, may be weakened.
Vogel et al. proposed a hand occlusion management method that is used between a hand and a tablet device. This method proposes a method to select important information hidden under the palm of the hand and reproduce and presenting it like a balloon. In addition, Brandl et al. proposed a method to move hidden information and present it to the user [17]. They proposed a method to arrange a menu display in consideration of the user's dominant hand and occlusion. Moore et al. investigated occlusion mitigation by the arrangement method of tablet terminals [18], which investigated holding and tilting the tablet terminals and calculated the angle of tablet terminals that can mitigate the occurrence of occlusion. However, these studies targeted tablet terminals, and, to the best of our knowledge, no management method has been proposed that considers hand occlusion created using projectors.
In this study, we propose the use of visual and auditory feedback in support systems. To realize hand occlusion management, we propose a management method that duplicates information to other locations rather than a method that avoids occlusion that may weaken the effect of superimposition.

3 Hand occlusion management

Four basic management methods are proposed, as shown in Fig. 1. Two methods focus on visual feedback, and two methods focus on auditory feedback. The reason we consider both visual and auditory elements is that sight and sound are significant components of human judgment. The methods shown in Fig. 1 is described as follows.

(a) Duplication

In this method, the line the user traces is displayed at a different location (Fig. 1(a)) in an attempt to complement the hidden line information by the user's hand.

(b) Map

This technique displays the current user's nib position over a line displayed at a different location (Fig. 1(b)) to complement the line information more easily than duplication.

(c) Change point notification

In this method, the position of change points (inflection and end point) is notified using sound (Fig. 1(c)) to easily identify direction changes and the end of work during tracing.

(d) Near change point notification

In this method, the position of the change point and in front of the change point are notified using sound (Fig. 1(d)). Here, the goal is to be able to easily pass through change points by playing a sound near the change points.

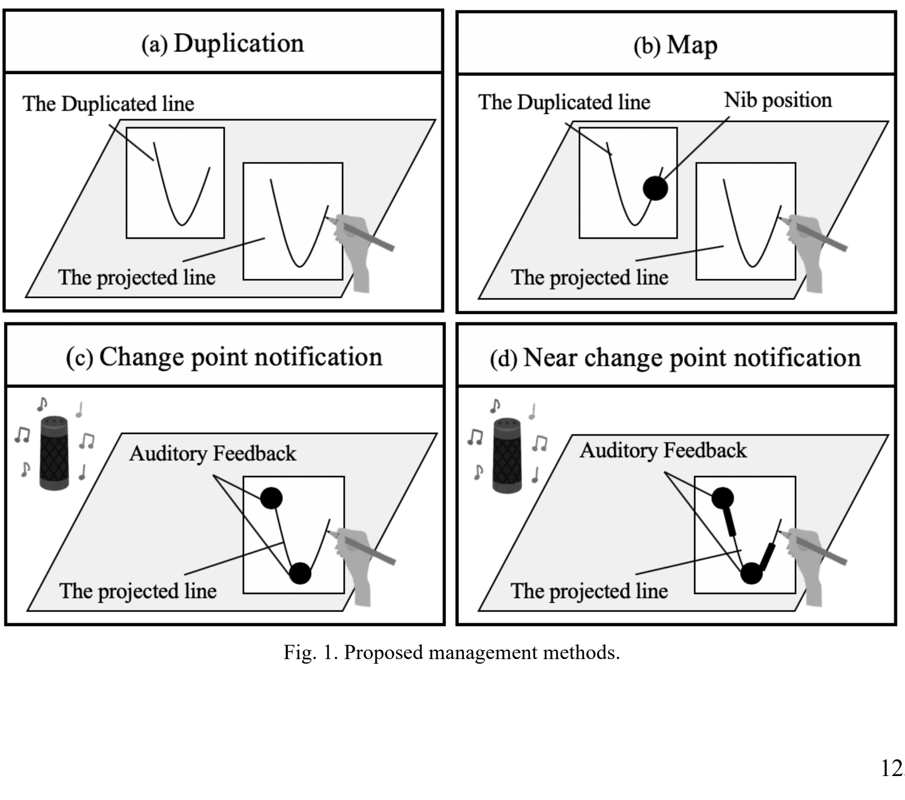

Fig. 1. Proposed management methods.

To combine visual and auditory feedback, we also propose (e) duplication and change point notification, (f) duplication and near change point notification, (g) map and change point notification, and (h) map and near change point notification.

4 Experimental system

The experimental system requires the following features.
(1) The position of the user's tool can be detected.
(2) Digital information can be presented using a video projector.
(3) Sound notification is possible.
Figure 2 shows an overview of the developed system based on these three requirements. The tool position detector (Fig. 2) is realized using Microsoft Leap Motion, which can detect the nib. Detecting the nib is because the work contents are focused on the line traces. Here an image is created and sound is generated according to the coordinates of the acquired position. The created image is projected downward. The sound is output the projector's built-in speaker. In the following, we describe the position coordinate processing component, the data rendering component, and the audio notification component, which are processes executed on a PC, as shown in Fig. 2.

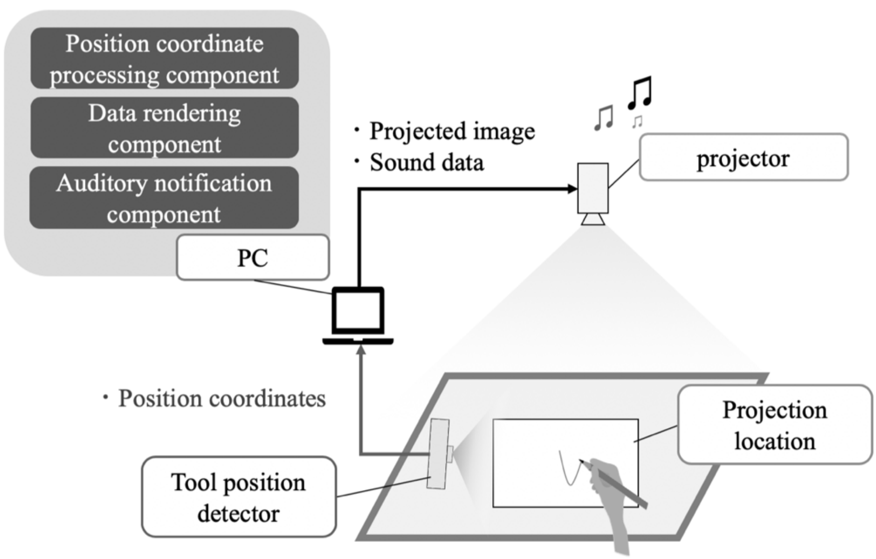

Fig. 2. System overview.

Position coordinate processing component
Leap Motion can detect the top of a pen and nib of pen at approximately 80 fps; however, it was difficult to obtain accurate coordinates because the nib contacts the desk because the task is line tracing. Therefore, the top position of the pen is detected by

Leap Motion, and the coordinates of the nib are calculated using Equation (1), which was derived in reference to a study that calculated the position of the brush using Leap Motion [19].

$$P_{nip} = P_{top} + aL \quad (1)$$

As shown in Fig. 3 (left), P_{nib} is the coordinates of the nib, P_{top} is the coordinates of the top of the pen, and a is the tilt angle of the pen, which is acquired by the Leap Motion relative to the coordinates of the top of the pen. L is the length of pen, which is measured in advance using a ruler. Figure 3 (right) shows the nib position calculated using Equation (1). The white point is the detected top of the pen, and the black point is the calculated nib.

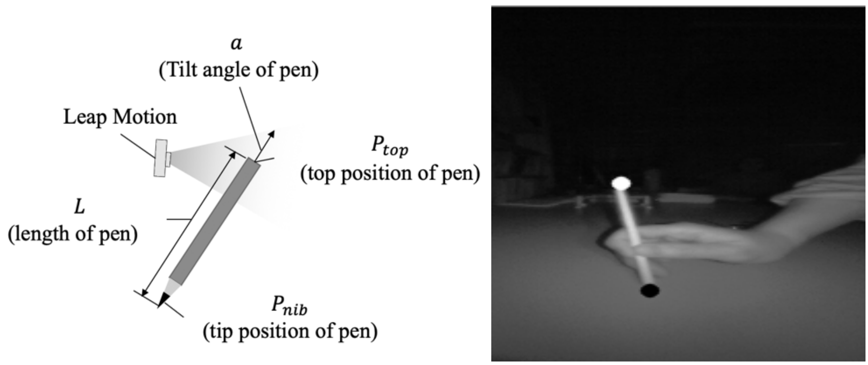

Fig. 3. Left: overview of nib coordinate calculation. Right: black circle and white circle represent nib detection result and the top of pen detection result, respectively.

Data rendering component

As discussed in Section 3, the line to be traced is always displayed at a fixed position regardless of the management methods, and the current nib position is also shown depending on the management methods. When nib position is acquired, the process of rewriting from the previous frame's nib position to the newly acquired nib position is repeated, and the latest detection result is displayed red as the current nib position. Figure 4 (1), (2), and (3) show the line for trace only as a control group, "duplication", and "map" methods, respectively.

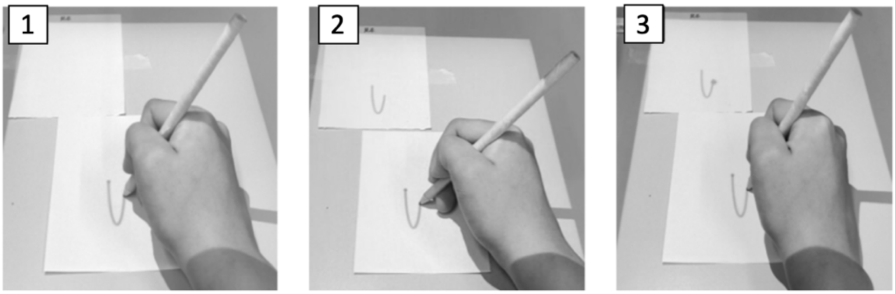

Fig. 4. (1): Line to trace, (2): duplication, (3): map.

Auditory notification component

As discussed in Section 3, auditory feedback informs the user of line change points. Therefore, when the position coordinates of the nib become a pre-registered change point coordinate, a beep with duration of 150 ms and frequency of 800 Hz is output. In addition, a beep with a frequency of 400 Hz is played continuously around the change point.

5 User study

Task

We conducted an evaluation experiment with 11 people in their twenties who were right-handed to investigate the effectiveness of the proposed methods in an actual hand occlusion management task. In this evaluation, the traced line had three curvatures, i.e., 0.913, 5.700, and 14.610. These curvatures categorize 26 alphabetic curves by visual information only, and the top three groups (curves based on "s," "u," and "w") were obtained by approximation using an ellipse. Furthermore, the line was rotated 0°, 45°, 90°, 135°, and 180° for a total of 15 curves were obtained (Fig. 5). In this experiment, the lines projected onto the desk were traced using nine methods, i.e., the eight proposed management methods (Section 3) and a "no management method." and the nib coordinates and tracing time were recorded. The was evaluated using a nine-point Likert scale (9 for "highest" and 1 for "lowest"). In addition, the influence of hand occlusion was evaluated using a five-point Likert scale (5 for "I feel strongly" and 1 for "I don't feel at all"). The users were also interviewed in a free interview session.

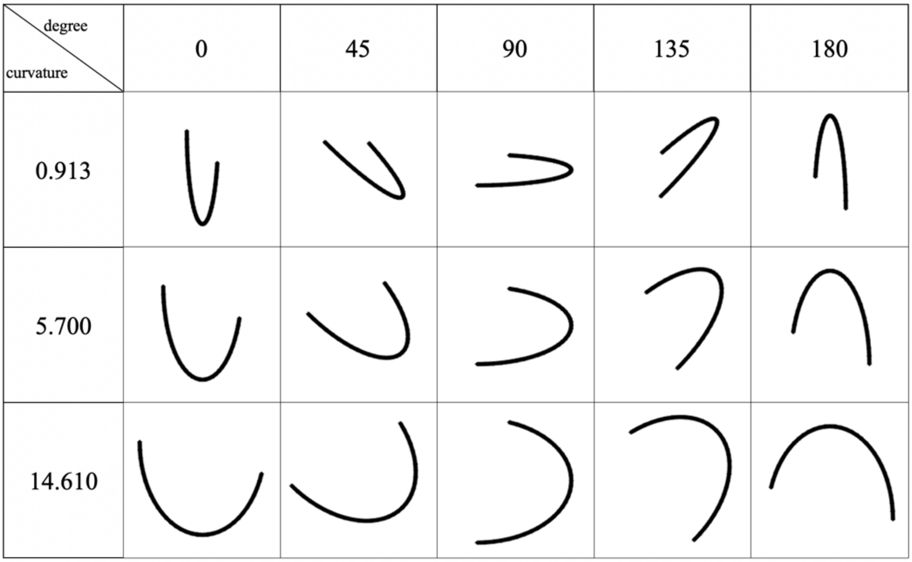

Fig. 5. Curves used for tracing.

Results

The trace error is the average value of the distance from the nib coordinates to the target line. Figure 6 shows the trace error results. The no management method in Fig. 6 is a state in which hand occlusion management was not performed, i.e., the control group. For the control group and each management method, the Wilcoxon signed rank test was performed at a significance level of 5% to investigate whether each management method contributes to trace error reduction, and those with significant differences are marked with "*" in Fig. 6. Although depending on curvature and placement, the change points notification, duplication and change point notification, duplication and near change point notification, map and change point notification, map and near change point notification methods were effective in improving work accuracy. It was confirmed that combining visual and audio elements likely contributes to accuracy improvement; however, there was a difference in the influence of hand occlusion because the results differed depending on the curvature and arrangement angle. When the influence of hand occlusion was small, the results were the same as those of the no management method, and when the influence of hand occlusion was large, all the proposed methods was insufficient.

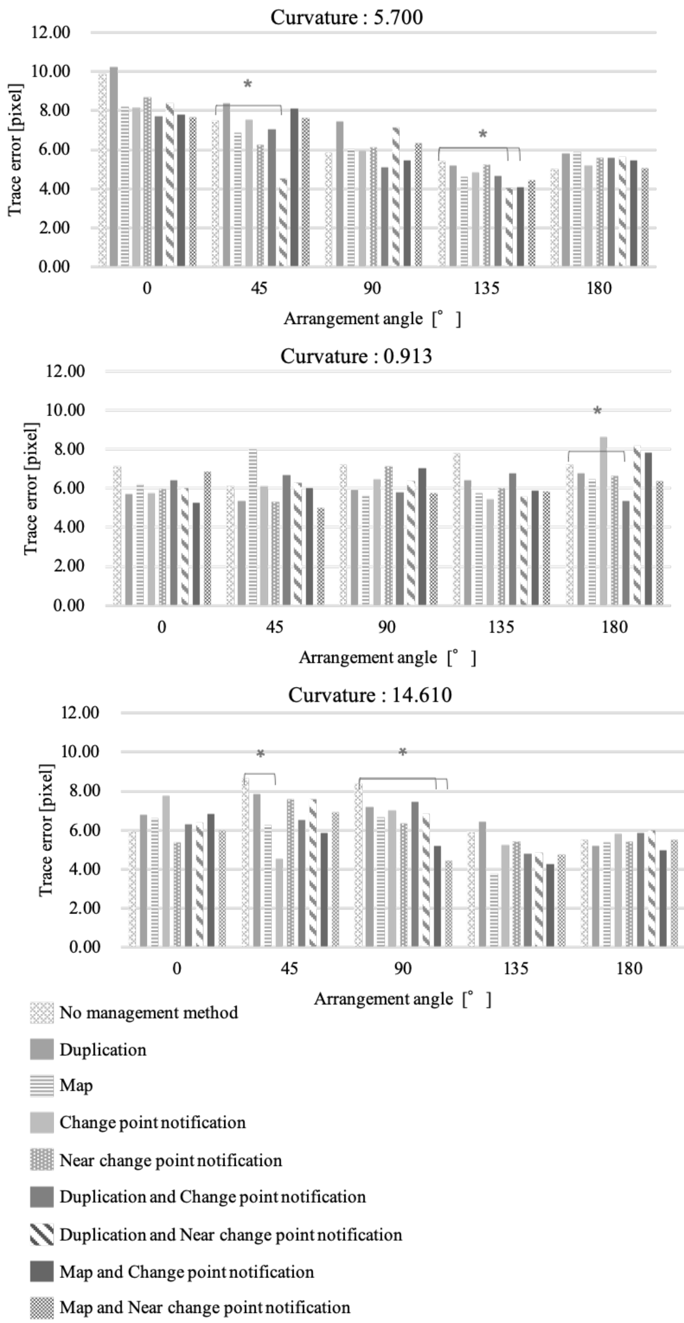

Fig. 6. Trace error in various arrangement angles and curvature.

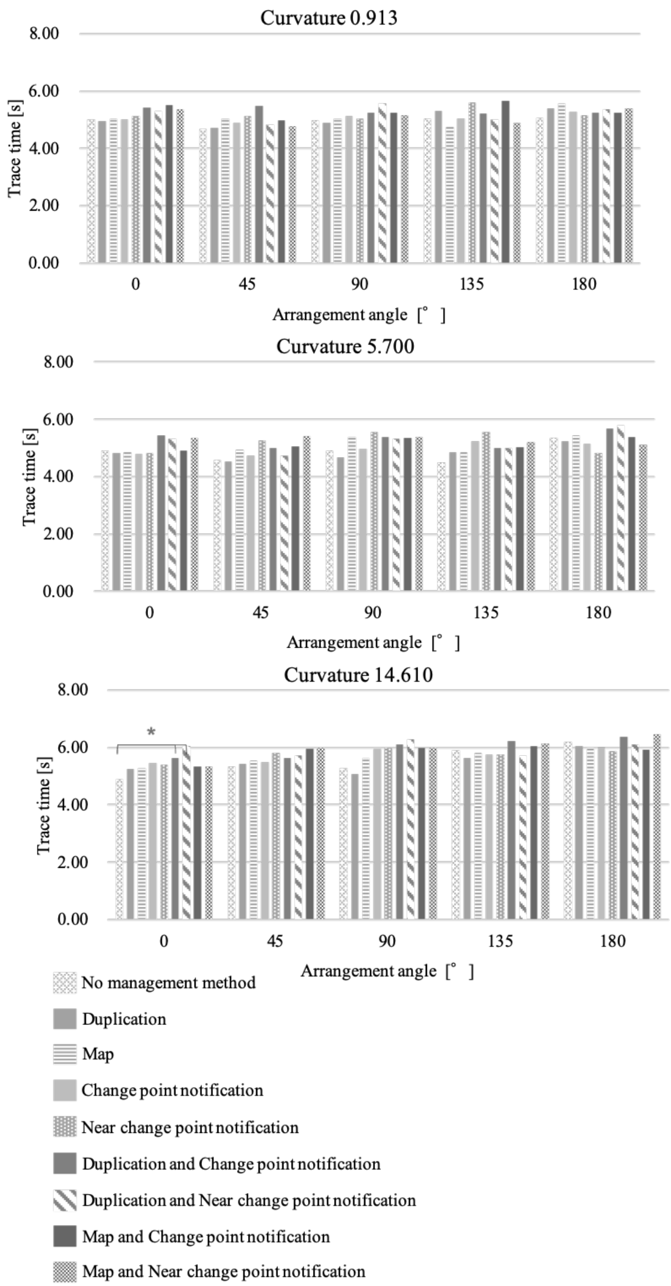

Fig. 7. Trace time in various arrangement angles and curvatures.

Figure 7 shows the trace time results. The Wilcoxon signed rank test was performed at a significance level of 5% to investigate whether each management method increased work time. Each management method with significant differences are marked with "*" in Fig.7. It was confirmed that tracing time was significantly longer only for the duplication and change point notification and duplication and near change point notification methods when the curvature was 14.610 and the rotation angle was 0˚. There are four possible reasons for the increased work time. First, visual feedback affected work time; however, other visual feedback methods have not been shown to increase work time. Thus, it is unlikely that this was the direct cause. Second, auditory feedback affected work time. This is also unlikely to be a direct cause because no other auditory feedback method has been confirmed to increase work time. Third, work time was affected by combining visual and auditory feedback. Although the map and change point notification and map and near change point notification methods appear to provide more information to users than the duplication and change point notification and duplication and near change point notification methods, no increase in work time was confirmed. Fourth, the system's sound notification timing affected work time. The sound notification was made when the current pen tip position was at the pre-registered coordinates; however, acquisition of the pen tip position may not have been stable. It is considered that the sound notification timing was delayed because the position acquisition was unstable and the user waited for the sound to be generated; thus, work time was extended. Whether or not the time increase is truly dependent on the system's notification timing must be verified. Therefore, we must develop a method to acquire the pen tip position in highly stable manner.

Figure 8 shows the user evaluation of the management methods. When the control group and each management method were tested with the Wilcoxon signed rank test with a significance level of 5% to investigate whether each method contributes to ease of work, it was confirmed that all methods (with the exception of the duplication method) were preferred significantly. It appears that duplication was not preferred because there was no information about the nib position. In addition, a comparison between the visual feedback only method (method (a)) and the combined visual and auditory feedback methods (i.e., methods (g), and (h)) confirms that the combined methods were evaluated highly. Comparing the change point notification (c) and near change point notification (d) methods showed no significant difference.

Relative to the results of the user questionnaire, four users liked the methods that combined visual and auditory feedback, and eight users gave the opinion that the duplication (a) method was meaningless. As well duplication (a) method is also not favored even in the results of nine-point Likert scale of user evaluation of management method. Relative to auditory feedback, five users commented that the near change point notification (d) method allowed them to recognize the distance to the change point. However, this method was meaningless for four users. It is considered that the above opinion was obtained because the curvature of the line could not be recognized even when sound was generated near the change points. We consider think that there was no significant difference in the 9-point Likert scale in the user evaluation of the management methods due to the divided opinions about auditory feedback.

Figure 9 shows the effects of hand occlusion summarized for each arrangement angle and curvature. To investigate the relationship between arrangement angle and hand occlusion, the Friedman test was conducted at a significance level of 5%, and a significant difference was observed. It was confirmed that the influence of hand occlusion increased as arrangement angle increased. According to the user questionnaire, tracing from left to right was difficult for four users, and seven users said that it was difficult to trace from bottom to top. Thus, as the placement angle increased, the trace work changed from left to right and from bottom to top (Fig. 10). Therefore, the influence of hand occlusion is considered to have increased for right-handed users. Note that there was no difference in the influence of hand occlusion due to the difference in curvature. In the user questionnaire, the following was found from six users: (1) a curve with a small curvature has a large area hidden by hand but can be complemented even if it is not visible; (2) a curve with a large curvature has small area hidden by the hand or is difficult to memorize and store a gentle curve. Thus, we consider that there was no difference in the arrangement angle in the influence of hand occlusion due to the differences in lines.

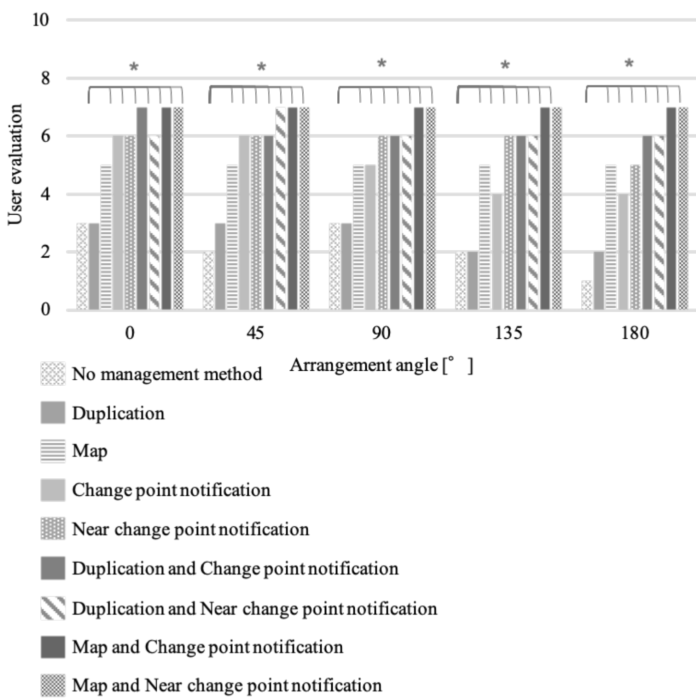

Fig. 8. Results of user evaluation of ease of drawing with each management method.

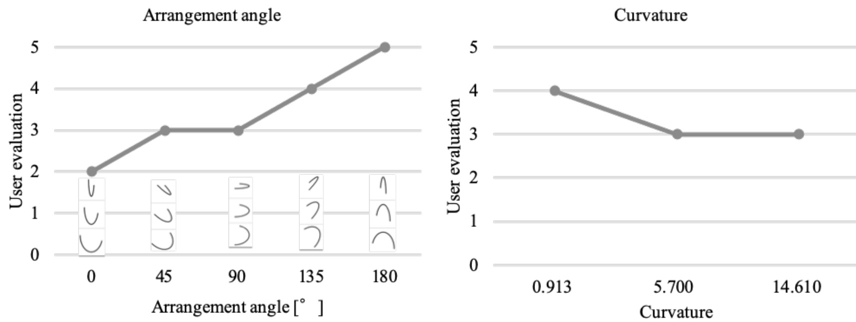

Fig. 9. Results of user evaluation of hand occlusion
Left: the effects of hand occlusion summarized for each arrangement angle. Right: the effects of hand occlusion summarized for each curvature

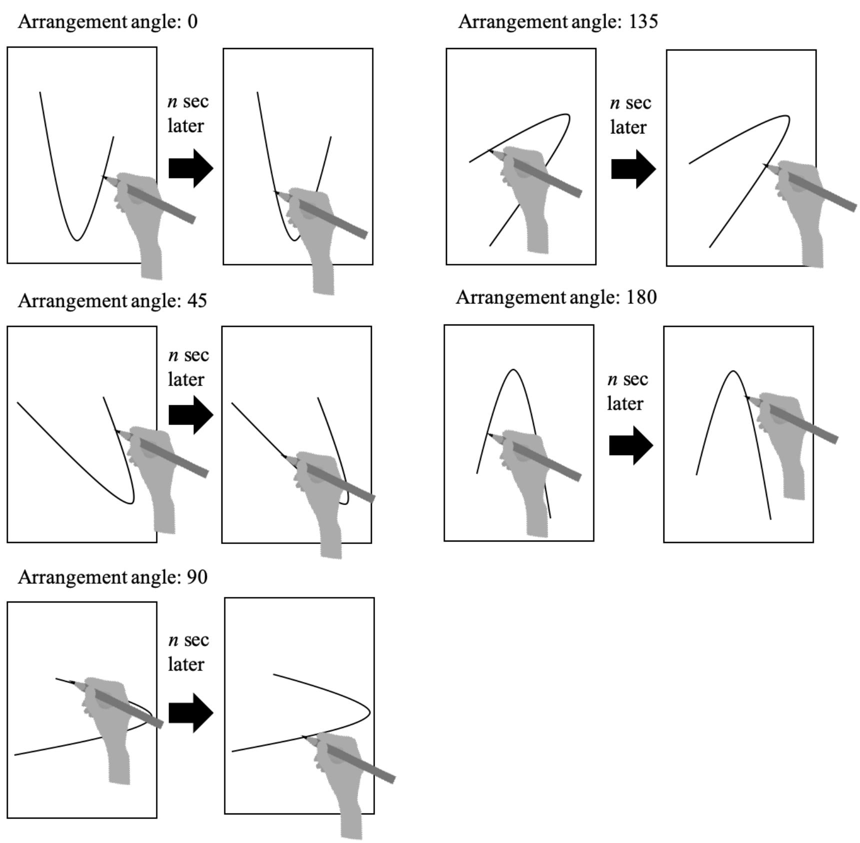

Fig. 10. Overview of hand movements based on placement angle

6 Discussion

In this paper, we have proposed hand occlusion management methods for a desktop work support system using a video projector. We evaluated the effectiveness of each management method. Relative to trace error, the effectiveness of the proposed method was recognized in some lines and arrangement angles. With the exception of the duplication (a) method, the effectiveness of the proposed method was confirmed in a user evaluation. The first reason for the difference in evaluation may be the acquisition of unstable pen position coordinates by Leap Motion. It is possible that the tracking position was shifted due to the way the users held the pen; thus, correct coordinates could not be obtained. In fact, two users stated that the current nib position in the map (b) method shifted occasionally. Therefore, it is necessary to reconsider how we obtain position coordinates. The second reason can be thought of as a gap caused by visual feedback. Three users stated that it was easier to write because there were visual feedbacks; however, they sometimes deviated from the line if they continued to see visual feedback. Since the frequency of viewing visual feedback varied depending on the user, in future, it will be necessary to detect and investigate each user's gaze. In addition, it will be necessary to further evaluate the proposed method it may be insufficient when the influence of hand occlusion is large. Three users felt that the auditory feedback was effective when the curvature was small and that the sound was meaningless if the curvature was large. This means that the line-tracing task was unclear when only sound notification was employed. Therefore, a new management method that allows the users to trace lines using only sound information will be investigated in future.

In order to find the difference in evaluation, we will review the detection method and management method of the pen position coordinates and detected the user's eye line. In the future, after overcoming the issues, we will not trace the work contents, but will verify the generality of knowledge by adapting to a wide range of work such as assembly work and soldering work.

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Michele Della Ventura, editor

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