Development and Evaluation of Gaze Tracking Integrated E-Learning Contents

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***Abstract*—No learning could take place without input attention. In order to promote students' attention in e-learning content, this study focuses on gaze tracking data as a kind of enhanced input. Gaze tracking integrated video and slide synchronized e-learning contents were developed and evaluated in the study. An eye mark is showed at e-learning contents to indicate where the teacher is explaining. A comparison survey is conducted. As a result, students' learning attention is promoted with gaze tracking data in e-learning.**

***Index Terms*—e-learning, gaze tracking, multimodal interface, learning attention.**

I. INTRODUCTION

Studies in the fields of cognitive science [1] and cognitive psychology [2] demonstrated that no learning could take place without input 'attention'. Researchers [3][4] have been trying to find methods to attract learners' attention. The methods such as textual enhancement, input flooding and processing instruction were employed by some researchers as a means of guiding students' attention toward the learning contents. Textual enhancement, for instance, highlights the forms to be noticed by using bold or uppercase letters, underlining, shadowing and different fonts. However, the advantages of textual enhancement over unenhanced input have not been clearly demonstrated [5]; some studies have reported no positive benefits whereas others have [6]. More studies are, therefore, needed to clarify whether enhanced input can trigger processes of giving attention. The current study is an attempt to contribute to both this line of research and multimodal input studies. In this study, gaze tracking integrated e-learning content is conducted. In addition, it seeks to determine whether learners find this kind of enhanced input effective in attracting attention and improving accuracy than other methods.

A. Gaze Tracking

Gaze tracking has been well researched in the field of human-computer interaction [7][8]. Gaze-based computer interfaces so far have often focused on using gaze as the input channel, for instance for eye-typing or for moving the mouse cursor for disabled persons [9]. Prior studies show that multimodal interaction using click activation increases the efficiency of gaze interaction with respect to gaze-based selection such as dwell [10]. Moreover, recent studies have shown that the performance of a low-cost gaze tracker compares well to the commercial gaze systems in target-acquisition tasks [11]. However, the accuracy of the measured point of gaze is problematic. Due to drifting, the practical accuracy is often worse. This means that selection of small items is hard by gaze.

In real world, we often use pointing devices to indicate the important point on the contents, for example, we cloud use a mouse or laser pointer to catch students' attention in classroom lectures. However most of e-learning contents are produced in a professional studio room. The teacher just has a lecture before a camera without students. Most of the time, there is no blackboard and laser point in the studio, since the low resolution by video camera. Instead, we use a touch panel to display and indicate the important points on the contents. In e-learning environment, students have no face-to-face communication with teachers; therefore they could miss some important information by just watching teacher's video. Even though the teacher could use touch panel to add handwriting memos in e-learning contents, we found little handwriting memos in our e-learning practice. As we mentioned gaze tracking could be used in target-acquisition tasks, we consider of using gaze tracking to promote students' attention in e-learning.

B. Purposes

The aim of this paper is to conduct a gaze tracking integrated e-learning content with accurate commercial gaze system (NAC Eye Mark Recorder EMR-8) and evaluate its effects to learners' attention. Since our eyes represent a natural substitute for the mouse, an eye-mark is showed at the gaze position on teaching slides to indicate where the teacher is teaching.

To our knowledge, gaze tracking integrated video and slide synchronized e-learning contents have not been researched. This pilot study is the first step towards promoting attention by gaze tracking. We believe this area offers a rich set of opportunities for future research and development.

II. DEVELOPMENT OF GAZE TRACKING INTEGRATED E-LEARNING CONTENTS

A. Previous Research

In order to verify enhanced input effects on promoting attention in video and slide synchronized e-learning contents, prior to the study, a questionnaire (see Table 1) was conducted on students' attention in handwriting memo integrated e-learning content. 16 participants were asked to learn a 20 minutes video and slide synchronized e-learning content which was integrated with teacher's handwriting memo such as underline, circle, and arrow (see Fig.1). Hand-writing memo can represent varieties of information, for example, to indicate the important point, the range of the contents or the position of where he is explaining.

Figure 1. handwriting memo integrated e-learning content

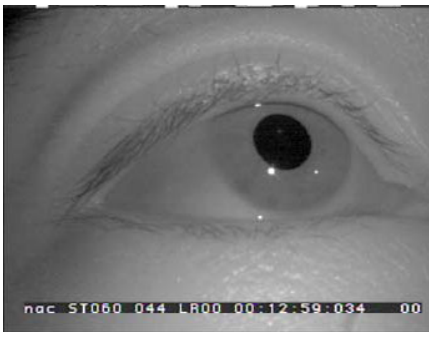

Figure 2. pupil detection

TABLE I.
QUESTIONNAIRE ON IMPRESSION OF HANDWRITING MEMO

Question items	M	SD
I think handwriting memo in e-learning content is important.	3.75	1.29
I became to concentrate on the positions of teacher's handwriting memo.	3.62	1.2
I am satisfied with teacher's handwriting memo.	2.94	1.06
I prefer teacher's handwriting memo in e-learning content.	2.87	1.2
I have a deep impression on teacher's handwriting memo	2.69	1.08
I became concentrate on the learning content	2.69	1.25
I became to know the key points of the content	2.69	1.25

The results of the questionnaire (5-scale question, 1 means not so much, 5 means so much) show that students think teacher's handwriting is important in learning(M=3.75, SD=1.29), and they became to concentrate on the positions of teacher's handwriting memo(M=3.62, SD=1.2). It is also showed that handwriting memo cannot result in a positive effect on understanding the key points of the contents (M=2.69, SD=1.25). In other studies, handwriting has also reported a positive effect on memory and teacher's presence [12]. It is also suggested that teachers should use different feedback strategies and offer appropriate types of feedback according to the level of students' proficiency in order to enhance their skills and learning motivations [12].

The results show that as a kind of enhanced input in video and slides synchronized e-learning content handwriting memo has positive effect on learning attention, but as a matter of fact, teachers have little handwriting memos on e-learning contents, since most of teaching contents are involved in e-learning slides, they do not need to write it again and some teachers said that handwriting sometime interrupt their teaching. Therefore, we consider using gaze tracking as an enhanced instead of handwriting input to promote students' attention.

B. *Task and Procedure*

The task of the study is to record teacher's gaze tracking data, and to integrate the data in e-learning contents to indicate where he is teaching.

C. *Eye-movement measuring*

First, teacher's eye-movements were recorded using a video-based eye tracker (nac:EMR-8). The teaching material (MS. PowerPoint) was displayed on a touch panel connected with a laptop computer positioned 60 cm from the teacher. The teacher could add handwriting memos on the slides with touch panel. Teacher's video, teaching materials and handwriting memos were synchronized with e-learning contents producing tool (CyberLink: StreamAuthor V4). The adjustment for pupil detection and calibration were conducted before recording (see Fig. 2). Eye-movement was tracked on a 1024 by 768 pixel screen at 60 Hz. The accuracy of the spatial resolution of this equipment is noted in the manufacturer's catalog as being a visual angle of 0.1 degrees (see Fig. 3). Since it is an accurate gaze tracking measuring equipment, we select it in eye-movement recording. Eye-movement coordinate data was recorded synchronously on another laptop computer as time course data, while teacher read the text content of each slide. The tracking data of teacher's eye-movement was recorded in 640 by 480 pixels and then it was converted into the same resolution with slides in order to overlay the eye-mark on the e-learning contents.

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;00000096,0,999,640,480,512,091,290
;00000097,0,999,640,480,512,092,293
;00000098,0,999,640,480,512,091,297
;00000099,0,999,640,480,514,091,295
;00000100,0,999,640,480,514,091,294
;00000101,0,999,640,480,516,091,295
;00000102,0,999,640,480,516,092,296
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Figure 3. Sample data of gaze tracking 2-9 digits mean time code, 29-35 digits mean right-eye movement coordinate

D. *Gaze tracking integrated e-learning content*

In order to duplicate the teacher's eye-movement, an eye mark of 30 by 30 pixels transparent gif is conducted by Adobe Flash. It could wink like a real person.

Since movement of mouse cursor could be recorded and showed on e-learning content by StreamAuthor authoring tool, in the study, we use the eye mark represent mouse movement. The gaze tracking data was converted into mouse movement data so that the eye-mark could be showed at the gaze position on teaching slides to indicate where the teacher is teaching. As most of the e-learning contents in our e-learning practice are recorded in a professional studio without students, the teacher just watches his teaching material displayed on a touch panel to have a lecture. When he moves his eyes inside the touch panel display, the gaze tracking data and time code (see Fig.3) could be recorded and converted into eye-mark moving data. When he moves his eyes outside the display, the over-data are recognized and there is no eye-mark displayed in the e-learning content (see Fig.4).

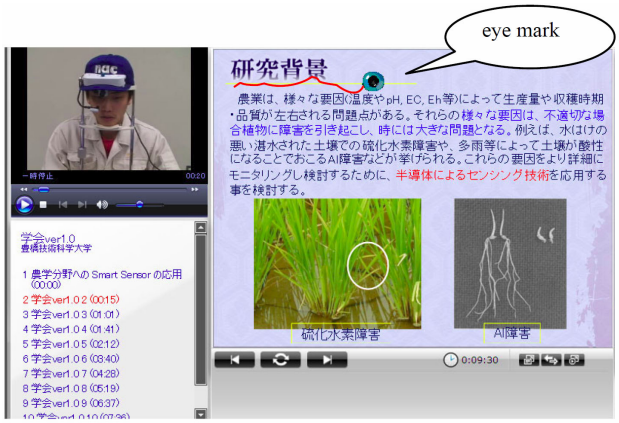

Figure 4. gaze-tracking integrated e-learning contents

III. EVALUATION OF GAZE TRACKING INTEGRATED E-LEARNING CONTENTS

A. Questionnaire

In order to evaluate the usability of the gaze tracking integrated e-learning contents and effects on promoting learning attention, a questionnaire was conducted with 21 students (see Table 2).

We got the same positive results of gaze tracking as previous research on handwriting. The students thought that gaze tracking in e-learning contents is important (M=3.67). They became to concentrate on the positions of the eye-mark which indicating the teacher's teaching position (M=4). They are satisfied with eye-mark integrated e-learning content (M=3.67). And they have a deep impression on teacher's eye-mark (M=4).

B. Comparison of Eye-mark and without Eye-mark e-learning content

In order to evaluate the different learning effects between gaze tracking integrated e-learning contents and general e-learning contents, the students were divided into two groups randomly. One group was asked to learn eye-mark integrated e-learning contents, and the other group was asked to learn the same contents without eye-mark. Then a questionnaire was answered by the two different groups (see Table 3). Group with eye-mark got a significant different effect than the group without eye-mark on question (1). I became to know where the teacher is teaching ($t(20)=2.49$, $p=0.017$), question(2). I became to know where the teacher is looking. ($t(20)=6.0$, $p=0.00$), and question(3). I became to concentrate on the learning contents where the teacher is teaching ($t(20)=3.41$, $p=0.002$)

The results of comparison survey show that, students could not know where the teacher is looking in no-eye-mark e-learning content (M=2.70). In contrast, as an enhanced input gaze tracking could attract learners' attention that could lead to understand the teaching position and improve understanding of the contents.

C. Limitations of the study

Since gaze tracking coordinate data (see Fig. 3) would be changed with little head movement, in order to get an accuracy data of eye-movement, in this study, we asked the teacher to wear a commercial gaze system on his head and his head was fixed on a stand. By fixing his head on the stand, we could get a reliable gaze tracking data for study, but it is discommodious to the teacher in video recording. Furthermore, the commercial gaze system used in the study is a high-accuracy device but too expensive. A low-cost gaze tracker and unfixed gaze tracker should be developed in later studies.

And some features of eye-movements should be extracted by trials and errors. Since the measured point of gaze has drifted a few pixels off from the actual focus point, it is difficult to place the eye-mark exactly on the desired location in the text material with drifted data.

Also, further study is needed to compare gaze tracking with other enhanced input such as handwriting and mouse in terms of learning efficiency and accuracy with large samples.

TABLE II.
QUESTIONNAIRE ON IMPRESSION OF GAZE TRACKING

Question items	M	SD
I think gaze tracking in e-learning content is important.	3.67	0.58
I became to concentrate on the positions of teacher's eye-mark.	4	0
I am satisfied with teacher's eye-mark.	3.67	0.58
I prefer teacher's eye-mark in e-learning content.	3.33	0.58
I have a deep impression on teacher's eye-mark	4	0
I became concentrate on the learning content	2.67	0.58
I became to know the key points of the content	2.67	0.58

TABLE III.
QUESTIONNAIRE ON COMPARISON WITH EYE-MARK AND WITHOUT EYE-MARK E-LEARNING CONTENTS

Question items	Eye-mark		No-eye-mark	
	M	SD	M	SD
I became to know where the teacher is teaching.	4.15	0.93	3.35	1.09
I became to know where the teacher is looking.	4.35	0.67	2.70	1.03
I became to concentrate on the learning contents where the teacher is teaching.	4.15	0.99	3.05	1.05

IV. CONCLUSION

In this study, in order to promote learning attention, gaze tracking integrated e-learning content was developed. Teacher's eye-movement was recorded and represented with a eye-mark to indicate where he is teaching. A questionnaire and a comparison survey between eye-mark integrated e-learning content and without-eye-mark e-learning content were conducted. As a result, gaze tracking integrated e-learning content could improve learning attention and understanding. This pilot study is the first step towards promoting attention by gaze tracking. We believe this area offers a rich set of opportunities for future research and development.

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