Animated agent to maintain learner's attention in e-learning

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Abstract: Long time learning tires learners, and then the learners' attention or concentration degreases. The author measured the learners' mental workload in e-learning using an eye mark recorder (Ueno 2004). Almost of all learners begin to feel some mental workload in e-learning 18 minute after they started to learn. The main idea of this paper is to propose an animated agent to maintain learner's attention during the learning. The animated agent provides some attention cues when the learners begin to feel some mental workload. Some experiments using the eye mark recorder in this study show that the proposed animated agent relieves the learners' mental workload.

Introduction

It is well known that the pupil size changes according to the viewer's emotional state or their workload (Hess E.H. and Polt J.M. 1964, Nakayama M. and Shimizu Y. 2002). Therefore, pupil size is often used as a measure; as an index of the emotional situation and mental workload (Kuhlmann J. and Boettcher M. 1999). The main idea of this paper is to evaluate some kinds of E-learning contents by using the Eye Mark Recorder and to improve the presentation method by using the results.

Motivation is essential to learning and performances, particularly in e-learning environments where learners must take an active role in their learning by being self directed (Lee, 2000). However, empirical data is lacking on how to positively effect self-directed learning and satisfy the motivational needs of learners (Visser and Keller 1990) Despite the importance of motivation to learning , less than one percent of papers in the international conference concerned with distance education focused on motivational issues between 1988-1995. Maslow (1970) defines motivation as psychological process where a behavior is directed toward a goal based on an individual's needs. Keller (1999) argues that although motivation is idiosyncratic, learner motivation can also be affected by external aspects. Visser (1990) reported that the motivational messages could reduce the rates of the dropout learner. Moreover, Visser, Plomp, and Kuiper (1999) intended to enhance the learners' motivation in e-learning situation by using motivated messages. Gabrielle (2003) applied technology-mediated instructional strategies to Gagnes events of instruction and showed the effects of the technology-mediated instructional strategies to motivation. The author also developed a data-mining tool which detects learner's irregular learning processes in order to support finding the learners who needs teacher's advices (Ueno 2003). Although this research, which is based on instructional design approach, emphasizes that the instructional method using motivational messages is an important factor to cultivate learners' motivation, it has not yet suggested how to develop E-learning contents which motivate learners enough.

On the other hand, some multimedia contents design researchers tried to improve learners' motivation and their performances by using multimedia contexts. Boyle (1997) proposed a systematic theoretical basis for educational multimedia design. According to Boyle, the central challenge for educational multimedia designers is creating interactive contents that promote effective learning. Bradley (2003) evaluated multimedia contents compared with text based contents. In this study, the animated contents were evaluated superior to the text contents in the questionnaires about usefulness. Botturi (2003) also provided results which show efficiency of the multimedia contents in the case of theoretical instruction. Mayer (2000) compared instruction methods using illustrations with instruction methods using words. The results show that there is significance difference in the questionnaires results between the two methods but there is no significance difference in the learners' performances. Mayers (2001) showed that animation with narration provides better performances. In all of these studies, conclusions have been reached by questionnaires, tests, or interviews, but the accuracy of the results must be questioned in a strict meaning.

The main idea of this paper is to evaluate e-learning contents (text contents, illustration contents, animation contents, and video clip contents) presentation methods by using the eye mark recorder in order to improve the contents presentation methods. This study proposes that the results gained by the eye mark recorder are more reliable. First, this paper compares the averages of learners' pupil sizes during learning various kinds of contents. The results show that animation and video clip contents are effective presentation method to derive learner's curiosity about instructional materials. In addition, this study propose an e-learning contents presentation method by using animation and an animated agent with various kinds of attention cues in order to relax the learner's mental workload in e-learning. The data obtained from some experiments shows that the proposed method is effective in easing the learners' mental workload in e-learning.

E-learning Contents

We have developed a LMS (Learning Management System) and provided many e-learning courses (see, for example, Ueno (2003)). Figure 1 is an example of the e-leaning content. The system presents the content by clicking the menu button which the learner wants to select. The sound data of the teacher's narration is also presented according to Mayer and Anderson (1991), and the red pointer synchronously moves. This course corresponds to a 90 minute lecture in university and includes 42 contents concerned with the structure of computer. Although the content in figure 1 is a text content, there are four kinds of contents in the contents data-base as follows; 1. Text content, 2. Illustration contents, 3.Animation or CG contents, and 4. video clip contents as shown in Figure 2. In this lecture, there are eleven text contents, eleven illustration contents, ten animation contents, and ten video clip contents.

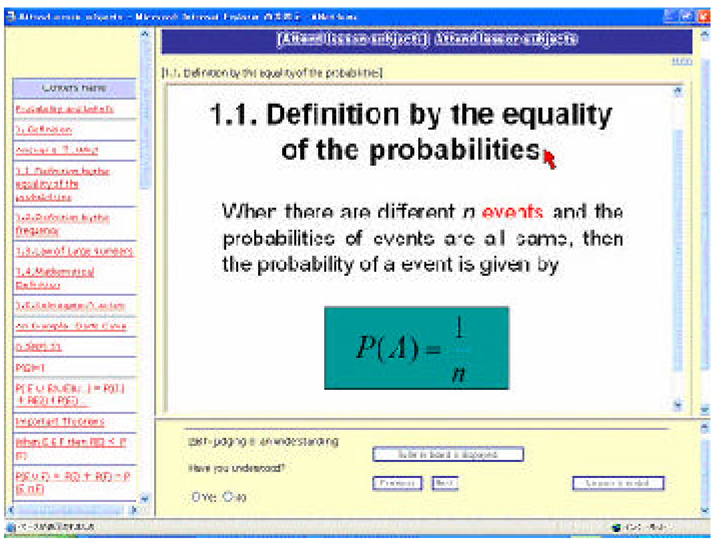
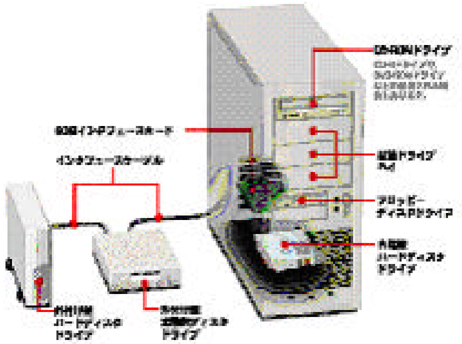


Figure 1. An example of LMS

Evaluation

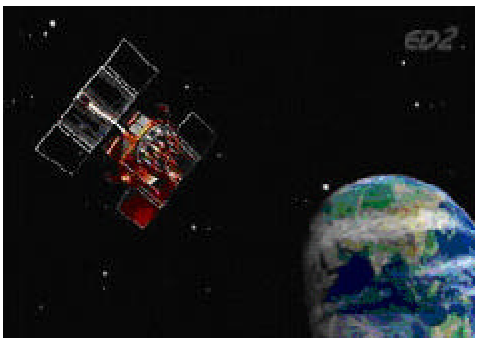
In this experiment, the eye mark recorder was used to measure learners' emotions and mental workload. This tool memorizes the points which the learner gazes at and the pupil sizes (the radius of the pupil) during his or her learning. It is well known that the pupil sizes reflect the learners' interests. It is reported that the pupil size becomes large when the object is interesting for a viewer and the pupil size becomes small when the object is not interesting for the viewer. For example, Nakayama and Shimizu (2002) evaluate some TV programs by using the pupil sizes characteristic. Thus, in the case of evaluation of e-learning contents, the pupil sizes are considered to reflect the learner's interests for the contents. From observation of learners' behaviors in e-learning situation, it is often shown that learners sometimes gaze at other points besides the contents. Accordingly, the time learners gazed at the contents was also measured in this experiment. Thus, the rate of time the learner gazes at the content is given by

$$\frac{\textit{The time the learner gazes at the content}}{\textit{The total time the learner has the content file open}}.$$



(a) Illustration Content

(b) Animation Content



(c) Video Clip Content

Figure2. Examples of various kinds of E-learning multimedia contents in this study

In this experiment, twelve learners learned by using the e-learning system, and their pupil sizes and the movements of their eyes were measured as shown in Figure 3. The results are shown in Table 1. Here, the average sizes of the learners' pupil and the averages of the rates of time the learners gazed at the contents can be seen. From the results, it is found that the significance statistical difference of the pupil sizes averages between text contents and the other contents and the significance statistical difference of the averages of the rates of gazing the contents between the (text or illustration) contents and the (animation or video clip) contents ($a = 0.05$) .

Now, we assume that the pupil size reflects the learner's interest, and so the illustration, animation and video contents are important for inducing the learners' interest. This result means that visualization of content tends to induce the learners' interest.

In addition, the following questionnaire was provided to the learners after their learning.

"Which method do you think is the best presentation method?"

The results are that 54% of the learners answered "animation", 22% of learners answered "video", and 24% of the learners answered "illustration". These results are the same as the reported papers before (for example, Bradley (2003), Botturi (2003) and Mayers (2001)). The results from the eye mark recorder show that there is no difference between illustration content, animation content, and video content. The reason is that the questionnaire results tend to be effected by learner's impression to the media. In fact, almost all previous studies reported that there were no significance deference in learner's performance (test score) between illustration contents, animation contents, and video contents. That is, the main effect depends on whether the content is visualized or not.

On the other hand, the results of the averages of the rates of the time how long the learners gazed at the contents are considered to reflect the characteristics of each media. The rates of gazing time of animation or video contents are higher than ones for text or illustration contents. From interviews with the learners, the following reasons are obtained:

- Text or illustration contents never change. The learners can read it faster than the speed of the narration, and then they sometimes do not listen to the narration.
- Animation or video contents always change, so the learners must gaze at the contents until it finishes.

This means that animation or video contents have a characteristic of keeping the learner's attention in the sense of the learner's pure curiosity about the instruction materials.

Figure 3. An example of experiments situation

Table 1. Learners' pupil sizes averages and the rates of gazing the contents during their learning

	Text contents	Illustration contents	Animation or CG contents	Video clip contents
the pupil sizes averages	2.49	2.98	2.96	2.97
The averages of the rates of gazing at the contents	62.82%	64.34%	74.85%	77.54%

Mental Workload in e-learning

In the previous section, we considered the media characteristics of each media. However, how mental workload effects e-leaning hasn't been considered previously. Long time learning in e-learning tires the learners, and then the learners' attention or concentration degreases. Here, we are concerned with how long the learner can continue to learn in e-learning and how to relieve the learners' mental workload in e-learning. The pupil size reflects the mental workload as mentioned before. Figure 4 shows an example of the time series of the pupil size changes of a learner in e-learning. The figure shows that the learner's pupil size became smaller 15 minute after he began to learn. The data about the other learners shows a monotony decreasing curve as same as Figure 4. This means that any learners' attention or concentration in e-learning decreases. The next question is "how long do learners continue to learn in e-learning? ". To answer this question, this study employs a data-mining method by using MA (Moving Average) method (see V.Barnett and T.Lewis, (1994)). By applying the MA to each learner's time series data of the pupil sizes data, we try to detect the time when the learners begin to feel mental work load in e-learning.

The MA in this analysis uses the average of five seconds data in the time series of the pupil sizes data. In order to detect the time when the learners begin to feel mental work load in e-learning, the statistical test (t-test) is employed. That is, each pupil size data is tested as a outlier compared with previous sequences of data (see, for detail, Ueno 2003) .The statistical test was executed for each learner's data with the significance level 0.01. The frequency distribution of the detected learners' pupil size derived from the t-test is shown in Figure 5. From figure 5, it is known that the learners' pupil sizes began to change, about 18 minute after they started the learning. Furthermore, it should be noted that the time when the learners pupil sizes begin to change is about 36 minute after they started to learn. All of this amounts to saying that the learner began to feel some mental workload about every 18 minute.

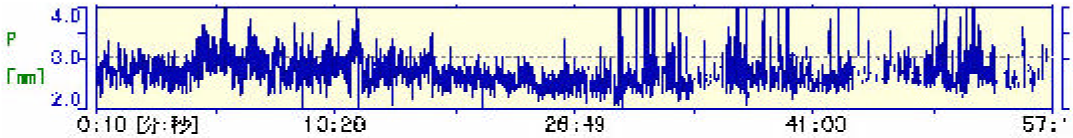


Figure 4. An example of the time series of the pupil size changes of a learner in e-learning

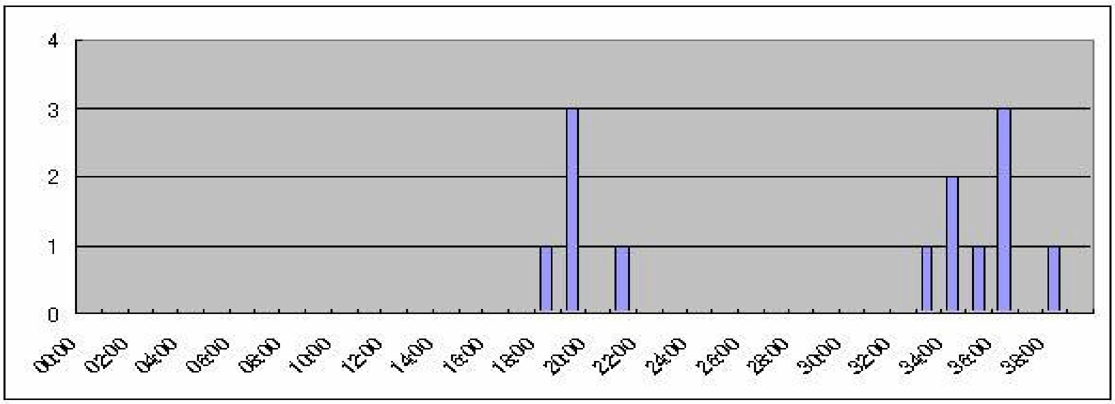


Figure 5. The distribution of the detected pupil size changes of a learner in e-learning

Figure 6. Animated agent

Figure 7. An example of Attention Cue

Animated Agent and Attention Cue

Although it seems very difficult to ease the learners' mental workload in e-learning, it is considered worthwhile trying. The main idea of this paper is to introduce an animated agent to enhance learner's attention to learning.
In this experiment, animated agent as shown in Figure 6 is employed in the contents. The animated agent acts as a virtual teacher using the teacher's narration. Furthermore, 18 minute after the learner started, the animated agent provides an attention cue as shown in Figure 7. After that, the other kinds of cues are presented every 10 minute. There are some kinds of attention cues prepared as shown in Figure 8, and the system presents one of cue by using random number. The attention cue is expected to refresh learners in e-learning. Eight new learners participated in this e-learning experiment, and the same experiment as the previous experiment by using the eye mark recorder was provided.

Figure 9 shows the time series of the pupil size changes of a learner in the e-learning using this animated agent. It is shown that the learner's pupil size is maintained during the learning. By using the previous data mining method by using the MA, there is no detected pupil sizes data as a statistical outlier from t-test

In addition, we have to consider the averages of the pupil sizes and the averages of the rates of gazing at the contents for each kind of content. The results are obtained as shown in Table 2. From statistical test , the significance statistical difference of the pupil size averages between text contents and the other contents, the significance statistical difference of the averages of the rates of gazing the contents between the (text or illustration) contents and the (animation or video clip) contents are found ($a = 0.05$). These results are the same as the previous experiment without the animated agent, but it should be noticed that the averages of the pupil sizes and the averages of the rates of gazing at the contents for all kinds of media show larger values than the results of the previous experiments without an animated agent. Therefore, the results show that an animated agent with some attention cues is effective in refreshing learners during e-learning.

Furthermore, it can be said that the results obtained from this experiment are more reliable than the previous experiment results. The reason is that the previous experiment results implies some influences of the learners' mental workload but the later experiment results were hardly effected by the learners' mental workload.

Table 2. Learners' pupil sizes averages and the rates of gazing the contents during their learning

	Text contents	Illustration contents	Animation or CG contents	Video clip contents
the pupil sizes averages	2.93	3.18	3.15	3.16
The averages of the rates of gazing at the contents	79.82%	79.34%	89.85%	92.54%

Figure 8. Examples of the Attention Cues used in this experiment

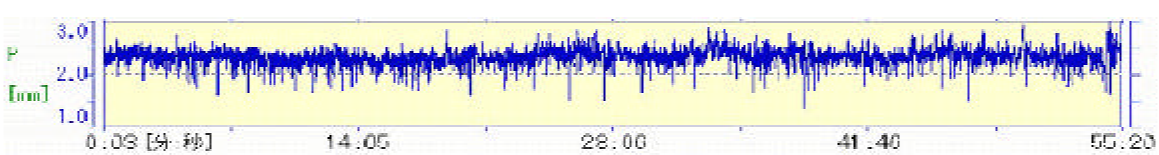


Figure 9. The time series of the pupil size changes in e-learning using animated agent

For example, the pupil sizes averages and the averages of the rates of gazing at the contents for text contents are statistically low compared with statistical averages data for the other kinds of contents in table 1. However, the results in table 1 are strongly effected by the learners' mental workload as shown in figure 5, for example, if almost all text contents are presented to the learners at the end of the course, the results are strongly effected by the learners' mental work load. Opposing this, the results in the table 2 are more reliable because they are not effected by the students' mental workload as shown in figure 9. In addition, the important point to note is that all numerical values in table 2 are higher than corresponding numerical values in table 1. The reason for this is also that attention cues in the results in table 2 were effective at relieving the learners' mental workload.

Thus, the results show that the animated agent with some attention cues is effective at refreshing learners in e-learning.

Conclusions

This paper proposed an E-learning contents presentation method based on an animated agent with some attention cues in order to relax learners' mental workload in e-learning.
The results obtained in this study can be summarized as follows:

- Almost all learners begin to feel some mental workload, 18 minute after they started their learning.
- The attention cue provided from the animated agent when the learners begin to feel some mental workload is effective to maintain learner's attention in e-learning. And the actual experiments results show the effectiveness of proposed method to relax learners' mental workload in e-learning.
- The statistical test shows the significance difference of the average sizes of the pupil between text contents and the other contents.
- The statistical test shows the significance difference of the averages of the rates of gazing at the contents between the (text or illustration) contents and the (animation or video clip) contents.

This study has not sufficiently discussed whether measured pupil sizes are affected by the learner's interest or mental workload, it is a future task.

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