Implementing Eye-Based User-Aware E-Learning

We propose an e-learning scenario where eye tracking is exploited to get valuable data about user behavior. What we look at — as well as how we do that — can in fact be used to improve the learning process, revealing information which would otherwise remain hidden. The eLearning project takes into account both the user’s “emotional states” and the way learning activities are carried out, employing such data to adapt content presentation in real-time.

The offer of e-learning courses is increasing at an unrestrainable pace. However, the learning experience is often perceived by the user as a one-way communication process, where the “emotional” part of the interaction characterizing the relationship between teacher and learner is totally missing. In a computer-mediated tutoring system, eye monitoring can disclose important information concerning what the user is doing, as well as interesting data about how and when certain actions are being (or have been) performed.

Monitor of accessed screen areas

The author of the e-learning course can decide “how much attention” the user must pay to certain portions of content.

In our prototype, a course is made up of web pages. Through an ad-hoc-built web browser, the author can define screen rectangles — corresponding to relevant pieces of content — and impose (through a dialog box) constraints on them.

For textual areas, the system tries to understand whether they have been actually read by the user. For non-textual elements (e.g. images or animations), the course author simply specifies how much time the user should look at them.

History recorder

The History recorder module relies on the Monitor of accessed screen areas and keeps track of which portions of content (defined by the author) have been accessed by the user, as well as “how much”.

When the user presses the ‘Next’ button to load the next page in the course, if in the current page there are portions that have not been fully read/observed, the system emphasizes them by means of colored rectangles.

Contextual content generator

The creator of the course can associate new content to rectangular screen areas, and indicate the requirements for the additional information to be displayed.

Requirements are typically the minimum number and length of eye fixations inside the areas, or, for text portions, the detection of a reading process.

"Emotion" recognizer

Several studies (mainly carried out in the Psychology and Physiology fields) have found correlations between eye behaviors and emotional states. Within regular time intervals, we consider the number of blinks $n_b$, the number of eye fixations $n_f$ and the arithmetic mean of pupil diameters $p_d$. We try to identify two main user conditions:

1. **High cognitive load** and/or understanding problems

   - if between two successive time intervals a decrease of $n_f$, an increase of $n_b$ or an increase of $p_d$ is noted, then the user may have gone through a high workload or non-understanding phase; the occurrence of more than one of these cases can be considered a further confirmation of that.

2. **Tiredness**

   - considering a certain number of successive intervals $n_{fix}$ lasting a certain time $t$ (e.g., 2 minutes), for each one of them we compute $p_d$ and $n_f$: if the last $n_{fix}$ values obtained for $p_d$ are monotonically increasing, then this may be interpreted as a tiredness sign. To confirm such a possibility, we check if also the last $n_{fix}$ values obtained for $n_f$ are monotonically increasing.

The aim of the eLearning project (enhanced exploitation of eyes for effective eLearning) is to implement an e-learning environment characterized by four main components: a monitor of accessed screen areas, a history recorder, a contextual content generator and an “emotion” recognizer.
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We propose an e-learning scenario where eye tracking is exploited to get valuable data about user behavior. What we look at – as well as how do we do that – can fact in fact be used to improve the learning process, revealing information which would otherwise remain hidden. The eLearning project takes into account both the user’s “emotion states” and the way learning activities are carried out, employing such data to adapt content presentation in real-time.

The offer of e-learning courses is increasing at an unmeasurable pace. However, the learning experience is often characterized by a monolithic communication process, where the “emotional” part of the relationship characterizing the mediatrice between teacher and learner is totally missing.

In a computer-mediated learning system, eye monitoring can disclose important information concerning what the user is doing, as well as interesting data about how and when certain actions are being performed.

Monitor of accessed screen areas

The author of the e-learning content can decide “how much attention” the user must pay to certain pieces of content. In our prototype, a reader is made up of web pages. Through drill and task (which will be the user’s cardinal screen objects), the system imposes (through a dialog box) constraints on them.

For textual areas, the system tries to comprehend elements that have been actually read by the user. For non-textual elements (e.g., images or multimedia), the course author explicitly specifies how much time the user should look at them.

History recorder

The history recorder module logs the monitor of accessed screen areas and keeps track of which parts of content (defined by the author) have been accessed by the user, as well as the time spent on them.

When the user presses the “Next” button to load the next page in the reader, if in the current page there are contents that have not been fully displayed, the system emphasizes them by means of colored rectangles.

Contextual content generator

The creation of the course can associate new content to reconfigure screen areas, and to instruct the requirements for the additional information to be displayed.

The system is responsible for the minimum number and length of eye fixations inside the areas, or, for textual portions, the detection of a reading process.

“Emotion” recognizer

Several studies (mainly carried out in the Psychology and Physiology fields) have found correlations between eye behaviors and emotional states.

It has been found that successful learners have a high degree of attention to visual stimuli, while lower-achieving learners have a lower degree of attention. A recent study [2] indicates that students who score higher on the Attentional Awareness Scale (AAS) tend to have higher academic performance.

To identify these factors, we consider the number of times, the number of eye fixations, and the amount of pupil diameter. We try to identify these main user conditions.

1. High cognitive load and understanding problems
   - If between two consecutive time intervals a decrease in the number of eye fixations is observed, then the user needs a better understanding.
   - If the number of eye fixations remains high or increases, then the user needs a higher level of understanding.

2. Persistence
   - Considering the number of consecutive intervals during a certain time (e.g., 2 minutes), for each one of these intervals we compute the time of fixation for each eye.
   - The number of times this value is obtained for the same eye is considered.
     - If the number of times the value is obtained for the same eye is constantly increasing, then it is possible to infer that the user is focusing on the same area of interest.
     - If the number of times the value is obtained for the same eye is constantly decreasing, then it is possible to infer that the user is no longer focusing on the same area of interest.