CONCENTRATION TESTS

An Application of Gaze Tracker to Concentration Exercises

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Abstract: This paper presents different methods of concentration tests. Some existing methods are reviewed and more thoroughly described. The gaze tracking system developed at the Multimedia Systems Department of the Gdańsk University of Technology is presented and its principle of working is explained. Performed tests of the gaze tracker system show that it could make a useful system for concentration exercises. Some selected applications of the gaze tracker to concentration tests are also discussed in the paper.

1 INTRODUCTION

Nowadays, people are attacked by information constantly. Children are even more susceptible to media exposure because they are not critical in their perception. Consequently, many of them cannot concentrate on one activity. Therefore, a method of exercising concentration was proposed by the Multimedia Systems Department (MSD) of Gdansk University of Technology. This approach consists in using an inexpensive gaze tracking system developed in the MSD. The gaze tracker is a tool which allows for tracking eye movements and for estimating a localization of the fixation point that is a point a user is looking at the computer screen. This paper describes shortly some existing methods of concentration tests, then presents the gaze tracking system developed at the MSD and points out its potential as a practical and easily accessible tool for concentration exercises.

2 EXISTING METHODS OF CONCENTRATION TESTS

For many years people have tried to develop methods of concentration enhancement. Concentration tests could be reviewed in many aspects. One of the approaches is an analysis of the attention level which helps checking if a user is not tired or sleepy. Other tests are used to select a person who needs to process information in a systematic way accurately. Another group of concentration tests enables to develop skills and possibilities of autistic children and those affected by the ADHD (ADHD - Attention Deficit/Hyperactivity Disorder).

2.1 Standard Tests

In the Internet we can find many interesting exercises, applications and movies which could be helpful in concentration tests.

Some methods consist in ability to perform tasks at the same time or while solving a logical task. One of the examples of such a method could be an application described below. There is a matrix with values from 0 to 3 as shown in Fig. 1a. A user should set all values (buttons) to ‘0’ but when he/she chooses one button, then its value and values of four neighboring buttons are decreased by ‘1’. This is shown in Fig. 1b. When a user sets all values faster, he/she scores more (BM, website).

a) b)

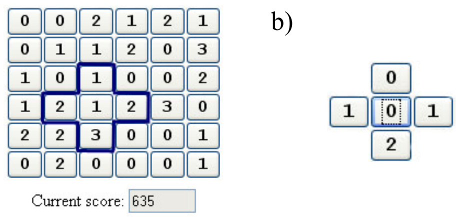

Figure 1: a) Matrix with input values; b) Chosen part of matrix with updated values (BM, website).

Other methods available in the Internet are some interactive games. An example of this approach is

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the Supermarket Game. It is basically a labyrinth that must be traversed while the player acquires items shown in the shopping list. An additional restriction is that the player can cross most of the paths only once. The game includes specific rules and challenges that allow for scoring positively, by acquiring a correct item, or negatively, in case the player commits a fault by breaking one of the rules. An important criterion is the elapsing time (Andrande et al., 2006).

2.2 Specialized Tests

There are concentration tests that focus on autistic children and those affected by the ADHD. Methods used in that area are more complex and typically may require more hardware equipment.

Most systems dedicated to children with neurological disorders are based on processing EEG signals (Electroencephalography). EEG signals contain information on electrical potentials in various parts of the brain, thus they are the recorded electrical activity of the brain.

3 GAZE TRACKING TECHNIQUE

As mentioned in Introduction, the gaze tracking system engineered at the MSD enables to track fixation point on the computer screen. The current version of the system works correctly with definite space resolution. It is assumed that the gaze tracker system may be applied to concentration exercises (Czyzewski et al., 2008).

3.1 System Description

The gaze tracking system developed at the MSD is based on infrared (IR) illumination. Lighting IR LEDs cause arising characteristic corneal reflections, technically known as “glints”. Glints are usually the brightest points in the image. They form a shape of quadrangle because they are created by four sections of LEDs located in four display corners. Also, localization of glints is characteristic. They are localized in the iris and the pupil. The pupil is always very bright because of IR LED illuminator beaming light along the camera optical axis. Therefore, contrast between the brightness of the iris and pupil is relatively large, therefore finding area with glints is possible. All data gathered are used in the eye detection procedure and they are usually sufficient to detect eye regions correctly. Processed images are recorded in grey scale because they were IR-illuminated. The hardware configuration of the developed gaze tracker system along with the detected region of eye are presented in Fig. 2.

a)

b)

Figure 2: a) System configuration of the gaze tracker developed by the MSD; b) Part of the image with the detected eye region.

The main assumption of the gaze tracking system is hands-free application. The second assumption concerns the head position. A user should sit in front of the screen at a distance of about 60cm. The system does not require to be seated very still but the user should try not to move his head too much. The latter assumption is connected to the system accuracy. The space resolution of the system, also associated with the accuracy, amounts to 9 parts of the screen. In fact, the gaze tracker works correctly and discerns each of 9 areas with a sufficient accuracy.

3.2 Results and System Accuracy

The current version of the gaze tracking system is unaffected by different eye colors and small head movements. Influence of light conditions on correct working is described below. Tests were organized in real conditions involving 50 persons. Results of these tests are presented in Fig. 3.

The lens used had a focal length of 16mm and the chosen image resolution was 800x600 pixels.

The outcome of the tests indicates that gaze tracking system engineered in MSD allows to apply this technology in concentration tests. Group of 50 persons was tested in equal conditions. Results of person who reached the worst effectiveness were characterized by more scattering than results of person who reached the best effectiveness. Moreover, some regions were detected incorrectly what is not seen in this picture (Fig. 3). The cause of the effectiveness differences could be light conditions or too large head movements.

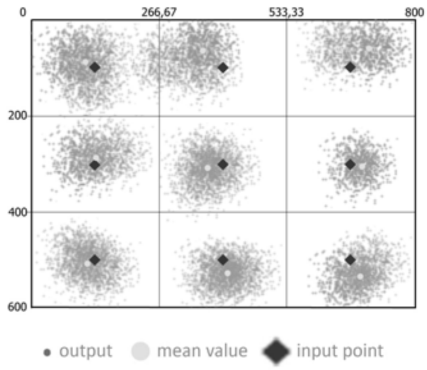

Figure 3: Gathered outcome of the worst, normal and the best results of tested persons.

It is proved that additional infrared emission, contained in sun radiation, disturbs the gaze tracker based on infrared illumination. Therefore, the gaze tracker depends on light conditions, unfortunately.

Nevertheless, the gaze tracker could be regarded as a promising solution for concentration tests, particularly in systems with space resolution of 9 areas per screen.

4 GAZE TRACKER IN CONCENTRATION TESTS

4.1 Concentration

The gaze tracking system could be applied in two types of concentration tests. Firstly, a user is engaged in an exercise, i.e. it is an interactive activity. For example, he/she tracks the moving object (as shown in Fig. 4). The second type is the tracking of the user's passive activity. He/she can read a text or watch objects on the screen and the gaze tracking system analyzes the fixation points in real time.

It is worth to mention that concentration is related to the commitment of a user, enthusiasm for the task, skills to perform the task, psychological and physical state and environment (UC, website). Therefore, the problem of concentration tests is more complex, and fully measurable.

4.2 MSD Concentration Test

There are many research studies associated with applying eye tracking methods to improvement of the learning process. An example of this is *AdeLe*, a framework for adaptive e-learning using eye tracking technology. The *AdeLe* utilizes the commercial eye tracking system *(Tobii 1750)*. It enables to obtain a very high accuracy and it is unaffected by eye changes (e.g. blinking), head movements and light conditions. Therefore, *AdeLe* has more possibilities of the concentration monitoring. It is possible to measure a saccadic velocity, blink velocity and the degree of the eyelid openness. Saccadic velocity is said to decrease with increasing tiredness and to increase with increasing task difficulty (Pivec et al., 2006).

Effectiveness of the gaze tracking system, developed in MSD, is lower than *AdeLe* but its functionality could be useful in improving methods of concentration exercises as well. The MSD proposes some applications cooperating with the gaze tracking system. They are directly associated with time measurement. Two of them have been currently engineered and tested. It is worth to mention that the gaze tracking system is calibrated for each user therefore not looking at the screen is detected as well.

The first application is based on the redeveloped version of one of the methods based on animation, described in Section 2. The main idea of this exercise is looking at the indicated object in the image and gaze-tracking it. The application enables to choose one of two options: smooth/sudden and random changes of the object movements. The user is distracted by other objects which move in the image freely. A change of game levels is possible. In the easiest configuration distracting elements move relatively slow. The most difficult level contains quickly moving and flickering objects. An additional difficulty is the moving background. During each exercise time of the object being correctly tracked is measured. A so-called 'concentration ratio' (CR) computed according to formula (1) can be determined:

$$CR = \frac{t_{CF}}{t_T} \cdot 100\% \qquad (1)$$

CR – concentration ratio;

t_{CF} – time of correct fixation (when the user tracks an object correctly);

t_T – total time of exercise.

An example of the screenshot of the application interface is shown in Fig. 4.

Figure 4: An example of the screenshot of the user interface; the bee is the tracked object.

The second proposition of application is slightly similar to creating a visual heatmap. A visual heatmap is a graphical representation of the distribution of screenparts observed by the user. The frequency of looking at the objects in the image generates colors – from blue (the most infrequent) to red (the most frequent). This application does not force a user to constant concentration but check what elements of the given image are more interesting than the others. This approach enables to find out how long the user can concentrate on one object and how often he/she changes a direction of looking. The map of transitions is generated in order to visualize these changes. A therapist can observe a heatmap generated in real time or screenshots with heatmaps after finishing a test. The project of the graphical interface of this application with an example of the visual heatmap is shown in Fig. 5.

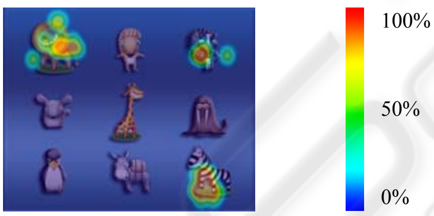

Figure 5: An example of the visual heatmap.

5 CONCLUSIONS

Nowadays, concentration tests become more frequent, and they are often used in education. Paying attention is a skill that is very important during the learning process and the career development as well.

The rapid development of multimedia technologies enable to apply interactive methods in concentration exercises. The existing *AdeLe* framework is directly connected to using expensive eye tracking system. Therefore, its common usage is still impossible. Initial tests of gaze tracking system proposed at the Multimedia Systems Department allow for regarding this system as a promising approach of modern solution to the concentration exercises. Children who were tested with this interface very easily and correctly understood and follow all guidelines. Besides, working with the gaze tracker was pleasant for them. Thus, a game-like exercise with such an interface could be very pleasant for a child and at the same time may be an attention examination tool for parents or therapists.

Even though applying the gaze tracking system in concentration tests is not a fully objective measure because it doesn’t e.g. examine commitment of the user, enthusiasm for the task, skills to perform the task, psychological and physical state and influence of environment. However it may be treated as a tool allowing for exercising children’s concentration.

The research on gaze tracker carried out at the MSD directs to increase its usability in other applications in which the attention/concentration assessment is needed.

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