

# Application of eye-tracking to analyze a computer exam test

Tibor Ujbanyi, Gergely Sziladi, Jozsef Katona and Attila Kovari

**Abstract** From human aspect, several cognitive factors can be determined, which can be examined by modern engineer tools thanks to the technical development. Motivation introduced in the article was provided by the opportunities of observation cognitive processes related to learning by engineering tools. By measuring the motion of human eye, visual attention, thus some hidden cognitive processes may be revealed and examined. Research performed in the article shows, that during solving a task, parameters describing eye motion correlate with the testing subjects prior knowledge regarding the actual topic. The results provide useful information in control and examination of learning process, so these devices and methods may become an organic part of futures educational infrastructure.

## 1 Introduction

Such science field deals with human-computer interaction, which includes design of interactive computer systems made for humans, and studies main relevant phenomena. In human-computer interaction, such tools play a major role, which are used for controlling computer systems. Design of computer systems is achieved by such (traditional) input peripherals, like keyboard and mouse. By technical development, control features (a command or click) can be achieved by alternate solutions, like eye-motion based control, which opens brand new possibilities in human-computer communication. From human look, several parameters can be learnt, and it is also much more informative, than pure motion of the mouse (and a click), or pressing a

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Tibor Ujbanyi, Gergely Sziladi, Jozsef Katona  
University of Dunaujvaros, Tancsics M. u. 1/A, Dunaujvaros H-2401 Hungary  
e-mail: katonaj@uniduna.hu

Attila Kovari  
University of Dunaujvaros, Tancsics M. u. 1/A, Dunaujvaros H-2401 Hungary  
e-mail: kovari@uniduna.hu

control button on the keyboard. In human-computer connection, human behaviour, interaction between the two parties plays a major role. Interaction between human and the computer may be examined in several forms, whether we are talking about brain activity, gestures or eye motions.

Motivation performed in the article was gained from opportunities of observation of cognitive processes by engineering tools. Measurements are performed not by research methods common in pedagogy, but by the support of a destination hardware-software based on eye tracking and manual gesture control. This way, we can get more accurate image about the correlation of eye- and hand moving processes, and we may reveal connections between them. By tracking human eye motion, visual attention can be defined, thus some hidden cognitive processes can be revealed and examined. Basics of eye-tracking researches are defined by observations based on eye-tracking. By examination of eye motion, geometric location of visual focal point can be defined during watching an object. By measuring eye motion, way of look can be defined, as well as which details remain focused on a bit longer. Based on these parameters, it can be examined, how visual stimuli correlate with the performance of a concrete task, which can not be analysed with other methods. Processes introduced above, are influenced by visual information detected by the eye, connections between them have a great importance. Important element of cognitive processes is human learning, where the most important information sources are visually observed and detected information. Thus, in the observation of learning process, eye-tracking systems give such new opportunities, which enable much wider range of examinations for current and future researches, compared to those, which are already available.

### ***1.1 Role of eye motion in the observation of cognitive processes***

As we have already referred, in human-computer relation, as a context between two systems, human behaviour, interaction plays a major role, which may be examined in different ways, whether through brain activity [1], [2], gesture [3], or even eye motion [4]. Human-computer interaction itself deals with such a science field, which covers design of interactive computers made for humans, and studies main relevant phenomena [5]. Importance of eye-tracking examination is that computer users receive most information via visual stimuli, as information channels [6]. Examination of human eye motion is also useful, that by the measurement of eye motion, defining visual attention, less examinable, hidden cognitive processes can be indirectly figured out.

## **2 Parameters of eye motion, methods and tools of eye-tracking**

The goal of eye-tracking is to define the geometric location of users visual focal point, so it shows, what and how long do we watch, observe. By measuring eye motion, it can be defined, what pattern, way does the look follow, and on what details does it spend longer time, on which frequency. These data may provide detailed information, how do users perform a task or activity by using visual stimuli, like searching, reading, viewing images, or even a walk, car drive, which could be less observed by other methods.

### ***2.1 Eye-tracking***

It can be observed in photography in many cases, that some photographers take much better pictures with the same devices and equipment than others. What could be the reason of that? The technology is the same, but the quality of the images are different. Then where should we search the reason of difference? Dealing with the question more thoroughly, process of image taking shall be examined. Before the photographer takes a picture, he looks around, what region of the field of view should he capture. When location of this zone is ready, he holds the camera in front of him, and by directing the focus on the selected area, takes the picture. So the key of the solution is the human factor in this case, the photographer himself. When looking for the reason of difference, we have to examine, on what points are the photographers attention aimed at, when taking pictures. The so-called eye-tracking deals with this phenomenon, which is the tracking of eye motion itself.

### ***2.2 Motoric operation of eye motion, as a vision system***

In the operation of vision system, positioning of looks direction, focus is performed by eye muscles, that viewed image shall be projected on the location of sharp view, the fovea centralis. Motion of eyeballs may happen consciously by directing them on the selected area of interest, then keeping in the field of view is performed primary by spontaneous eye motions. If we fix a still object, then eye performs spontaneous eye motions. This motion may be 3080 Hz frequency tremor, slow floating motion, when the image of fixed object slowly passes in front of the fovea, or quick reflex motion, after the image of the examined object is projected on the fovea again. When the look follows a fast moving object, during reading, recurring observation of image details, the eye fixes the image again and again. Between fixation points, the eye performs quick, spontaneous eye motions, the so-called saccades [7].

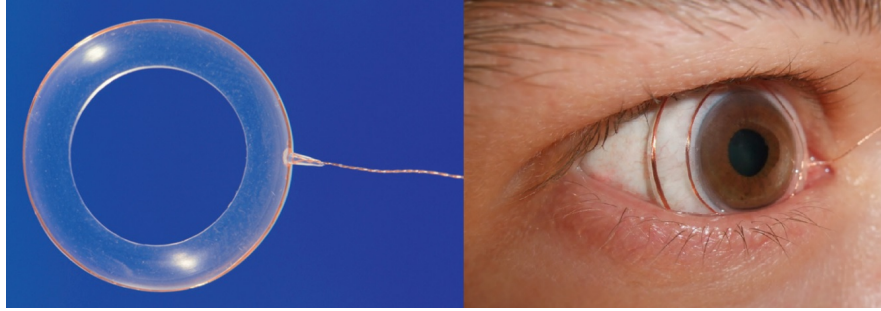
### 2.3 Methods of eye-tracking

For the definition of eye motion, the location of visual focal point, several methods have been worked out. An examination method of eye motions is electro-oculography (EOG). The base of the examination is, that eyeball behaves like an electric dipole: its positive pole is situated on the surface of the cornea, while its negative pole behind the [7] [8] (Fig.1).

Voltage difference between the two points above varies between 0.4 and 1.0 mV, which is partially caused by Donnan-balance emerging between intra-ocular fluid and blood, and light effect on sense cells [7]. This potential difference creates an electric field around the eyeball, which change together with eye motions, and can be measured by electrodes placed next to the eyeball. By temporary placed electrodes the horizontal, while by the electrodes placed above and under the eye, vertical eye motions can be recorded [7]. Electrodes meaning zero voltage level are usually placed in the middle of the forehead or on the earlobe [7]. By this method, eye motions may be examined up to 70(0 the frontal, while 90 the fully lateral or vertical direction) [7]. In case of the other examination method, contact lens were applied to define eyes position. In case of the first solution, the lens located on the cornea contains a roll, in which, in case of motion in magnetic field, voltage is induced [9] (Fig.2), or the lens may be a reflecting surface, similar was applied by Yarbus.



**Fig. 1** Electro-oculography (EOG)



**Fig. 2** Torsion coil inserted on the eye

Eye location can be examined by applying infrared light beam. Infrared light is advantageous from the aspect, that it is invisible, thus not disturbing. Detecting light reflected from the eye, eye position can be figured out [10] (Fig.3).

Nowadays image process based eye-tracking is getting more-and-more widespread. We may choose a destination hardware suitable for eye-tracking from several manufacturer, where such tools can be found, like the Tobii, the Eye Tribe, Mirametrix, GazePoint or Smart Eye. The basics of camera systems is the definition of pupils position through image process algorithms. Camera may be placed a bit farther from the eye, for instance fixed to the computers monitor, or close to the eye on an eye-glass [11] (Fig.4).



**Fig. 3** Spectacleframe recorded oculography based on infrared light reflection

## 2.4 Eye Tribe tracker

Among the eye-tracking systems based on image processing, for performing researches to be introduced later, the Eye Tribe tracker (Fig.5) has been applied. The Eye Tribe tracker is a video based, portable eye-tracker tool, which enables the observation of the direction of the look, and measurements may be performed regarding eye-moving parameters. The device works with infrared (NIR) detection. The tracker consists of two main components: a camera and a high-resolution infrared LED. The camera follows users eye motion, including even the tiniest motions on the pupil. By sophisticated computer algorithms, it is able to read coordinates, which then become visible thanks to a utility software. Camera sensors of the tool work in different light conditions as well, further enhancing users experience. The device works in 30 Hz and 60 Hz sample rate operational mode, with an average spatial accuracy of 0.5 and 0.1 (RMS). Its operational range is between 45 cm and 75 cm. The Eye Tribe tracker, contrary to its cost-efficiency, can be well-used in psychological researches. [12]

## 2.5 Eye motion parameters

Human eye is one of the basic elements of mechanisms processing information received from our environment. As referred above, thanks to our eyes, reception of different visual stimuli, and then their process by our brain become available. In the control of eye motion, complex nerve background cooperation is required. Motoric operation of vision system is achieved by eye muscles. Move of eyeball may be performed consciously, by directing them to the area of interest, while keeping on the field of view by series of spontaneous motions. Basically, motions can be divided into two types: fixation and saccadic motion. (Fig.6)

Fixation: It designs focus on a particular point, where the look spends more time. Average fixation length is between 100 and 1000 ms, in most cases this period is between 200 and 500 ms. The period greatly depends on the quantity of information to be processed, and on the current cognitive load. Fixation designate that condition of the eye, when eyeball stands still, and input or decoding of information is



**Fig. 4** Tobii EyeX and Tobii Pro eye tracking systems

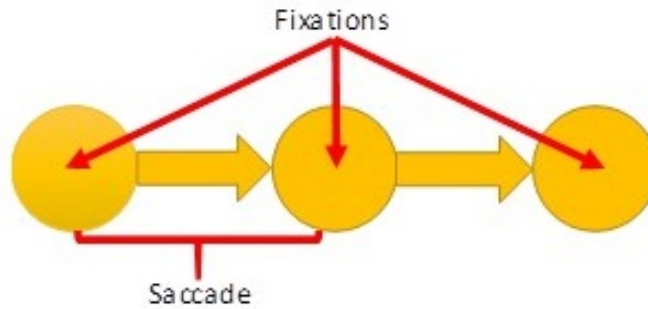


**Fig. 5** The Eye Tribe tracker

in progress. From fixations, different index numbers may be derived, such as fixation length, number of fixations, location of first fixation, time passed until the first fixation, total length of all fixations or visual information input during fixations [4].

Saccade: also known as regression, designates the short, quick and leaping motion between two fixations. Visual search (scanning) is one of its main factors. Average length of a saccade is between 20 and 35 ms. It designates the next looking position for the eye. If a motion above 30 is performed, then the head moves together with the eye. During visual information process, the eye automatically hides all saccades, which may cause the blurring of the observed area. Index numbers may be derived from saccades as well:

Length of look: also known as fixation cluster or fixation cycle, dwell. During the length of look, the length of all fixations and saccades are understood regarding a pre-defined, observed area. By analysing the look, distribution of attention can be measured among each target areas. It may be also used for a kind of forecast: when look spends a long time on a particular point, a relevant event caused by it is likely to emerge (e.g. if the subjects look spends a lot of time on a detail or heading when watching a website, the subject will probably click on it).



**Fig. 6** Fixations and Saccades

## 2.6 Eye motion analysis

The goal of eye motion analysis is to evaluate, how parameters specific for eye motion change, while the observed testing subject is performing a particular activity. Continuous observation of eye motion is available by eye tracking systems, but process of data provided by these systems, definition of parameters describing eye motion require further analysis and evaluation. In order to understand and display data related to eye motion, a software or software bundle performing a particular task is required. For devices listed above, there are analysing software solutions available, either based on open source, or created by the manufacturer. The free, open source OGAMA software is being briefly introduced below.

## 2.7 Eye motion analysis by OGAMA software

Manufacturers producing eye-tracking systems develop such destination softwares based on the analysis of eye motion, but these softwares are usually very expensive. However, a freeware, open source software, the OGAMA (Open Gaze And Mouse Analyser) is available, which enables recording, process and analysis of eye motion and mouse motion data. The program is able to cooperate with most eye-tracking systems, whether we are talking about a destination hardware or a web camera. Its main properties are database controlled pre-processing, as well as filtering eye motion and mouse motion data. Measured data may be exported in text, or depending on the module, in video format. Data may be displayed and evaluated in several formats, the program contains more (particularly 10) modules accordingly.

**Stimulus Design Module:** Here we can create different slides and contents, which we can make different subjects observe.

**Record Module:** In this module eye movement data can be recorded by observing content showed on screen. Recording data is performed in four steps: when device

has to be connected by clicking on Connect button, then record testing subjects data to store them in the database and for eventual statistical representations. Recording data is preceded by the calibration phase, where following nine accurate calibrations, we can accept that depending on the quality of calibration. Then by clicking on Record button, recording data can be started, which finishes by passing exit conditions set for the presented slide in Design Module (e.g. clicking or expiry of given period of time).

Replay Module: We can replay recorded fixations, by connecting recorded fixations route of view becomes visible.

Attention Map Module (heat map): Based on the number of fixations, distribution of attention can be tracked between each parts of the viewed slide.

Scanpath Module: Route of view is visible, with different visualization modes. We can chose from point, circle, light and attention map (heat map) based visualization forms.

Fixations Module: All parameters of fixations can be analysed. In tabular form, number, length, recorded X and Y coordinates can be presented. The module presents fixations graphically as well, in the way presented in Scanpath module.

Saliency Module: It is intended to calculate the salient locations on the stimulus images. It uses the bottom up saliency model from the ilab toolkit from Prof. Laurent Itti. It can predict the scanpath and calculate saliency maps.

Statistics Module: Following calculations from recorded eye movement data, further data can be received regarding fixations, saccades, views and move of mouse.

Areas Of Interest (AOI) Module: Separate areas can be defined on the slide to be observed, which can be then examined one-by-one.

### 3 Role of eye motion in the observation of cognitive processes

In case of a research defined in the introduction of the thesis, aiming to examine students cognitive processes base on eye tracking, knowing the correlation of eye motion and cognitive processes is crucial. During solving IT problems, whether we are talking about system and network engineer, or software development field, very complex tasks need to be solved. Virtually in all of these tasks, high-level pre-knowledges, way of thinking enabling design, description and overview of complex systems, and solution of problems in a logical, sequential way is inevitable. Students have to be prepared for solving these kind of tasks, which, beside learning the theoretical principles, can be achieved most efficiently through working out practical tasks. Education of solving IT-specific problems has been analyses by different professional fields [13] [14], in the professional literature regarding several software developer [15] [16] [17] [18] [19] [20] [21] [22], and computer network related [23] [24] [25] [26] [27] [28] [29] [30] [31] competences. Analysis of eye motion helps to understand the operation of cognitive processes. Thanks to an eye-tracking system, by monitoring eye motion data, human attention may be examined [32] [33]. Eye motion is one of the main elements of cognitive processes, while we can per-

cept visual stimuli by our eyes, which then are processed by our brain. So visual attention launches, (activates) cognitive processes, which are inevitable during performing a task [34]. Application of systems based on eye-tracking may contribute in the acceleration of researches, also making them more efficient.

### ***3.1 Eye-tracking in the observation of learning processes***

From the parameters of eye motion, human activity, visual attention can be measured, so even emotional condition of the human can be concluded. Thus, a system based on eye-tracking can be well-used for studying efficiency of learning processes. Lately, more have been performing such researches. Calvi and others studied inside the e5learning project users behaviour during processing different e-learning contents [35]. Eye-tracking is used in several fields, in studies related to learning. Porta has taken students eye motion data into consideration in an experiment aiming to examine learning experience, where examination of learning experience was achieved by an adaptive system [36]. Pivec developed a monitoring framework in ADELE project, whose goal was to track students look during dynamic process of e-learning contents [37]. Hyskykaris iDict project evaluated students needs by observing the look [38]. Similar development was introduced by Wei and his team for virtual learning environments [39] Wang developed such a software agent, which maintained students attention by utilizing emotional reactions [40]. Porta also worked out a system, which helped to observe changes of students emotional conditions upon eye motion parameters [41]. In the studies of Drewes, such system is introduced, which helps to track, in what sequence and what extent do users read text items in the web browser. Thanks to the JavaScript code embedded into virtual learning environments HTML code, real-time percentage values became available regarding the intensity of text reading. The goal of the study was to define a visual indicator, regarding in what extent did reading process help students during learning. The study showed, that eye motion data may be used to enhance learning efficiency, however, authors also note, that currently applied adaptive systems are still limited in their features, because only a small part of learning conditions can be detected by them [42]. Schmidt-Weigand examined the relation between text and image items in a multimedia educational material. Based on the eye motion data of nine students, that visual distribution of learning environment was primary text-driven. In contrary, image materials defined students visual attention, when written text was replaced by voice. [43] The study of Al Wabil revealed, that students with different learning styles (visual/verbal) show different visual behaviour during learning. From the studies, we have learnt, that verbal students focused mainly on text content, while visual typed noticed only some parts of the text (spending a short period of time on the selected parts), and focused rather on multimedia contents [44]. Similar study was performed by Tsianos too, who compared eye motion data of students with different learning styles in hypermedia based learning environment. [45]

## **4 Examination of solving an IT-task by eye-tracking**

For the performance of examinations defined as the goal of the research, establishment of a testing environment was necessary. The first examination defined as the goal of the research aimed to examine, if there were differences in parameters describing the way, motion of the look defined by the eye move, in case of groups with different prior knowledges. The second examination of the research aimed to figure out, if there were differences in the manual motion of the mouse on the answer supposed to be correct during solving a computer network test, if it was performed by computer mouse or by manual gesture control. In the followings, description and results of these two studies are introduced.

### ***4.1 Testing environment achieving eye-tracking and gesture control***

For eye-tracking purposes, the already introduced Eye Tribe tracker was used, which connected via USB 3.0 port to a portable computer. For gesture control purposes, LeapMotion suitable for the definition of the position of arms and fingers was applied, which connected to the computer via USB 2.0 port. The notebook was equipped with Intel Core i5 CPU, 4 GB RAM, dedicated graphic card and 1 TB hard drive, which provided appropriate resources for running image processing method requiring more computing capabilities for eye-tracking (Fig.7). The computer was running Windows 10 operation system, as well as the Eye Tribe Server service required for the use of eye-tracking system, and also a self-developed application based on Leap Motion mouse cursor move, and OGAMA software performing the evaluation of eye motion and mouse cursor motion.

### ***4.2 Examination of eye motion, regarding the solution of an IT task, in case of groups having different prior knowledges***

The first examination of the research aimed to decide, whether there were differences between parameters describing eye motion between groups with different prior knowledges when solving an IT task. Main parameters describing eye motion aimed on the observed area were evaluated upon eye motion parameters, then their comparison were performed in case of testing subjects with different prior knowledges. Conditions, tools of the research, and the received results are introduced below.

### **4.3 Test subjects**

In the experiment, 32 graduated or prospective IT specialists took part, who had to solve a task related to computer networks. The group of participating testing subjects consisted of students from professional acquaintances, current or former students of the University of Dunaujvaros, and students participating in OKJ advanced studies on a voluntary basis, who held themselves healthy. Participants mainly represented the younger generation, and there was a student from abroad. Gender distribution of testing subjects: 28 men and 4 women. Their ages varied between 20 and 30.

### **4.4 Examination tests**

Prior to the start of the examination tests, testing subjects had to solve a test related to computer networks, which were then evaluated. The results received from the knowledge test, provided the extent of testing subjects prior knowledge. Testing subjects were categorized into three groups, according their answers on the test (max. 10 points): Lower Than Average (LTA) (0-3 points, Average (A) (4-6 points), Better Than Average (BTA) (7-10 points). Based on the test results, 13 persons were put into the group of Average knowledge, 11 into the Lower Than Average, and 8 into the Better Than Average group. Prior to the start of the first test, testing subjects had to sit down in front of the computer performing eye-tracking. Then, thanks to the OGAMA software, calibration was performed as a first step. Then, if calibration was successful, running of the test followed. During the test, a task related to computer network was displayed, on which the correct answer had to be chosen by moving



**Fig. 7** Test environment with eye tracking and gesture control

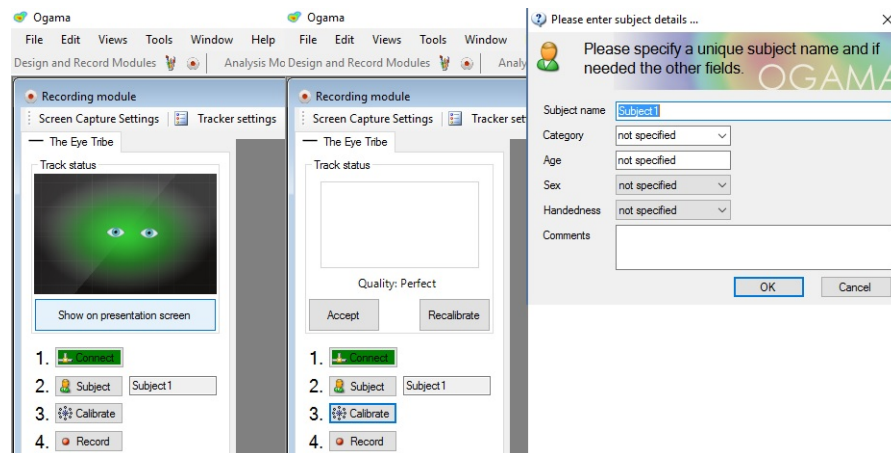
the cursor on the right one, from the three possibilities. The displayed task appeared on the slide, prepared by the Recording module of OGAMA software. The first test finished by selecting the answer supposed to be the correct one. The second test, which contained two test tasks, was launched right after the first one, where eye motion was also recorded. During the test, the correct answer had to be selected by traditional mouse, then by Leap Motion manual gesture control system. In this case, the test also finished by selecting the answer supposed to be correct. Post-process of data were performed following the performance of the tests.

#### 4.5 Measuring tool and process

Recording, process and evaluation of mouse cursors motion based on traditional mouse and hand motion were achieved by the testing environment providing eye-tracking and gesture control, which were based on Eye Tribe tracker eye-tracker and Leap Motion gesture controller devices. Process, evaluation and analysis of data recorded in the testing environment were performed by OGAMA software.

#### 4.6 Steps of performing eye-motion analysis test

Prior to the start of the examination, thanks to the programs Recording module, a calibration process was performed in all cases, which helped to check the proper detecting capability of the eye-tracker system (Fig.8).



**Fig. 8** Recording module of OGAMA

Calibration process consists of four steps: first, the device needs to be connected by clicking on the Connect button. For the connection, Eye Tribe Server application also has to run in the background, which monitors systems activity via 6555 TCP port, as well as the connection to the computer. Following the successful connection to the program, providing the testing subjects data is necessary. Data typed in here (name, category, gender, age) are important in a possible later statistic. Then Calibrate feature becomes available, so the 9-point calibration process can be initiated. About the accuracy of the calibration process, track status preview screen may provide information. Depending on the accuracy, calibration quality may vary between Perfect Quality, Good Quality, Moderate Quality and Poor Quality. On the preview screen, it is also visible, that during the calibration, watching the whole screen, on which part was the process inaccurate, fullness and colour of calibration points (circles) vary depending on the quality: circles may be semi- or fully filled, colour of filling may be red, yellow or green. Following the performance of calibration, by clicking on the Record button, recording of eye motion data can be launched. The question appears on the computers monitor, on the slide displayed by the Recording module of OGAMA software, which were able to be defined in the Stimulus Design module. From the moment of the show-up of slide containing the question to be answered, eye motion data recording starts, until the testing subject selects the answer supposed to be the correct one. Post-process of data was performed following the tests.

#### ***4.7 Evaluation of eye motion test results***

For data process and display in table and graphic form, built-in modules of OGAMA program can be applied. The program enables the evaluation of qualitative and quantitative results of performed eye-tracking based examinations. Analysis of qualitative and quantitative results of eye motion parameters recorded during the solution of computer network related task, are introduced in the sub-chapters below.

#### ***4.8 Qualitative test results***

Here the qualitative test results of eye motion are introduced: the relief, fixation and attention map of the observed area. In the saliency module of OGAMA software, a salient image can be displayed about the especially observed areas. Different colours may vary depending on the value of salients during solving the task. The map helps to examine, which are those areas, whose observation differs from other parts of the image. On Fig.9 and Fig.10, salient map is shown about the observed areas. On the figure, the question, possible answers and observation of computer network topology, and network parameters are well-visible.

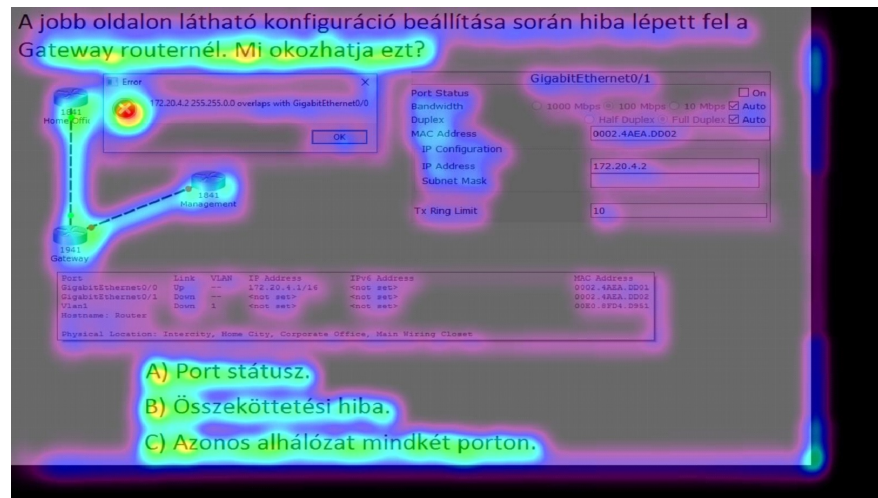


Fig. 9 Attention Map of Gaze I.

The programs Replay module helps to track fixations, and connections between them, this way the way of look becomes displayable. This provides information, what way do each subjects look follow, while the task is being read and interpreted. On Fig.11, the way of look is shown during the task, circles refer to fixations, lines between them refer to saccades, which together define the motion of look.

Thanks to the Attention map module, an attention map similar to heat map can be displayed, whereas areas more or less observed by the subjects can be separated.

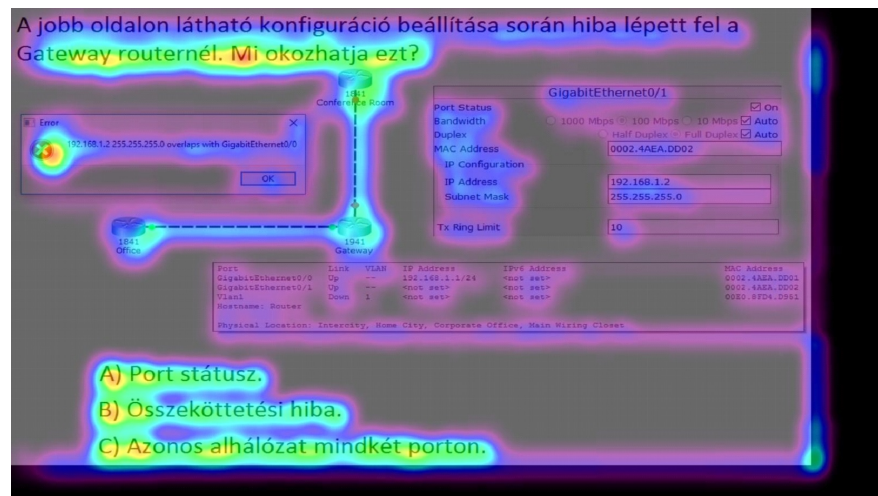


Fig. 10 Attention Map of Gaze II.



the mean value of fixation lengths, reverse proportionality is experienced: members of BTA group produced higher value (303), compared to A (288) and LTA (283) groups. Similarity is experienced between the number of fixations measured during the particular time period and the proportion of fixations/saccades. In case of the LTA group, these two values are the smallest: 1.92 and 543, while in A group, they are 2.21 and 636, while in BTA group, the values are 2.43 and 736. Proportion of average saccade lengths are similar to those, which were experienced in case of fixations. Average of LTA group is 228, whilst it is 219 in group A, and 198 in group BTA.

Results show, that during performing the task, in case of students with better backgrounds, solution of the task was performed in a better organized way, than in case of students with less knowledge. In case of students with less knowledge, watching of each network items in a repeatedly recurring, way in a not well-thought sequence refers to their uncertainty of the solution, which might be due to their lacking prior knowledge. In case of students with more knowledge, a well-organized checking of network items to systematically assemble a network system, and parameters was observed in the way of their look, in the location of more observed areas. As a summary, we can declare, that during solving the task, in the parameters of eye motion, difference was observed depending on the prior knowledge.



**Fig. 12** Gaze path, fixations and connections when one of the users reading the task

## 5 Summary

Result of examination of eye motion introduced in the article showed, that among student groups with different prior knowledge, during solving a task related to an IT-problem, differences were detected in parameters describing eye motion. Results got regarding eye motion give the opportunity in the future to determine, what correlation may be noticed between the success or the lack of success of solving a task with the subjects relevant prior knowledge. Results may provide useful information in checking learning process, in its examination, so these tools and methods may become organic parts of futures educational infrastructure. In our research, we attempted to act thoroughly, but the experiment mentioned above shall be performed again involving more participants, in order to get an even more complete image of the revealed correlations. The fact, that not every IT specialist have the same knowledge in this field of informatics, makes the performance of the examination more complicated, so in the future, it is worth to make this test done by other types of tasks too. Calibration process was performed prior to the examination of each testing subjects, and we attempted to provide optimal environment for the calibration process, however, calibration quality is not the same in all cases. Calibration quality might be influenced by several factors, such as light conditions, testing subjects eye motion coordination, posture or seat position. Profitability of the research can be further enhanced by involving other age groups. This research was based on the age group between 20 and 30, in the future, by widening age groups, we may get even more representative data to be evaluated later. Further examinations may be performed to figure out, that during solving practical tasks (programming, simulation, electric measurement), in what extent do arm or eye motion parameters differ in case of subjects with more or less prior knowledge; as well as that during the performance of different type practical tasks (primary practical tasks, which can be performed at the same speed), in what extent do observed parameters differ. In the future, a possible goal could be the creation of such a device system, which contains more measuring tools (suitable for observing cognitive processes), such as a brain wave and eye-tracking interface. This way, a complex human-computer interface could be established, which helps through the observation of students cognitive processes, we may conclude students learning capabilities. Educators could utilize these features at the selection of material and formal items of the educational material when compiling it, and during the application of knowledge transfer methods. Educators, during educational process, based on real-time feedback, may receive information about students attention level, direction, and even to determine, how they are able to follow the educational material. It provides the option, that through indirect observation of eye motion, at the determination of the forms and method of exams, these results offer new opportunities. Although in this thesis application on the field of pedagogy has been introduced, there are several other possibilities available in human-computer interfaces.

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## References

1. Katona J (2014) Examination and comparison of the EEG based Attention Test with CPT and T.O.V.A. Proceedings of 15th IEEE International Symposium on Computational Intelligence and Informatics, IEEE pp 117-120
2. Katona J (2015) The examination of the application possibilities of brain wave-based control. DUF Press, p 167-176
3. Szildi G Kvri A (2016) Gesztusvezrlsen alapul ember-szmtgp interfjszek. Dunakavics, p 63-73
4. Hari S Jaswinder S (2012) Human Eye Tracking and Related Issues: A Review. International Journal of Scientific and Research Publications, 2(9), 1-9
5. Hewett B C Strong V (1992) ACM SIGCHI curricula for human-computer interaction. New York, USA: ACM.
6. Brdos G Dtri L Hajnik T Kiss J Schlett K Trnok K Vilgi I (2012) lettani gyakorlatok. Budapest: ELTE.
7. Yarbus A L (1967) Eye Movements and Vision. New York: Academy of Sciences of the USSR.
8. Metrovision (2016) Electro-oculography by Metrovision. Retrieved from Electro-oculography by Metrovision: <http://www.metrovision.fr/mv-eo-notice-us.html>
9. Chronos Vison (2016) Scleral Search Coils 2D/3D. Berlin: CHRONOS VISION GmbH. pp 1-4
10. Murray W J Andrew T Robert C Kate C Natalie M (2007) Monitoring eye and eyelid movements by infrared reflectance oculography to measure drowsiness in drivers. Somnologie, 11, 234242
11. Tobii AB website (2016) Tobii. Retrieved from <http://www.tobii.com/>
12. Dalmaier E S (2014) Is the low-cost EyeTribe eye tracker any good for research? PeerJ PrePrints 2:e585v1, p 1-35
13. Kori K Pedaste M Altin H Tnison E Palts T (2016) Factors That Influence Students' Motivation to Start and to Continue Studying Information Technology in Estonia. IEEE Transactions on Education, 59(4), 255-262
14. Hadi A Ping J S Hantao X Emmanuel H E Bart K J Guy A E Dominique M M P (2013) Implementation of a Project-Based Telecommunications Engineering Design Course. IEEE Transactions on Education, 57(1), 25-33
15. Silva-Maceda G Arjona-Villicaa P D (2016) More Time or Better Tools? A Large-Scale Retrospective Comparison of Pedagogical Approaches to Teach Programming. IEEE Transactions on Education, Issue 99, 1-8
16. Perkins D N Hancock C Hobbs R Martin F Simmons R (1986) Conditions of Learning in Novice Programmers. Journal of Educational Computing Research, 2(1), 37-55
17. Putnam R T (1986) A Summary of Misconceptions of High School Basic Programmers. Journal of Educational Computing Research, 2(4), 459-472
18. Cadenas J O Sherratt R S Howlett D Guy C G Lundqvist K O (2015) Virtualization for Cost-Effective Teaching of Assembly Language Programming. IEEE Transactions on Education, 58(4), 282-288
19. Guo Y Zhang S Ritter A Man H (2013) A Case Study on a Capsule Robot in the Gastrointestinal Tract to Teach Robot Programming and Navigation. IEEE Transactions on Education, 57(2), 112-121
20. Mok H N (2011) Student Usage Patterns and Perceptions for Differentiated Lab Exercises in an Undergraduate Programming Course. IEEE Transactions on Education, 55(2), 213-217

21. Jorge A Nadya A Camilo H (2009) Developing programming skills by using interactive learning objects. In Proceedings of the 14th annual ACM SIGCSE conference on Innovation and technology in computer science education, New York, USA: ACM, pp 151-155
22. Chrysafiadi K Virvou M (2013) Dynamically Personalized E-Training in Computer Programming and the Language C. IEEE Transactions on Education, 56(4), 385-392
23. Ma X-M (2010) Probe of bilingual education in computer network course for undergraduates. 2nd International Conference on Education Technology and Computer (ICETC) IEEE, pp 22-24
24. Lu H-k Lin P-c (2012) Effects of interactivity on students' intention to use simulation-based learning tool in computer networking education. IEEE 14th International Conference on Advanced Communication Technology (ICACT), pp 573-576
25. Dobrilovic D Jevtic V Stojanov Z Odadzic B (2012) Usability of virtual network laboratory in engineering education and computer network course. Villach IEEE, pp 1-6
26. Nunes F B Stieler S Voss G B Medina R D (2013) Virtual Worlds and Education: A Case of Study in the Teaching of Computer Networks Using the Sloodle. In 2013 XV Symposium on Virtual and Augmented Reality (SVR) IEEE, pp 248-251
27. Skoric M M (2013) Amateur radio communications, software and computer networks in education. In 2013 IEEE International Conference on Signal Processing, Computing and Control (ISPCC) IEEE, pp 1-8
28. Qun Z A Jun W (2008) Application of NS2 in Education of Computer Networks. ICACTE '08. International Conference on Advanced Computer Theory and Engineering IEEE, pp 368-372
29. Yan C (2011) Bulid a laboratory cloud for computer network education. 2011 6th International Conference on Computer Science and Education (ICCSE) IEEE, pp 1013-1018
30. Papadopoulos P M Lagkas T D Demetriadis S N (2012) How to Implement a Technology Supported Free-Selection Peer Review Protocol: Design Implications from Two Studies on Computer Network Education. In 2012 IEEE 12th International Conference on Advanced Learning Technologies (ICALT) IEEE, pp 364-366
31. Bodnarova A Olsevicova K Sobeslav V (2011) Collaborative resource sharing for computer networks education using learning objects. IEEE, pp 25-28
32. Duchowski A (2007) Eye tracking methodology: Theory and practice. Springer-Verlag New York Inc London: Springer-Verlag London, p 334
33. Rayner K (1998) Eye movements in reading and information processing: 20 years of research. Psychological Bulletin, 124(3), pp 372-422
34. Just A M Carpenter P A (1980) A theory of reading: from eye fixations to comprehension. Psychological Review, 87(4), pp 329-354
35. Calvi C Porta M Sacchi D (2008) e5learning, an e-learning environment based on eye tracking. International Conference on Advanced Learning Technologies Spain IEEE, pp. 1-5
36. Porta M (2008) Implementing eye-based user-aware e-learning. CHI'08 Extended Abstracts on Human Factors in Computing Systems, ACM, pp 3087-3092
37. Maja P Trummer C Pripfl J (2006) Eye-tracking adaptable e-learning and content authoring support. Informatica, pp 83-86
38. Hyrskykari A Majaranta P Aaltonen A Rih K-J (2000) Design issues Of iDICT: a gaze-assisted translation aid. Proceedings of the 2000 symposium on Eye tracking research and applications. New York, NY, USA: ACM, pp 9-14
39. Wei H Moldovan A Muntean C (2009) Sensing learner interest through eye tracking. 9th IT and T Conference Dublin Institute of Technology, pp 1-8
40. Wang H Chignell M Ishizuka M (2006) Empathic tutoring software agents using real time eye tracking. Proceedings of the 2006 symposium on Eye tracking research and applicatons. ACM, pp 73-78
41. Porta M Ricotti S Perez C (2012) Emotional e-learning through eye tracking. Global Engineering Education Conference (EDUCON) IEEE, pp 1-6
42. Drewes H Atterer R Schmidt A (2007) Detailed monitoring of user's gaze and interaction to improve future e-learning. Universal Access in Human-Computer Interaction, Ambient Interaction, 4555, 802-811

43. Florian S W Alfred K Ulrich, G (2010) A closer look at split Visual attention in system-and self-paced instruction in multimedia learning. *Learning and Instruction*, 2(20), 100-110
44. Al-Wabil A El-Gibreen H George R P Al B (2010) Exploring the validity of learning styles as personalization parameters in eLearning environments: An eyetracking study. 2nd International Conference on Computer Technology and Development Cairo: IEEE, pp 174-178
45. Tsianos N Germanakos P Lekkas Z Mourlas C Samaras G (2009) Eye-Tracking Users' Behavior in Relation to Cognitive Style within an E-learning Environment. *Proceedings Of the Ninth IEEE International Advanced Learning Technologies*, IEEE, pp 329-333