EYETRACKING – METHODOLOGY AND APPLICATION

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Summary: Eyetracking gives great capability of computer's systems control and study of usability applications. In this paper we show construction of eyetracker and range of applications.

Keywords: eyetracking, usability applications, heatmap.

1. INTRODUCTION

At present a much attention is focused on the development of alternative methods of communication and computer control. One of the noninvasive and contact less method is the eye tracking method. The important feature of this method is no interference in natural human behavior and a broad range of application. The goal of this paper is the presentation of the eye tracker operation principles and possibilities of its applications.

2. EYETRACKER – CONSTRUCTION, PRINCIPLES AND OPERATION IMAGE PROCESSING

The construction of the eye tracking device is based on the processing of the image from camera situated on the front of the computer operator and few infrared light sources, which illuminate the observer eyes [2]. In the first stage of operation is the eyes localization, determination of the sight lines and the distance between the centers of eyeballs. The eyes must be localized on horizontal line and the observer face should be directed to the camera objective. These operations can be realized on many ways as for example the way using brightness gradient. Next, the image of both eyes recorded by

camera operating with frequency of 16-60 Hz is processed in order to determine the coordinates of eye pupil. In this purpose is used a phenomenon of the Purkinje reflection. Usually is used so called first Purkinje reflection it means the reflection of the light wave from the front surface of the eye cornea. This reflection is visible in the form of white point in the pupil vicinity (big black circle) and allows on detailed analysis of its movements. The image of the Purkinje reflection is shown in Fig. 1. The characteristic feature of this reflection is its stability during the eyeballs movements [1].
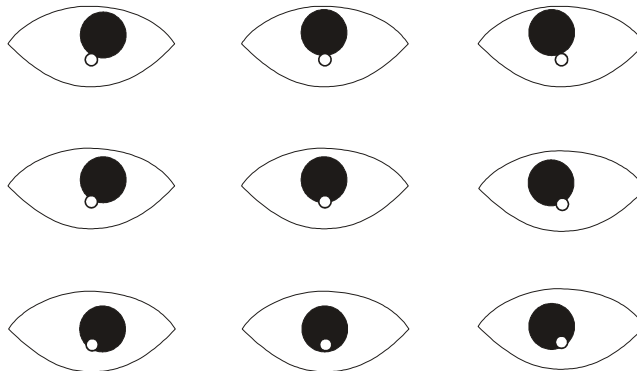

Fig. 1. Localization of pupil in relation to Purkinje reflection – camera view

On the basis of standing item-the Purkinje reflections should be determined, on the image from camera, the coordinates of crossection of the line from eye crossed the computer monitor. The coordinates should be determined separately for each eye assuming that the point of view for both eye is the same. It is shown in Fig. 2.
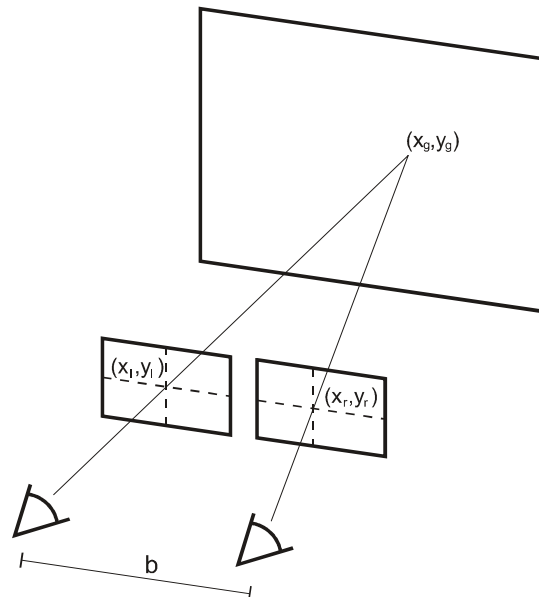

Fig. 2. Basic principle of gaze lines define

On the basis of the determined coordinates of left eye (x_l,y_l), right eye (x_r,y_r) and the distance b between ayes it is possible to determine the coordinates (x,y) of the point on which the sight is directed according to following equations:

$$x_g = \left(1 - \frac{b}{x_l - x_r + b}\right)x_h + \left(\frac{b}{x_l - x_r + b}\right)\left(\frac{x_l + x_r}{2}\right)$$

$$y_g = \left(1 - \frac{b}{x_l - x_r + b}\right)y_h + \left(\frac{b}{x_l - x_r + b}\right)\left(\frac{y_l + y_r}{2}\right)$$

$$(1)$$

The main problem of the devices proper operation is the observer movements. The movements of the whole body or of the head have negative influence on the proper determination of the eye pupil positions. By using of the additional algorithms it is possible to minimize these unfavorable factors [1].

3. EYETRACKING – THE RANGE OF APPLICATIONS

During the studies the eye tracker very precisely tracks the eye movement of the analyzed person. In the effect we can get two types of information's. The first information is the precise localization of the points (fixations) on which the sight of the analyzed person stopped for certain time (fixation time in general is the range of 0.15-1.5 s). Secondly we analyze the so called sakkad, it means the path on which the sight of the analyzed person is moved between fixations. The sakkad is performed in average 4 to 6 times per second with duration from 0.03 to 0.06 s. On that basis we are able to make (formulate) conclusions on type of the cognitive processes of the analyzed person.

The properly prepared software collects all information concerning the eyes positions at certain time and time duration of the sight stop on chosen position on the screen. The whole path on which the sight moves is also registered.

In the result the suitable processed data give the possibility of the generation of so called heatmaps and the focus maps i.e. the images on which, using suitable colors, are presented the average results of the sight localizations of the analyzed persons. The heatmaps essentially present the heat distribution of the focus points of chosen objects, which are easier observed than other negligible objects. In the case of leader of eyetracker producers- Tobii company- the software allows on the generation of two type of the heatmaps: gray-scale heatmaps (more intense focus point corresponds to certain level of transparency) and color heatmaps. Bright red color usually corresponds to point on which the sight is most frequently focused and lightgreen color corresponds to points at which the sight is rarely focused.

The next results of the studies by using eyetracker are, so called gazeplots. The gazeplots present the direction of eye scanning path during subsequent fixations. At is was shown in Fig.4 the single circles illustrate the subsequent fixations (the circle diameter is proportional to the duration of fixation). The lines which connect the circles correspond to direction of the eye scanning path. This process is called the eye sakkad movement.

Fig. 3. Heatmap shows regions which attract especial attention of user

Fig. 4. Gazeplots show order and length of particular fixations

Additional forms of the eyetracking analysis are so called areas of interest (AOI). The investigator is able to determine the crucial, from his point of view, elements and to verify their popularity among respondents (how long and when the elements were observed). It is possible to perform the analysis of direction and duration of fixation in frame of given area. Moreover this method offers the possibility of comparison of the results between different areas what can lead to very interesting and valuable conclusions. Finally we can get the consistent information about number of peoples, which are especially interested in chosen AOI and how long continued the everage fixation.

The data obtained from eyetrack experiment allow to determine the time the persons spend on observation of the interesting us elements on the screen (especially prepared presentation as for example videos or websites); what is the sequence of observation; what disturb the observers. Additionally we can also to determine which element immediately catches the eye and which are ignored.

The biggest popularity the problem of eyetracking achieved in group of neuromarketing specialists. Neuromarketing is interested in problem of the using of measurement tools used in psychophysical studies and in the studies of human behavior in the optimization process of marketing stimuli. Neuromarketing supports the studies of psychophysical processes and that basis checks the reaction of consumers on, for example, products and advertisement.

Nonregular eye movements correlate with difficulties of finding chosen element and longer fixation are connected with more intense stimuli processing. These data allow to have deeper insight into conscious and unconscious processes during interaction with consumer.

The second, also very big area of eyetracking applications is the support of software (desktop type and websites) usability analysis. The usability is the science which concerns to ergonomics of the interactive devices and their application. Generally speaking usability covers the problems of the convenience of the using of different devices.

The creators bandy himself in products improving and in applying of new technologies. It is, unfortunately, the proper operation of the given software is screened by other contents (not necessary in explicit way).

Usability or webusability is the proper way of the golden mean finding between the number of functions and convenience of using them. The final recipients will be not happy from the ergonomic WWW formula if they will not able to perform desired action. From the other hand they will be not satisfied if they will have theoretical possibility to performed desired tasks but in very complicated way that practically is unusefull. For this goal the eyetracking studies of softwares and WWW services are performed. The obtained data allows to propose new models or the products graphical structure before it emerges on the market.

The both, the neuromarketing and usability studies are the areas which have only business character. The other eyetracker application was proposed by scientist, who are interested in the support of the daily life of disabled peoples. It was discovered that studies of sight position of the person sitting in front of the computer monitor (classical eyetracking) can be a basis for elaboration of special software to control mouse by eyes. This idea is based on analogical assumption which are applied in PDA type devices where special stylus is used. At very beginning always the calibration is performed i.e. adjusting eyetracker operation conditions to person in front of the monitor.

The transfer of eye activity on text field activates virtual keyboard QWERTY, which then allows of the content introduction. In summary, the correlation of the sight of the person in front of monitor with operation of the sight controlled mouse allows for used different devices.

4. CONCLUSIONS

Undoubtedly from point of view of practical use of collected information, the best feature of the studies with eyetracker use is a potential objective determination of the consumer activity and perception as function of chosen time unit. The properly constructed software is able to support the studies of usability of the created software market realized in Internet on WWW Websites and also to support the advertisement realized by TV Advertisement Agencies, billboards etc.

The eyetracking has also certain limitations. It may happen that due device construction (the necessity of eye illumination by infrared, camera position etc.), some analyzed persons during the procedure must dress off the glasses or to take of the contact lenses. Additionally, it necessary for respondent to have stable position during the studies procedure and sight must be in the range of camera operation. All these elements can have a negative influence on the activity of stimuli and in consequence the whole procedure can be unbelievable. In the context of eyetracker use as a transducer element between the disabled human sight and the fulfill of all condition can be problematic.

It is also important to mention that the necessity of averaging of the obtained data have an influence on proper interpretation and proper conclusions formulation. The stimuli (advertisement movie, static images) which are presented to the respondent influence them not uniformly. Each of them reacts on chosen presentation or Website in different way. In the consequence the data of honestly performed studies on the big group of peoples must be averaged and extreme opinion removed.

An interesting point of view on eyetracking seems to be the determination of the emotional activity for chosen moment of studies. In the order to achieve that goal the studies cam be enriched to record electroencelograph measurements. Because the unequivocal interpretation of such a record is very difficult and is characterized by big error therefore the problem is undertaken more and more frequently by specialist from the field of neuropsychology.

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METODOLOGIA I ZASTOSOWANIE EYETRACKINGU

Streszczenie

Eyetracking znajduje bardzo szerokie zastosowanie w systemach komputerowych do sterowania komputerem oraz w badaniach nad użytecznością aplikacji. W niniejszej pracy przedstawiono budowę eyetrackera oraz scharakteryzowano obszary zastosowań.

Słowa kluczowe: eyetracking, badanie użyteczności, mapy ciepła