ESTIMATION OF EXECUTION TIMES FOR TASKS OF OBJECTS COUNTING AND LOCALIZATION USING THE OBER2 DEVICE

Z. Mikrut*,. P. Augustyniak

Institute of Automatics, University of Mining and Metallurgy, Krakow, Poland

*zibi@biocyb.ia.agh.edu.pl

Abstract: In the paper methodology is presented for eyetracking experiments, comprising human eyeball movements tracking during execution of objects counting and localisation tasks. The OBER2 device (based on infrared reflection method) has been used for registration of the eyeball movements. The algorithms for automatic estimation of observation times have been presented and evaluated. It was shown that the differences in the task execution times could be used for the evaluation of the task's difficulty level.

Keywords: eyetracking, visual path, visual tasks.

Introduction

The analysis of the eyeball movements is a method of studying human behaviour, which can be applied in many fields, which at first sight are quite distant. Among many interesting examples of psychological applications the one that should be mentioned is the attempt of evaluation of reading disorder level for children carrying out the task of reading a short text sample. In everyday life that technique can be applied for analysis of commercial material (banners) or in the devices that prevent the driver's falling asleep [2].

The presented work is a part of wider research program, oriented towards elaboration of a compression method for certain class of biological signals (e.g. ECG signal registration), comprising the application of a variable sampling frequency [1]. The method of frequency variation should be based on the analysis of the expert's (namely physician's) level of interest, expressed by the intensification of attention focusing on the particular parts of the ECG signal.

The objective of the described study is the construction and testing of methodology for carrying out such experiments with particular focus on two types of tasks: counting and localisation of objects visible on charts. A directly related question, that should be answered, is: how great is the variation of the time required for task execution, and to what extent its automatic evaluation is possible.

Equipment, Methods and Algorithms

The equipment used for registration of the eyeball movements was the OBER2 device, consisting of special goggles, 12-bit A/C converter, processor and a memory buffer. The whole instrument is connected with a PC-class computer. The sources located on the goggles generate pulses in the IR band, and the detectors located on the opposite side register their reflections from the eyeball surface [2]. During the experiments described here the device's working frequency was 1000 Hz.

Two types of charts, used for carrying out the tasks of object localisation and counting respectively, has been prepared for the experiment. On each chart 9 objects have been placed, differing in shape and filling. The consecutive tasks have been gradually made more difficult, by making the objects more alike and by introducing various shadings of the background and the object interior.

A single experiment consisted of 13 computer presentations: one calibration chart and 12 object charts. Before each presentation the investigator issued a short instruction, e.g. "find the ellipsis that is most similar to a circle" or "count the sharp cornered squares". Each presentation has been registered for 8 seconds. Nine persons took part in the experiments, what altogether made more than 100 registrations.

For precise determination of the task's execution time, each of the volunteers was supposed to direct the sight below the monitor screen with the chart after finishing the task. Due to that procedure all errors resulting from the motoric reaction time have been avoided, which are present when e.g. a key pressing is required.

At the start of each presentation a dot was shown in the middle of the screen, on which the sight should have been focused. After a short time the dot was replaced by the actual chart and from that moment the registration started. The examined person started the chart scanning after a short time period, called the initial reaction time (idle time). The total task execution time has been calculated as difference between the end time and the idle time. For the automatic estimation of both times several simple, iterative algorithms have been constructed and tested, from which the best have been chosen.

In the first step of the idle time detection algorithm the average was calculated for several initial points of the eye's horizontal position function $x(t)$. Then a point (A) was estimated, for which the function of $x(t)$ was equal to the evaluated average value mentioned above increased (and decreased) by a certain, predefined margin (see Fig.1). In the next step the "new" average and standard deviation σ were calculated for the [0, A] range. As in the previous step the (B) point was determined, using the new average and the margin values set to $c*\sigma$ (c=1.2 was chosen experimentally). The consecutive iterations can be repeated, generating the next point C, but in practice the location of B point determines the idle time with sufficient accuracy.

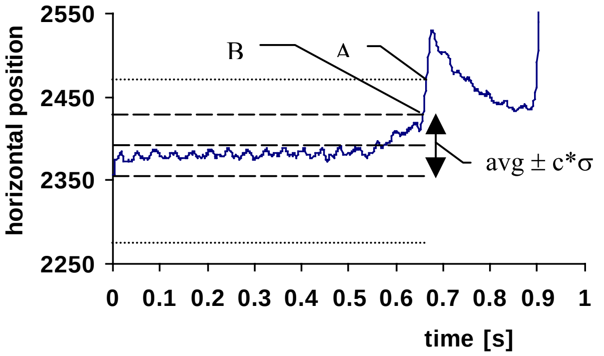

Figure 1: Iterative determination of the idle time for one eye (only the horizontal eyeball movements are shown).

The end time is roughly determined by the threshold method, i.e. by studying the condition when the vertical eye position function exceeds a given value. From that moment the function is analysed backwards, and the point of maximum eye movement speed is selected.

Results and Discussion

For every examined person and for every experiment the time differences have been calculated both manually and by the program, and then the standard deviations for the time differences have been calculated. The results for the first group of persons are presented in Table 1.

Table 1: Standard deviations of time errors [ms]

Eye	Idle time						
left	34	47	2	13	11	263	87
right	8	104	17	82	80	135	103
	Task execution time						
left	51	1900	190	30	1580	516	483
right	184	2500	350	109	1590	550	458

The algorithm of automatic determination of the idle time works correctly for most cases (see Table 1, row 1,2). The greater values of standard deviations for the errors of the task execution time (row 3 and 4) in all the analysed cases result from the fact that the sight direction was not transferred below the screen's lower edge.

Taking into account all the observation times estimated manually, the analysis has been carried out for all the examined persons, depending on the type of executed task. The summary of the execution times (counting task) for one of the examined persons is shown in Figure 2. For the remaining persons and tasks the time variation covers similar ranges. After choosing proper rules describing the mutual relations between particular times and their averages and standard deviations an objective evaluation is possible for the difficulty level of the executed task (see Fig. 2).

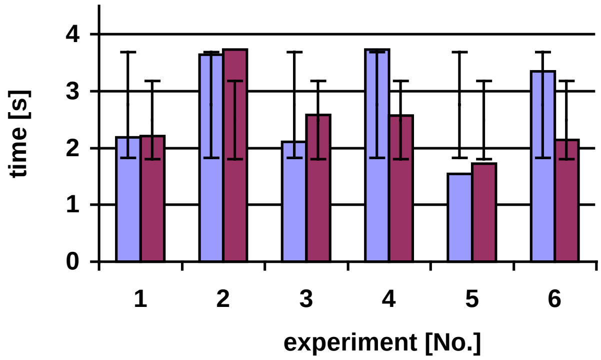

Figure 2: The execution times for the counting task, together with their standard deviations, estimated for both left and right eye of one of the examined persons.

Conclusions

The obtained results fully confirm the possibility of drawing conclusions regarding the difficulty levels of localisation or object counting tasks from the analysis of their execution times. The times can be estimated by analysis of the eye movement signals, registered using the OBER2 device.

Due to the proposed methodology the execution times can be determined very precisely. The algorithms described above can be used for their automatic calculation. However it should be remembered that a visual control of the results is necessary, because some of the examined persons are not fully co-operative and will not fully adhere to the proposed standards.

Acknowledgement

This work is supported by Polish State Committee for Scientific Research under grant No. 8 T11E 007 17. Authors want to thank their students: Lukasz Rymarczyk and Maciej Schmidt for their invaluable help in carrying out the experiments.

REFERENCES

[1] AUGUSTYNIAK P., WRZEŚNIOWSKI A. (2001): 'ECG recorder sampling at the variable rate', Proc. 6th Int. Conf. SYMBIOSIS, Szczyrk, Poland, pp. 128-135.

[2] OBER J., HAJDA J., LOSKA J., JAMICKI M. (1997): 'Application of eye movement measuring system OBER2 to medicine and technology', Proc. of SPIE, Infrared technology and applications, Orlando, USA, vol. 3061, part 1, pp. 327-33