The System of a Touchfree Personal Computer Navigation by Using the Information on the Human Eye Movements

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Abstract. **Disability is one of the major problems of the contemporary world. There are new technical means, methods of work and education for people with disabilities, making it possible to use a computer. The aim of this work is to allow people with upper limb dysfunction to use a computer. This aim was implemented by creating a system controlled by moving the eyeball. The solution proposed by the authors is simple and effective. It is based on a safe method of recording eye movements and the software that is easy to expand and improve.**

Keywords**: eyetracking, human-computer interaction, touchfree navigation.**

I. Introduction

INFORMATION technology is an integral part of everyday life, because it provides the tools by which people can work more efficiently, gain knowledge, communicate and relax in their free time. Progressive computerization makes that the ability of operating a computer becomes necessity. These are also standards which are required by employers.

Modern operating systems equipped with a graphical user interface give the possibility of almost intuitive work by mastering a few simple operations on the widgets without using the complex syntax of the console commands, and a computer mouse is a basic tool which is used to control the operation of the system itself and started several applications in it. Such a solution and the previously mentioned advantages make that more people use computers at almost any age. However, what is easy for a healthy person is not easy for people with disabilities and becomes an obstacle or even prevents them from using the computer.

Disability is one of the major problems of the contemporary world. According to the World Health Organization (2007) in the world live more than 650 million people with disabilities, representing approximately 10% of the population. In Poland the number of disabled people is growing steadily. According to the Polish Central Statistical Office there were 3.8 million disabled people in 1998, 5.5 million in 2002 and now it stands at over 6.2 million, representing 16% of the population. Forty six per cent of these people are motor handicapped. In 2008 the participation of workers among people with disabilities was only 13.7%, and most people with disabilities remain outside the labor market, and this is unfortunately a phenomenon observed for many years. Certainly one of the reasons for this barrier is related with the attendance of the computer.

There are new technical means, methods of work and education for people with disabilities, making it possible to use a computer, depending on the degree of disability. Visually handicapped are able to use the software that can enlarge a piece of a picture, increase contrast, change colors and animations. Speech synthesizers are good support for the visually handicapped and blind, thanks to them it is possible to read texts that appear (are presented) on a computer monitor. For the deaf prepared visualization of the messages and warnings that appear usually in the form of sound. Also, people with upper limb dysfunction can use the advanced solutions that enable a non-contact operation of their computer. Here we can mention about control using by movements of the head, eyes, facial muscles, voice, breath, or alpha waves recorded from the brain [1-3].

Modernization of existing and seeking new methods of promoting the possibility of using a computer for people with disabilities is an area that requires the involvement of computer scientists and biomedical engineers in cooperation with designers, graphic designers, sociologists, psychologists, linguists, and representatives of many other fields. Creating such possibilities is worth every effort and costs [3].

The aim of this work is to allow people with upper limb dysfunction to use a computer. This aim was implemented by creating a system controlled by moving the eyeball.

The cursor control system should meet the following project goals:

- use noninvasive, safe method to record the movements of the eyeball;
- work in real time;

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- support the movement of the cursor and clicking on (several types) and allow the execution of such activities such as: running and finishing programs, typing text, manipulating windows programs, games;
- have a simple and automatic way of calibration;
- starting when the operating system is running;
- be a natural interface and do not disturb the user;
- have a high CPU priority;
- not to burden the system;
- have easy program options.

In section II is described the OBER2 measurement system (principle of operation, parameters, calibration) as the tool which is used in this work. Next is described how the authors execute the operations of the cursor, by supporting the clicks with the application, based on the OBER2 eyetracker. The authors discuss the improvement of ergonomics. In section III the authors discuss about the conditions and results of the experiment. Section IV is the summary of the work, which includes the suggestion about the further work with the system of touchfee navigation.

II. Material and Methods

A. Eye movements recording

There are several methods of the measurement of the eye movement: electrooculography - uses the differences of the electric potential around the eyeball, videooculography - works on the analysis of the eye image registered by the video camera, the photoelectrical method - uses the change of the intensity of light reflexed from the cornea during the eyeball movement [4]. Among noninvasive methods for testing the position of the eyeball the system OBER2 was selected, which uses the phenomenon of the reflected infrared light from the surface of the eyeball. Using a infrared radiation is one of the safest and the most exact methods to measure eye movement [5]. The system uses tracking the point of the user face through the video camera which is placed on a table or a screen, this is a different method of steering the cursor. [6].

This system measures the eye movement on the basis of measurement of the infrared radiation reflected from the eye, which is sent by transmitting diodes and collected by detectors placed in the goggles which are put by the observer (Fig. 1). Infrared radiation is sent in the direction of the eye only in a very short duration pulses of 80 microseconds. That is why eyes are not exposed to a continuous stream of radiation, but only to slightly aggravating flashes. Electrical signal is charged to the system and after being processed it changes into digital form (12 bits) which is available on the serial port in a form a series of fours which represent the center position of each eye in the vertical and horizontal axis. The correct interpretation of the data from the device is made possible by determining the position of the observer respect the presented scene (computer monitor), and the calibration of the device [7-8].

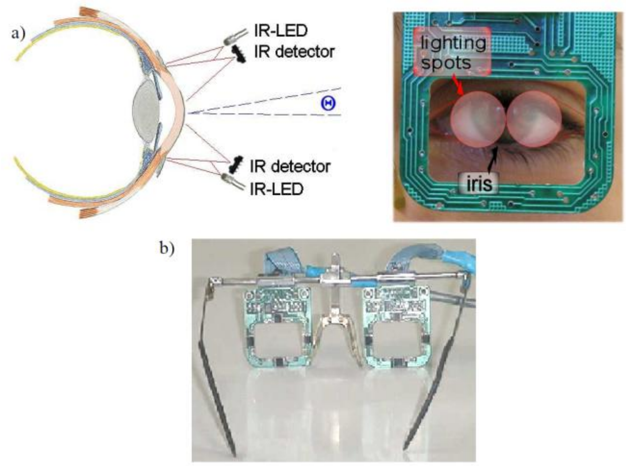

Fig. 1. Details on the OBER2 eyetracker (a) physical principle (b) general overview of goggles

The calibration is the realization of two actions: concentrate the eyes on the point in the centre of the screen and glance at the corners of a steady white rectangular contour (Fig. 2). Thanks to the calibration of the device the information about the center of the screen is stored and the amplification coefficients and shifts for each eye. Next begins the registration of the eye movement measurement through OBER2 system which works with the measuring frequency of 50 Hz. The result of this process was obtained the coordinates sequence in the vertical and horizontal axis for each eye position. The distance between the user and the monitor should be about 50 cm. The distance between the goggles and the table is set to the best view of the screen. An important advantage of the system OBER2 is that it is possible to transfer data to a host computer in real time, which is one of the key conditions in case of the proposed control method.

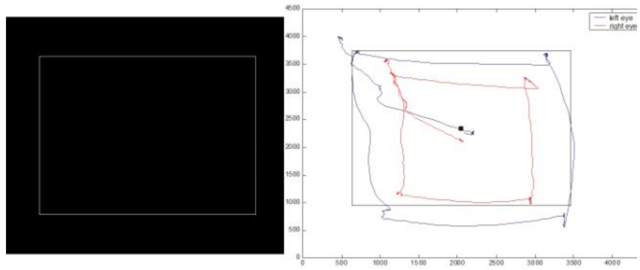

Fig. 2. Calibration (a) calibration contour (b) eyeball traces

If the OBER2 system was to be used to determine the operating parameters of the eye, the specific working conditions should follow here such as the proper position of the eye glasses and the person's relation to monitor the person's head immobilized during the measurement or to avoid any disruption. In this case, accuracy is not important, and the possible inaccuracies caused by small movements of the head are acceptable.

B. Operation of the cursor movement

Operation of the cursor movement required matching the data which was collected from the system OBER2 to the computer screen coordinates. To this end, decided to choose the signal only from the one eye. In the options of this program it is possible to select. The next step associated with the matching of the measurement data was scaled coordinates of the system OBER2 (4048x4048) on appropriate, detects automatically the screen resolution (1).

$$Px_{PC} = round\left(Px_{OBER} \cdot \frac{Rx_{PC}}{Rx_{OBER}} \right) \quad (1)$$

Px_{PC} – position in horizontal axis on the computer screen, Rx_{PC} – resolution in horizontal axis on the computer screen, Px_{OBER} – position in horizontal axis on the system OBER2, Rx_{OBER} – resolution in horizontal axis on the system OBER2

The position on the computer monitor in vertical axis was counted similarly.

Thus prepared data was sent to the function of controlling of the cursor position, thanks to it was possible to move the cursor by means of eyes [8-9].

C. *Support clicks*

Clicks have been achieved by focusing the sight on the appropriate indicator within about 2 seconds. After this time the follows in this same place displaying the context menu with a choice of options for the command click or drag&drop to the left and right key.

The concentrating of sight is recorded as a series of measurements of small differences. Taking under attention the size of icon (about 30x30 pixels) the parameter was established which determines the tolerance of differences between next sets of data. On this basis, it is possible to determine whether there has been the focus of sight. It realizes the simple algorithm.

```
if
(abs(PxPREV-PxACT)<tol) and (abs(PyPREV-PyACT)<tol)
  then   msd:=msd+1
  else   msd:=0
```

abs() - absolute value
tol - tolerance
msd - meter of similar data
Px_{PREV}, Px_{ACT} - position in horizontal axis: previous and actual
Py_{PREV}, Py_{ACT} - position in vertical axis: previous and actual

If the "meter of similar data" reaches a certain value then the system gets information about the click and the context menu is displayed (2).

$$\begin{matrix}\textit{meter of}\\\textit{similar data}\end{matrix} > \begin{matrix}\textit{number of}\\\textit{measurements}\\\textit{per second}\end{matrix} * \begin{matrix}\textit{number}\\\textit{of seconds}\end{matrix} \quad (2)$$

D. *Improvement of ergonomics*

The first task which enhance the ergonomics of the proposed system was to remove the bar of the taskbar and placing it in the system tray. Thanks to we can prevent the program from accidental closing (Fig. 3).

Another task connected with improvement of ergonomics such as automatic calibration or automatic selection of eye which controls the cursor are the subject of ongoing research.

Fig. 3. View of system tray icon

The further works will also concern on how to use this system to steering the home's devices, e.g. turning on/off lamps or television set, controlling air-conditioning or roller blinds, setting alarm etc. There also will be the personal calibration which will keep system configuration for every user.

III. Results

In order to carry out the experiment it has been prepared the measurement site consisting of a system for registering the eyeball OBER2 connected by serial port with a personal computer equipped in processor Intel Core2 Quad Q6600/2.4GHz, RAM 4GB, the graphic card NVIDIA GeForce 8800GT (Fig. 4). The resolution of the screen was set to 1024x768 and the OBER2 system to 4048x4048 (measuring frequency of 50 Hz). Also prepared an application containing a set of functions which download and process measurement data and realizing movements and clicks. This allowed to carry out the test designed control system. At first the application needs the calibration. Next the application (system tray) samples the eyes position form the OBER2 system, rescale it and gives the cursor coordinates. If there are differences between measurements in the defined range, then the context menu is displayed. In this menu user can choose the type of clicking (left or right, single or double).

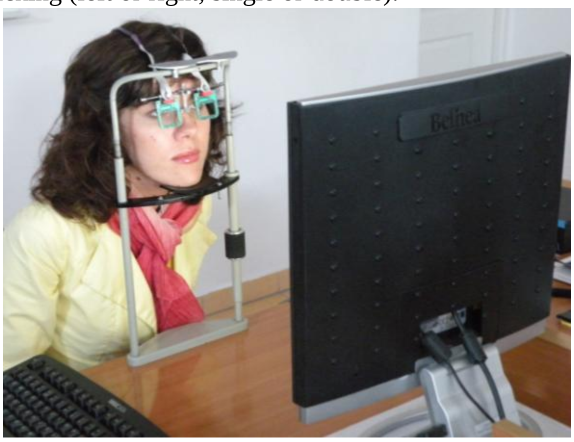
Fig. 4. View of the measurement site

Fifteen volunteers, men and women of all ages (pupils, students, middle-aged and old people) participated in tests. People testing the system were sitting near the table at the distance of about 50 cm from the monitor. As a result of the tests proved that the system is working well, but it is necessary to maintain the head in a fixed position - only small movements are possible. Definitely the system operate the best young people. Steering cursor is quite simple, but requires some concentration and practice. Tests have not been carried out on the disabled people yet.

Observation of software "behavior" also went well. Icon of the program located in the information area prevent accidental maximization the window of program and its accidental disconnection .Implementation of real-time calculations with scaling and comparing next measurements in aim to determine whether there has been the focus of sight, it does not burden the computer system and does not affect on the stability of working the program. The system has already been tested with a positive result at the various intensity of the light and in resolution 800x600.

After completing the tests the users of the system were of the opinion that the system was easy to operate and will be used with motor-impaired people.

IV. Discussion and Conclusions

Research related to facilitating people with disabilities use the computer equipment are certainly needed. Problem of disability affects a large part of society and we should these people facilitate the use of modern technology. The personal computer now allows many applications and that is why it is very important to not block people with upper limb dysfunction to the access to this device.

The solution proposed by the authors is simple and effective. It is based on a safe method of recording eye movements and the software that is easy to expand and improve. In the testers opinion the navigation by using eye movements is easy but it requires a concentration and a practice from users. Achievements related to the positive results of preliminary tests of the system of a touchfree personal computer navigation to encourage to the further work on that project. Only the main element of the system has been developed, and further works are carried out and relates to the manners of automatic calibration of the device, a convenient way to select the options and how to automatically select the eye, from which the signal will steer the cursor. These assumptions have been partially completed, but works on a full ergonomics system are still in progress. Further work will also develop ways of eliminating interference during the system caused by the movement of heads.

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