

CURSOR CONTROL SYSTEM OF A COMPUTER BY ELECTRO-OCULOGRAPHS SIGNS FOR MOTOR DISABILITY

Pinos Eduardo, epinos@ups.edu.ec; Mendez Xavier, xmendez@est.ups.edu.ec;

Centro de Investigación, Desarrollo e Innovación en Ingenierías, CIDII. Grupo de Tecnologías de Inclusión.

Universidad Politécnica Salesiana

Cuenca, Calle Vieja 12-30, Ecuador

Abstract.- A control system of a computer's cursor by recording eye movement using electro-oculographs (EOG) as its principle is presented in this paper. The EOG is the technique that allows detection of the angular displacement of the eye due to corneal-retinal potential present in the eyeball. The aim of this paper is to lay a foundation for the development of a complete systems support for both communication and in the mobilization of people with disabilities. The EOG signal processing involves three stages: acquisition, digitization and processing software. Finally, it is possible to control the computer cursor horizontally and vertically along the respective eye movements.

Index Terms – electro-oculographs, disability, EOG, control, computer

I. INTRODUCTION

With the development of new technologies and the growing interest of society for social inclusion and disability [1, 2], it is important to create tools for independence in daily activities for people with disabilities, or subjects of neuromuscular diseases. A mouse or keyboard are instruments that are used daily with a computer. Most of these instruments are unusable for people with Special Operating skills. The use of Internet and information who is forced in immobility is a real challenge. Therefore, it is of great importance to combat these barriers and developing technologies in order to collaborate in the integration process of the social and labor field.

In Ecuador it is estimated that of the total population, 13.2% experience some form of disability, of this percentage, 48.06% suffer from disabilities due to physical impairments. The provinces of Guayas, Pichincha, Manabí and Azuay have the highest percentage of these disabilities [3]. In these disability cases the subject generally retains the system of eye movement (oculomotor) intact. This system allows movement of the eyes in all directions at will, which also presents certain characteristics **saccadic like movements and fixations**. [4]. The electro-oculogram (EOG) is a technique that allows the detection of potential generation between the cornea and the retina the eye, which can be used to infer the orientation of the eye, and it can be used to infer the orientation of the eye. An example is the direction the subject is looking. There are other methods to detect angular displacement of the eyes, for example the video-oculographs, that by recording images at high speed and image recognition algorithms gives the direction of

motion of the eyes, [5] or oculography infrared rays that are reflected on the retina inferring allowing angular displacement of the balloon eye [6].

The EOG is being used around the world as the basis for the development of multiple tools to help people with mobility disabilities. From control of a wheelchair, to managing programs computation is possible by this technique [7, 8, 9, 10].

This article describes a system for acquiring and processing signals in order for electro-oculographs to control the cursor on a computer. Used in the interface are dry electrodes, easy to fit and comfortable for the user.

This system is composed of three parts: the acquisition and analog signal processing, digitization and finally processing by the computer. For assistance with mobility disabilities, the EOG is an excellent choice, thanks to the low cost representing its implementation, and the requirements of the user, such as only needing to have control over their oculomotor system. The following sections of this article are organized as follows. Section 2 briefly describes EOG technique. Section 3 describes the electronic computational algorithm and system. Experimental results are described in Section 4. Finally, Section 5 presents the conclusions and the future work to develop.

II. ELECTRO-OCULOGRAPHY.

The electrooculography (EOG) is the acquisition technique and recording of cornea- retinal potential present on the globe eyepiece. EOG signal is in a frequency range between 0.1 and 30Hz with an amplitude of 250u and 1000u volts [11] presenting a nearly linear behavior in a displacement angle , $\pm 50^\circ$ horizontally and $\pm 30^\circ$ in the vertical direction [9] . This is a potential to infer the meaning and the rotation angle of the eyes. The method used in this bioelectric signal is detected by placing medical electrodes on the subject's skin near the eyeball [12]. Two electrodes placed on the temples of the subject which records the movement of the eyes horizontally. By directing the gaze to one side, the electrode closest to the cornea becomes a more positive polarization for which the eyes move away. This is because the cornea is electrically more positive than the retina. This is the first electric generator EOG technique [11].

Because the eyes have a spherical shape, the same principle applies to capture the vertical movements. A total of four electrodes are positioned to determine the eye direction and a fifth electrode as a reference. These electrodes, are located as shown in Figure 1 give the indirect possibility of determining the meaning and magnitude of the rotation angle of the eye.

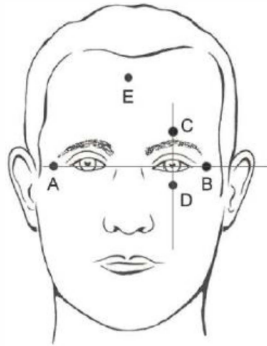


Figure 1. Medical electrode location EOG. [Urtúbia, 1999]

III. SYSTEM DESCRIPTION

A. Hardware

This section describes the electronic systems. No power is required from the power supply, because it uses batteries to function. The EOG signal has a frequency range 0.1 and 30 Hz with an amplitude of 250u and 1000u volts, it is therefore necessary to treat the signal before it is converted into a digital signal. The following briefly describes each stage EOG signal acquisition.

For the acquisition of the signals it is recommended to use medical electrodes, with a cup-shaped head gold, usually used in an EEG, because they are reusable. Also a gel electrolyte is used between skin and the electrode to minimize the friction interference caused by movement of the electrodes or skin against the potential high continuous component. The electrooculography signal amplitudes between 250u and 1000pc volts and is too low to filter it directly. Therefore, it is necessary to pre-amplify. Amplifiers used differential instrumentation presented, among others, feature common mode rejection (CMRR) to discard signals that are not required. , Such as ECG or EEG [13, 14]. The higher the index is the better CMRR the amplifier rejection present.

The integrated circuit with two instrumentation amplifiers, INA2126 (Texas Instruments) is used. It has a CMRR of 94dB typical conditions [15], which allows sufficient quality in the acquired signal [16]. The filtration step is required to evaluate the frequency outside the range of signals that are electro-oculographs between 0.1Hz and 30Hz, for which a system is implements analog filtering.

Two filters are constructed. A high pass filter, often 0.1Hz cut, and another low pass filter 30Hz. UAF42 integrated circuit (Texas Instruments) is used because of the ease of calculation by having the tool Filter42 [17]. This computer program based on DOS easily allows the implementation of a variety of filters with different settings. Subsequently amplified 10 times the previous signal to be converted to digital. This process is performed for both sensing EOG signal sense, vertically and horizontal and the calibration gain and offset by software and potentiometers respectively. Stage pre-amplification, filtering and amplification used conventional 9V batteries.

D converter card is used in data acquisition NI USB - 6009 (National Instruments) that has a data collection rate of 48K samples per second, sufficient for bandwidth 30Hz where electro-oculographic signal is present [18]. This data acquisition board is supplied with power through the USB port of the computer.

B. Software

The algorithm for obtaining command is the cursor controller of the computer interface and calibration program is described in this section and developed in the software graphical programming LabVIEW (National Instruments). An algorithm for obtaining the movements of eyes has been developed, allowing for commands of get up, down, right, left without direction. The procedures for setting the operating parameters and the orders are shown in Figure 2.

Figure 2. Acquisition parameters for the gaze direction of the user.



The wizard prompts the user to keep his eyes fixed on reference points, both in the center, the right and left, while recording data. This process is repeated in the vertical direction as well. Thus the program gets the values of angle and boundaries where the user can freely move the eyes without moving the cursor, these parameters are called motion limits (lnm). In case the angular value exceeding these limits whether you're positive or negative movement in both horizontal or vertical, the cursor moves in that direction.

The computer cursor controller is implemented using a virtual instrument (VI) previously developed and included in the LabVIEW program in the 2010 version. Figure 3 shows the software section to position cursor at the given position. We developed a computer program that allows: observation in real time EOG signal

acquired, activation of the cursor pad computer, and monitor and modify limit values do not move.

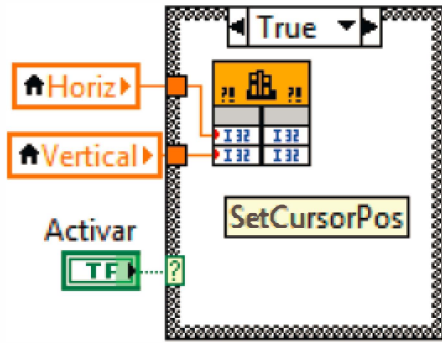


Figure 3. VI cursor positioning of the computer

IV. RESULTS

First, the electronics has been proven as giving result to the proper operation of the various stages of hardware. Figure 4 shows the correct operation of the step of analog filtering and amplification. The table above shows a sign of 25 and 50Hz respectively which has been contaminated with noise. The intermediate table sample shows the filtered signal and the amplified lower signal

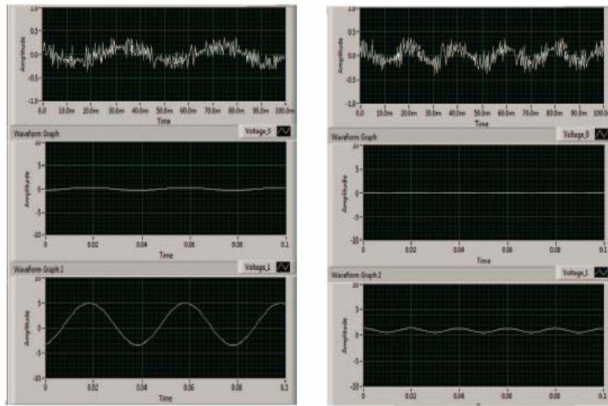


Figure 4. (Left) Signal processing at 25Hz. (Right) Treatment 50Hz signal

Figure 5 is recorded on the axes movements of both horizontally and vertically. It is appreciated that the first signal of instance starts from zero, the user's gaze in the central reference point on the screen, then it requires to look down to the right (there is a peak above) and then to the bottom, where it looks like the signal value falls. You repeated this several times the procedure to be observed as the curve changes to positive or negative values depending on the direction of the gaze, and retaining outliers in the same amplitude. It graphically checks the peak values and is repeated. This displacement procedure is repeated with the vertical axis and is recorded in the right of figure 5.

Peak values of the two figures are the electrodes that horizontally shift as they register and are located closer to the eyeball. Furthermore, the electrodes that register in

the vertical axis are located in a more distant movement and are not symmetrically placed.

After testing the electronic device constructed we proceeded to perform tests in order to register the operation of the statistics.

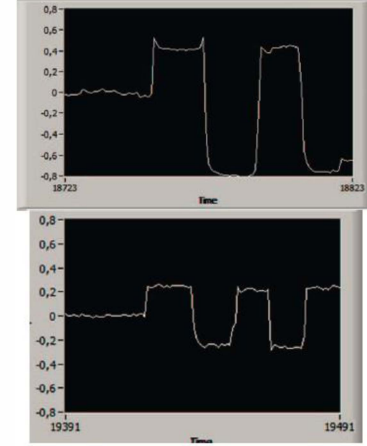


Figure 5. Registration EOG signal. (Top) horizontal scrolling. (Bottom) vertical displacement.

Table 1 records the time it takes for user movement from a central reference point to reference points on the margins of the screen in the computer. On the other hand in Table II tabulates the average time of cursor movement in the directions indicated. The vertical directions are observed more short times. It follows that due to the geometry of the screen of the computers.

Table 1. TIME FOR CHANGE IN CERTAIN ADDRESSES

Ctro-Der	Der-Ctro	Ctro-Izq	Izq-Ctro	Ctro-Arr	Arr-Ctro	Ctro-Aba	Aba-Ctro
9.3	12.1	8.13	14.33	4.32	4	6.06	5.21
8.47	13.5	7.73	13.68	3.76	3.81	11.52	6.4
8.68	11.95	6.49	9.31	3.81	3.77	8.79	6.04
7.59	12.63	14.13	9.47	4.17	5.37	5.92	6.09
7.9	13.21	12.34	11.37	6.28	5.03	6.82	7.93
12.27	9.26	14.29	9.05	4.49	3.74	6.52	5.71
6.85	7.27	6.65	15.65	5.01	3.6	11.14	7.43
7.05	9.08	7.25	15.95	4.92	3.4	15.81	9.99
6.37	7.89	7.43	13.96	3.98	3.69	12.07	5.98
11.65	13.24	7.19	15.39	7.71	5.09	10.73	9.24

Table 2. MOVING AVERAGE TIME CERTAIN POINTS REFERENCE.

Ctro-Der	Der-Ctro	Ctro-Izq	Izq-Ctro	Ctro-Arr	Arr-Ctro	Ctro-Aba	Aba-Ctro
7.745	10.6425	7.505	13.89	4.705	3.765	10.245	6.8375

V. CONCLUSIONS

This paper presents a control system of a computer cursor by electro-oculographs signals. This system represents a contribution to the development of inclusive technologies for the feasibility of development and multiple applications from this prototype which allows

access to information, such as controlling a wheelchair, writing text, and web browsing.

The experimental results show that this system is possible to have the location of the cursor anywhere on the computer screen. It was observed that the time cursor positioning from one position to another decreases depending on the user experience acquired. Use of this system is simple with a small training provided before the use it. It requires the Connection of the Wizard electrodes to the user and the acquisition parameters movement to have no limits.

For future work it is proposed that the development of an interface that allows control of a wheelchair and the incorporation of algorithms for linear tracks eye movements. The use of both software and free hardware also have in mind as an option for future work in view to make this system more economical, not to mention the search for a prototype based on surface mount electronics to make the device smaller and portable.

ACKNOWLEDGEMENTS

We are grateful for their help and support of the research center, Development and Innovation in Engineering from the Universidad Politécnica Salesiana, especially the Group of Inclusion Technologies where this project will be implemented.

REFERENCES

- [1] V. de la República del Ecuador, "Misión "Joaquín Gallegos Lara"." 3 de Mayo 2012. [Online].
Available:
<http://www.vicpresidencia.gob.ec/programas/joaquingallegoslara/jgl.html>
- [2] —, "Misión Solidaria "Manuela Espejo"." 3 de Mayo 2012. [Online].
Available:
<http://www.vicpresidencia.gob.ec/programas/manuelaespejo/misi.html>
- [3] C. N. de Discapacidades, "Número de Personas con Discapacidad Carnetizadas Distribuidas por Causa que Originó la Discapacidad," 3 de Mayo 2012. [Online].
Available:
<http://www.conadis.gob.ec/causa.php>
- [4] W. Becker, "Oculomotor Control (Theory)," in *Encyclopedia of Neuroscience*, M. D. Binder, N. Hirokawa, and U. Windhorst, Eds. Springer Berlin Heidelberg, 2009, pp. 2921 – 2926, 10.1007/978-3-540-29678-2-4117. [Online].
Available:
<http://dx.doi.org/10.1007/978-3-540-29678-2-4117>
- [5] E. Yecan, E. Sumuer, B. Baran, and K. Cagiltay, "Tracing Users Behaviors in a Multimodal Instructional Material: An Eye-Tracking Study," in *Human-Computer Interaction. HCI Intelligent Multimodal Interaction Environments*, ser. Lecture Notes in Computer Science, J. Jacko, Ed. Springer Berlin / Heidelberg, 2007, vol. 4552, pp. 755 – 762, 10.1007/978-3-540-73110-8-82. [Online].
Available:
<http://dx.doi.org/10.1007/978-3-540-73110-8-82>
- [6] K.-U. Schmitt, M. Muser, C. Lanz, F. Walz, and U. Schwarz, "Comparing eye movements recorded by search coil and infrared eye tracking," *Journal of Clinical Monitoring and Computing*, vol. 21, pp. 49 – 53, 2007, 10.1007/S10877-006-9057-5. [Online].
Available:
<http://dx.doi.org/10.1007/s10877-006-9057-5>
- [7] M. Lin and B. Li, "A wireless EOG-based Human Computer Interface," in *Biomedical Engineering and Informatics (BMEI), 2010 3rd International Conference on*, vol. 5, October 2010, pp. 1794 – 1796.
- [8] Z. Lv, X. Wu, M. Li, and C. Zhang, "Implementation of the EOG-Based Human Computer Interface System," in *Bioinformatics and Biomedical Engineering, 2008. ICBBE 2008. The 2nd International Conference on*, May 2008, pp. 2188 – 2191.
- [9] A. Ubeda, E. I. andez, and J. M. Azorin, "Wireless and Portable EOG-Based Interface for Assisting Disabled People," *Mechatronics, IEEE/ASME Transactions on*, vol. 16, no. 5, pp. 870 – 873, October 2011.
- [10] S. Yathunathan, L. U. R. Chandrasena, A. Umakanthan, V. Vasuki, and S. R. Munasinghe, "Controlling a Wheelchair by Use of EOG Signal," in *Information and Automation for Sustainability, 2008. ICIASF 2008. 4Th International Conference on*, December 2008, pp. 283 – 288.
- [11] M. Marmor, M. Brigell, D. McCulloch, C. Westall, and M. Bach, "ISCEV standard for clinical electro-oculography (2010 update)," *Documenta Ophthalmologica*, vol. 122, pp. 1 – 7, 2011, 10.1007/S10633-011-9259-0. [Online].
Available:
<http://dx.doi.org/10.1007/s10633-011-9259-0>
- [12] M. Lin and G. Mo, "Eye gestures recognition technology in Human-computer Interaction," in *Biomedical Engineering and Informatics (BMEI), 2011 4th International Conference on*, vol. 3, October 2011, pp. 1316 – 1318.
- [13] P. S. Croveti and F. Fiori, "Finite common-mode rejection in fully differential operational amplifiers," *Electron. Lett.*, vol. 42, no. 11, pp. 615 – 617, May 2006.
- [14] R. Pallas-Areny and J. G. Webster, "Common mode rejection ratio in differential amplifiers," *Instrumentation and Measurement, IEEE Transactions on*, vol. 40, no. 4, pp. 669 – 676, August 1991.
- [15] T. Instruments, "INA2126 Micropower Instrumentation Amplifier Single and Dual Versions." 5 de Mayo de 2012. [Online].
Available:
<http://www.ti.com/product/ina2126>
- [16] D. G. Navarrete, "Desarrollo de un Sistema de Adquisición y Procesado de Señales Electrooculográficas para el Diagnóstico de la Ataxia," *Universitat Politècnica de Catalunya*, pp. 41–42, 2007.
- [17] T. Instruments, "UAF42 Universal Active Filter. [En línea]," 5 de Mayo de 2012. [Online].
Available:
<http://www.ti.com/product/uaf42>
- [18] N. Instruments, "USER GUIDE AND SPECIFICATIONS NI USB-6008/6009," *Tech. Rep.*, 2012. [Online].
Available:
<http://www.ni.com/pdf/manuals/371303m.pdf>