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The system of electric brain activity acquisition from EEG equipment for Linux OS

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Abstract

The idea of electric brain activity acquisition for LINUX OS is presented. So far the only available software has been that for MS-Windows. The general concept of the modular data acquisition system as independent of its particular parts as possible and based on the LINUX pipe system will be discussed to some extent. Adapting the hardware to open source technology will allow us to design new methods of brain electrical dynamic analysis.

1. Introduction

The first attempts of brain bioelectrical activity analysis are dated to the end of 19th century [1]. Caton investigated the correlation of simple behaviour with the brain cortex electrical activity using specially constructed electrodes attached to the rabbit's skull. Later works by Berger [2] and Cybulski [3] began the rapid development of electroencephalographic techniques.

The general idea of electroencephalography (EEG) is to collect the potential changes generated by synchronic activity of neurons in a chosen part of the brain. Nowadays, more and more sensitive electrodes put on the head skin are used to register potential changes and then the signal is transformed by special filters and amplifiers finally reaching the PC with appropriate software.

The main objective of the research referred in this article is to create the possibility of EEG online data collecting for LINUX OS. Adaptation of the hardware to the open source operating system allows us to construct new methods of analysis and to design a wide range of new experiments, dedicated especially for our projects.

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2. The hardware

In the Division of Complex Systems and Neurodynamics the Mindset MS-1000 EEG System manufactured by Nolan Computer Systems is used [7] (Fig. 1). In terms of hardware it is a real-time device containing a 16-channel differential analog amplifier as the beginning of a signal trace. The amplifier gathers signals from electrodes placed on a special cap (Fig. 2) and amplifies them 32000 times. Next, the signal goes to an analog-to-digital converter. The Device contains 64kB RAM buffer for converted data which is also responsible for the device tolerance to the unrythmical co-operation with the computer.

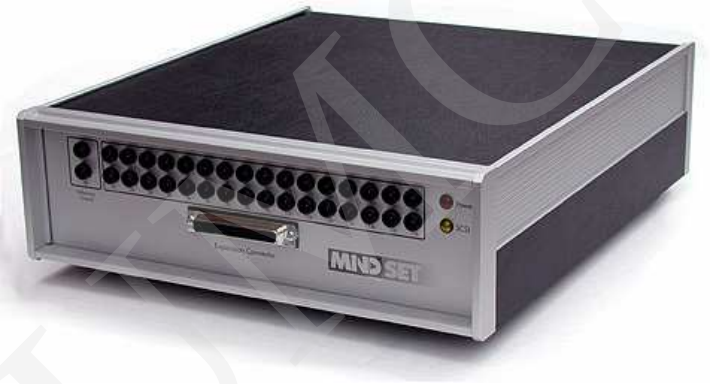

Fig. 1. Mindset MS-1000 EEG system

The device co-operates with the computer through the SCSI interface, using its own commands set. In the computer the co-operation is possible thanks to the PCI card with the external SCSI port. In this particular case this is the SCSI Adaptec AVA 2906 controller (Fig. 3).

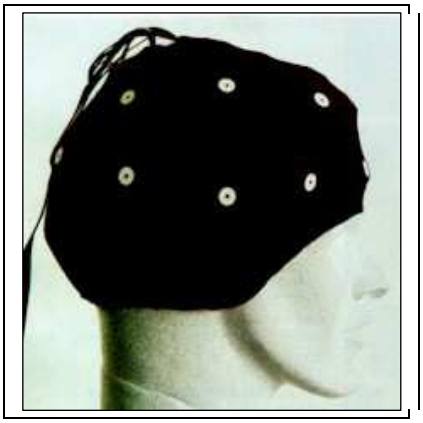

Fig. 2. Mindset MS-1000 EEG system Electo-Cap

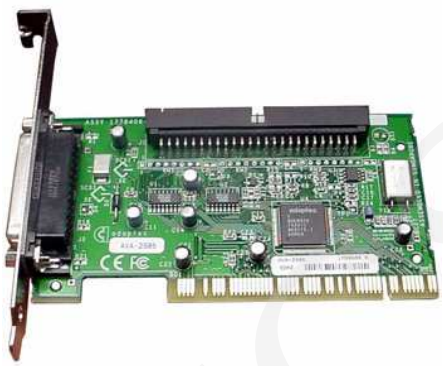

Fig. 3. Adaptec AVA 2906 controller

The devices are connected by means of a special multi-pin cable. In the original version, the data acquisition software was implemented for MicroSoft Windows OS. While using the driver delivered by Adaptec, data is acquired by the software produced by Nolan Computer Systems and can be immediately analysed, saved in a file and analysed from the file in offline mode.

The software makes it possible to display data in the form of an oscillogram similar to the record produced by traditional EEG devices on a paper tape or a histogram of spectral fourier analysis, and to display the electrodes' activity state in a picture similar to the human head.

3. The idea of Linux driver

An idea came up to transfer and expand the functionality of the device and the software as well as better analyse the data produced by them in the Linux OS environment. Starting with Linux 2.6 kernel one can use AIC7xxx driver working with the already mentioned Adaptec AVA 2906 board [5,6]. The necessary information concerning the set of SCSI commands for MindSet 1000 has been provided by Nolan Computer Systems in emails.

4. Modular system of data acquisition

It is planned to develop a system comprising modules as independent as possible, which, can however, be randomly connected by means of the Linux pipe system. Due to the very good support provided by Linux OS, as well as intuitive simplicity of usage, the pipes have been chosen as the mechanism of inter-process communication. Although they are a kernel process, they have their reflection in the Linux file system. Yet, they do not have real contents. This is exactly what makes it possible to add, remove, reorder etc. the co-operating processes. Additionally, the pipes have the blocking opening mode – the process

trying to open the pipe in write mode is blocked by the operation system up to the moment when the data-reading process appears. Using this property, initialisation of the Mindset 1000 device and data acquisition depending on ready-to-read processes can be easily automated.

One can also develop these processes without the knowledge of Mindset SCSI commands set and time restrictions related to device control. The idea of inter-process communication by means of those pipes is well known i.e., from MySQL database server [4], where, apart from sockets mechanism, they can be used to send queries and receive data from server. At the beginning of the pipe there will be a daemon (process, service) controlling MindSet 1000 using its own commands set. The daemon will transmit the acquired data to further modules, especially to that recording data in a file. Depending on the needs, the system will be extended with modules illustrating data in the form of an oscillogram, histograms of spectral fourier analysis, wavelet analysis, and depicting the state of electrodes in 2D or 3D graphics. Because of the modularity of the system, it will, for example, be possible to exchange the deamon co-operating with MindSet 1000 with its simulator which will replay previously recorded data from file. It will also be possible to analyse the data in offline mode, using computers otherwise unable to co-operate with the device. What is more, it will be relatively easy to adapt the system to co-operate with a different EEG device – it will be enough to change the daemon's module. It will also be possible to enhance the system ability with new modules or configure them according to arising needs. While doing research on the possibility of co-operation between the MindSet device and software working under the Linux OS environment, the attempts have been made to use active electrodes targeted on reducing noise signals registered by MindSet. While testing the software in order to estimate the quality of delivered results it can be necessary to use on oscillator of sinusoidal signal in the frequency range from 1Hz to 30Hz, as well as generate a file set containing prepared signals of known characteristics

Conclusions

The concept of the EEG data acquisition system for LINUX OS. Moving the software into the system makes us independent and gives the opportunity for the application of completely new functions and methods of analysis. In our opinion, a very important achievement was also allowing the end user to develop processes without the knowledge of Mindset SCSI commands set and time restrictions related to device control. Modular architecture of our system, daemon-based data exchange and the possibility of using the EEG simulator instead of the original hardware will make our project one of the most interesting in the discussed field.

Acknowledgements

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