COMPUTERIZED ELECTRONYSTAGMOGRAPHY SYSTEM

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Abstract: The present work shows the construction and operation of computerized electronystagmography (ENG) system, developed to automate the ENG exams stages and to control the involved devices, using an IBM-PC. The system incorporates automated forms for the patient's visual system stimulation, which releases the used objects in the traditional methods. For the electro-oculogram signs capture was developed a micro controlled acquisition device, which makes the acquisition and the electrical activity conversion into digital signs, storing these data. The system has mathematics tools that allow preserving or to remove certain existent patterns in the signs and it provides a total or partial visualization of the obtained signs.

Introduction

The electronystagmography (ENG) is the exam thoroughly used in the patients' evaluation that present symptoms related to the dizzy, vertigo and other disorders that affect the vestibular and visual systems. The exams are important in the body corporal balance's evaluation. A person that suffers of diabetes, for example, has its corporal balance affected directly for the labyrinth influences.

This exam bases on the nystagmus registration, through the capture of the potential variation between the cornea and the retina, produced by the eyes movement, by means of external incentives that induce the cerebral cortex to control the ocular muscles movement. Those stimuli are accomplished by means of not automated techniques that use objects about pendulums or points predefined in specific places, so that the patient can accomplish the persecution movements and fixation.

Many electronystagmography systems do not dispose of automated resources. To obtain the nystagmus, equipments as polygraph are used, which just capture and register the existent electric activity in the patient's ocular area, through the electro-oculogram (EOG) signals capture, generating great amounts of reports, what hinders its analysis.

The computerized electronystagmography system was developed, with the objective of become the ENG tests more versatile, with the construction of a low cost system, facilitating and providing new presentation forms and the captured signs treatment, providing to the doctor an including analysis of results as on-line as off-line.

Automated stimulation devices and EOG signals capture and a management system that controls the devices and the obtained data were built. The implemented system stands out of the other ones, for facilitating the use the EOG signals in a digital way, allowing its total manipulation, so much in its presentation or processing as in its storage.

The reports that the system provides are generated from the captured signals. For each accomplished test the specialist can to attach observations to each signal, personalizing the exams for each patient one.

Materials and Methods

For the project development three modules had been considered: of stimulation, acquisition and management. These modules are represented in figure 1.

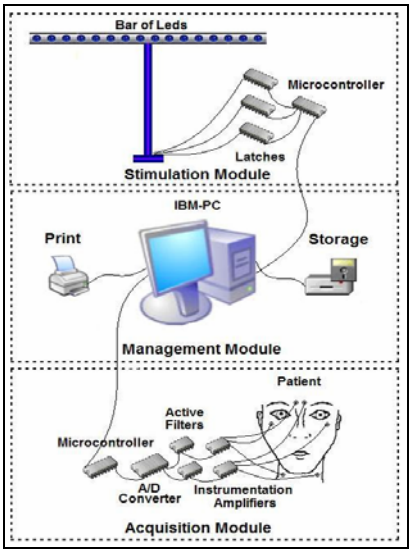

Figure 1: Presentation of the structure and of the components of the system.

The visual stimulation module is composed by a leds bar controlled by a 8 bits microcontroller, responsible for the generation of predefined lights sequences, necessary for each one of the tests that compose the exam.

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In the stimulation device the microcontroller selects the necessary lights sequences for each exam, sending a binary sequence for three latches 74LS373, where these store them, doing the leds bar executes the necessary combinations for the work of each composed segment for 8 leds. The arrangement (8x16) using the 3 latches 74LS373 can be visualized in the figure 2.

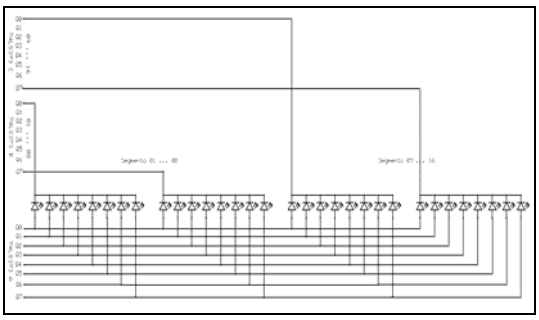

Figure 2: The arrangement 8x16 applied in the leds bar construction.

The capture signals module is based on an 8 bits microcontroller, responsible for the amplification, filtering and conversion of analogical to digital signals phases. The project considered the development of a robust hardware that presented few components, low cost and great capacity of signals bioelectrical capture. One of the main characteristics is its mobility, for the fact of being equipment of small load and of being connected a microcomputer easily.
For the signals amplification phase were used the INA101 instrumentation amplifiers, where these possess high precision and its respective gain can be adjusted by software.
For the filtering phase, the filter UAF42 was used, necessary for the elimination of interferences that can be on the amplified signal. Interferences as the 60Hz noise, resultant of the effect electromagnetic, coming of feeding sources, high intensity lamps, transformers, among other, that they induce the electromagnetic field generated to the patient's body.
The analogical conversion to digital is accomplished by the ADC0808 converter, that possesses 8 channels with a resolution of 8 bits and the converted signal is available in 8 parallel bits of data through tri-state buffers. Its conversion technique is based on successive approaches, making the signal be understood in the interval between 0V and 5V pass to do part of a new interval, between 0 and 255.
The microcontrollers used on the devices are AT89C2051, being composed by processor and some integrated outlying , embedded in an only chip, possessing 128 bytes of RAM memory and 2 Kbytes of Memory.
The signals obtained by the capture module are transmitted to the IBM-PC, through serial communication. The system makes the reception and the storage of those data, for posterior use and analysis for the specialist.

The management module is responsible for the stages accomplished in the exams and for the control of the involved devices. For the accomplishment certain test, the devices are initialized and gauged automatically by the system. The figure 3 presents the initial screen to select the test type to be accomplished.

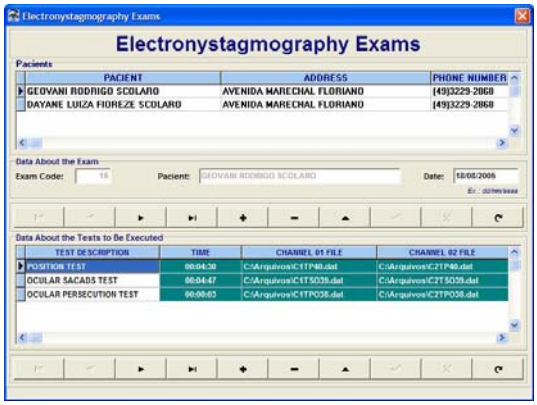

Figure 3: Selection tests screen.

Once test is selected, the system presents for the medical specialist an interface where EOG signals are visualized on-line, during the test execution, just as it is observed in the figure 4. The software incorporates better presentation forms of the obtained signals as well as processing tools.
For the signals visualization are used graphic screens that allow the verification partial or total of the obtained samples, sparing the great amounts of paper, generated by conventional ENG exams.

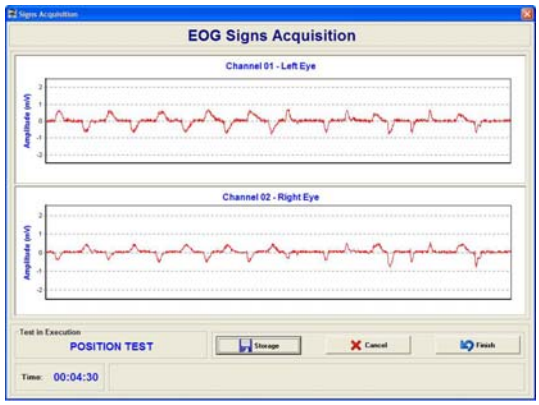

Figure 4: Signal acquisition screen.

There were implemented in the system algorithms of digital processing for the treatment of the captured signals. Through them the specialist can have a more detailed vision with the use of mathematical analyses, statistics and eventual filtering, using the median and moving average filters. The examples of the use of one of the mathematical tools (moving average) they are presented in the figure 5.

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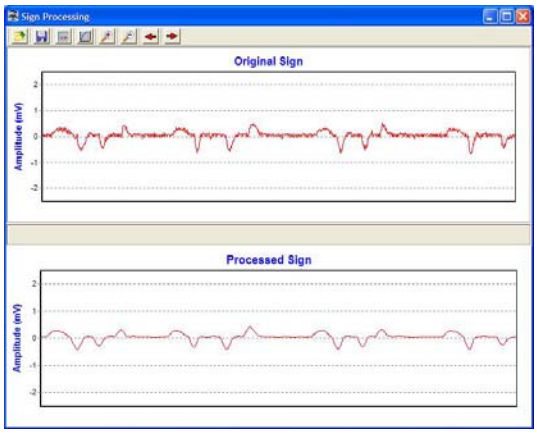

Figure 5: Moving average filter application for signal treatment.

The generated reports are personalized for each patient, using data of the results obtained with the tests.
To each accomplished exam, the medical specialist has the possibility to generate a report, could enclose referring additional information to the patient's evaluation and comments for each marked interval of the captured signal. The Figure 6 presents a generation reports screen.

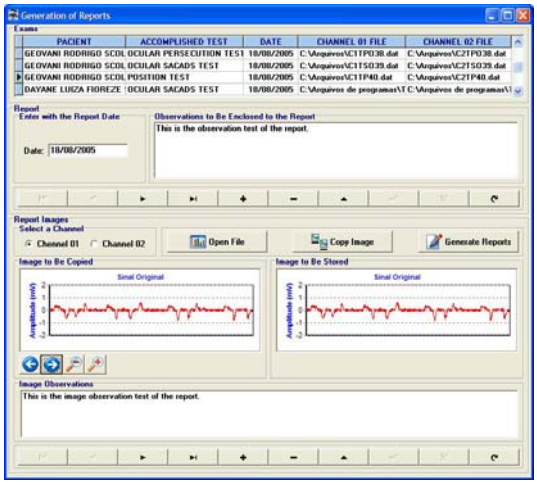

Figure 6: Report generation screen.

Once registered all the relative information to the patient, the report it is generated and available for visualization and printing. The system allows each report to be stored in disk for future verifications.
Figure 7 presents a report generated from an accomplished exam.

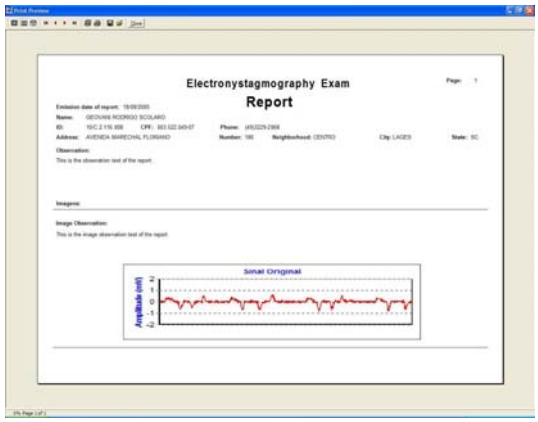

Figure 7: System generated report.

The system management module was implemented with the use of the programming tool Delphi 5.0 and the C language for the control code implementation of microcontrollers.

Results

The developed system works in the same way that conventional ENG, with the significant advantage of captured signals utilization, besides possessing better signals presentation forms and tools for their processing, improving the results obtained. Another system facilities system are storage of signals processed for future evaluations and the standardized reports emission of real usefulness to the cardiologist.

Discussion and Conclusions

The objective of this work was to develop a electronystagmography system. The electronystagmography exams contribute in the identification of disturbances in the vestibular system, among them the nystagmus. However, your evaluation is made through the stimulation of the vestibular system, using external stimuli and with the capture of EOG signals bioelectrical generated by the visual system in response to the stimuli accomplished by the vestibular system excitation.

With the development of the computerized electronystagmography system, the use of the bioelectrical signals, available in a digital way, it is possible the manipulation and signals captured storage for future uses. The visual stimuli are automated, and by this way making agile from a significant way the exams accomplishment. The system allows to the cardiologist to make reports personalized, for each patient, improving the obtained results presentation. The system still provides mathematical tools that make possible with that the medical specialist eliminates certain components that can not be associated to the captured signals.

Due to cables utilization that leads the signals captured to the IBM-PC, there is still limitation in the accomplishment of some of the tests related to the

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labyrinth disease. In the rotation tests, for instance, rotating chairs are used where the patient is submitted to the rotation, for the direct stimulation of the vestibular system.

As suggestion, for future works can be applied to the current system, effective transmission methods of data to PC that would substitute the existent communication method (serial communication), using wireless communication (infrared or radiofrequency). In that way, it would make possible the accomplishment of some tests that are not accomplished by the electronystagmography today, due to the limitation of the equipment cables. They will still be able to be added to the system methods of automatic identification of the nystagmus, facilitating the diagnosis for the specialist.

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