EVALUATION OF EEG MEASUREMENT NOISE DURING CLINICAL RESEARCH OF EPILEPSY IN MULTIPLE SCLEROSIS PATIENTS BETWEEN ADJACENT ELECTRODES

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Abstract

Data recorded with modules for processing of EEG signals for diagnostics of multiple sclerosis is highly susceptible to various forms and sources of noise especially in environments in close proximity to high power electrical equipment. It is the case when recording has to be done in emergencies in the intensive care units of the hospital. A number of strategies are available to handle the noise effectively at the time of EEG recording as well as post preprocessing of recorded data. The aim of the paper is to evaluate the noise artifacts of EEG data gathered by measurement equipment.

1. INTRODUCTION

It is not always the case that EEG can be recorded in a well set environment, avoiding strictly jamming and interference. This often happens in evaluating symptomatic epilepsy induced seizures when on time measurement is of utmost importance in patients with multiple sclerosis [1]. It is frequent that the same cannot be transferred to a better shielded location. Measurements in intensive care units have the disadvantage of the low preparation time and overexposure to a large variety of electrical equipment [2]. Having so there are many sources of noise, to most of which the available EEG equipment is highly susceptible. Biological, electrical and environmental artefacts are seen more frequently. Dealing with the issue of noise in EEG is a task significantly laboured by the stochastic character of the recorded signal. In [3] several strategies are investigated both at recording time and during preprocessing. A basic approach in eliminating unnecessary sources of EM noise is by separately measuring the noise source and then subtracting its components from the biosignal. A wide range and principle circuit diagrams of some of the major sources of interference presented in [4], show a firm dependence of noise from the measurement device's input impedance and wiring. Thus obtaining information for the measurement device, its main characteristics, noise sources, recording methodology and interdependence is crucial for noise reduction. Employing a separate device for a simultaneous measurement with methodology might thus increase the signal-to-noise ratio of the recorded signal.

2. METHODS AND MATERIALS

2.1. Multiple Sclerosis and ictal events

The methodology is highly dependent on the nature of the problem. And in our line of work close collaboration with a neurologist was done in order to evaluate the problem's specifics.

Multiple sclerosis (MS) is a chronic inflammatory disease of the immune system that affects the central nervous system, including the brain, spinal cord and optic nerves. It is considered an autoimmune disease, which means it occurs as a result of the body's immune system attacking and damaging its own nervous system. More specific consequences subside to epilepsy seizures. Although not often manifested, they are more frequent than in the general population [5], with the average 2-2.5% [6]. Those types of seizures are called symptomatic. EEG helps determine seizure type and epilepsy syndrome in patients with epilepsy, and thereby choice of antiepileptic medication and prediction of prognosis. EEG findings contribute to the multi-axial diagnosis of epilepsy [7][8], in terms of whether the seizure disorder is focal or generalised, idiopathic or symptomatic, or part of a specific epilepsy syndrome.

2.2. EEG signal acquisition

In accordance with the above mentioned we have used as part of our investigation a universal analog to digital converter with broad software compatibility. The conversion involves quantization of the input, so it necessarily introduces a small amount of error. Instead of doing a single conversion, the ADC performs the conversions ("samples" the input) periodically. The result is a sequence of digital values that have converted a continuous-time and continuous-amplitude analog signal to a discrete-time and discrete-amplitude digital signal. This greatly reduces and simplifies the medical and engineering analysis.

2.3. EEG signal acquisition

The event logging with multipurpose ADC converter has the great benefit when combined with National Instruments LabView software. Being an efficient and cost effective solution that assists greatly in the communication with specialists and the consecutive signal processing.

3. EXPERIMENTS

3.1. Definition of specific characteristic parameters and equipment composites

The measurements are done in a standard EEG lab. Two types of recordings are made with differentiation in the electrode to electrode comparison. NRSE (detect the ground voltage provided by the signal for all EEG leads) and differential voltage between the electrodes. 3 to four leads are chosen for the measurement – Z (for ground), Cz, C4, T4. All are placed on the EEG cap and linked to bridge electrodes.

3.2 Materials

For the purpose of the benchmark measurement device we have chosen National Instruments USB-6211 bus-powered USB M Series multifunction data acquisition (DAQ) module (Figure 1). This was led by a consideration and discussion with a neurologist and evaluating EEG signal specifics. The module offers 16 analog inputs; 250 kS/s single-channel sampling rate and four programmable input ranges (±0.2 to ±10 V) per channel. Most important being the Minimum Voltage Range (from -200 mV to - 200 mV) and Minimum Voltage Range Sensitivity - 4.8 μV, well in the limits of normal EEG signals. Input impedance for the analog input is >10 GΩ in parallel with 100 pF.

Figure 1. NI USB-6211 DAQ with 4 electrodes

3.2. Recorded signals

The measurements in Figure 2 is done with the ground reference provided by external signal being measured - the setup is called non-referenced single-ended mode NRSE.

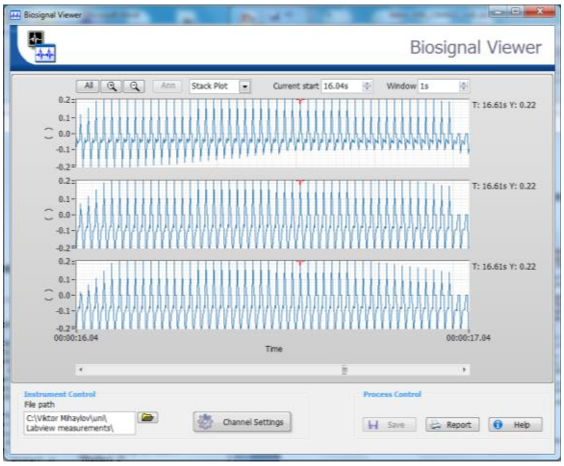

Figure 2. NRSE recording of Cz, C3 and T3

Second differential measurement is in Figure 3. Differential input connections are particularly well-suited for low-level signal and when the signal leads travel through noisy environments

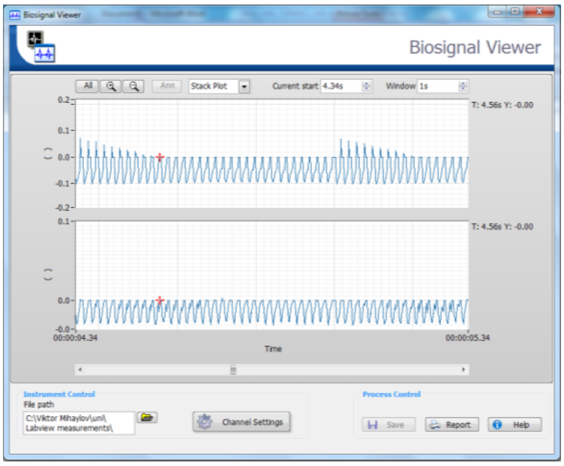

Figure 3. Differential recording of Cz-Z and C3-T3

4. ANALYSIS AND CONCLUSION

As visible on the graphics, the signals are in a good tolerance with standard EEG recording. Average signal amplitude is in between 6uV to100uV, thus meaning that NI USB-6211 could be utilized as a separate device for a simultaneous measurement and implemented methodology for the increase of the signal-to-noise ratio of the signal. Also easily observable is the 50 Hz component, mainly to the electrical grid magnetic induction.

As an extension the experiment several more approaches should be applied such as increasing the number of patient subjects, leads measured and inclusion of signal postprocessing.

5. APPENDIX AND ACKNOWLEDGMENTS

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