Nocturnal monitoring of pediatric patients with epilepsy based on accelerometers

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Abstract— **The first aim of the project is to construct an acquisition system for four accelerometer sensors, fixed to the extremities. The information is transmitted to a data-gathering-system which synchronizes the accelerometer signals with the video-electroencephalogram (EEG) data. The second aim is to synchronously monitor pediatric epileptic patients with the newly developed acquisition system and the video-EEG system. Based on the video-EEG data (the Golden Standard) the seizures are detected and labelled by an expert (as tonic seizures, tonic-clonic seizures jerks or others).**

For the accelerometer we utilized the ADXL330, which measures the acceleration along the three Cartesian axes. The signals are conditioned for A/D conversion and via an A/D converter (Schwarzer interface) read into the video/EEG acquisition software (BrainRT of OSG).

Index Terms— **accelerometers, pediatric epilepsy**

I. INTRODUCTION

Almost one percent of the world population suffer from the effects of epilepsy, which comes down to approximately sixty million people. It is the most common serious neurological disorder during childhood [1]-[3]. Epilepsy is a brain disorder, in which the brain cells produce abnormal signals. In this case, the normal neuronal activity is disturbed and leads to strange sensations, emotions and behavior. Some patients may also show convulsions, muscle spasms and loss of consciousness [4].

The standard detection of epileptic seizures, the Golden Standard, is a combination of EEG and video monitoring. The data is analyzed by an expert who labels the data, determining the time when the seizures take place. The video shows the movement of the patient's body, whereas the EEG shows the brain activity. A combination of those two elements has a very high performance.

A downside of this method is that it is uncomfortable for the patient and that the analysis of the data is labor-intensive. It is not possible, due to practical restrictions mentioned above, to track the disease on daily or weekly basis and this is needed to get a clear view on the patient's situation. Moreover it is hard to detect movement of the patient's body on the video if he lies under a blanket.

The addition of accelerometers to the patient's body can solve the problem of movement detection if the patient lies under a blanket. The accelerometers can even detect some seizures which are not visible on the EEG-signals [5]. A detection algorithm based on only the signals from the accelerometers is also a useful extension. In this situation the patient does not have to wear the uncomfortable EEG electrodes. This leads to a more comfortable detection method for the patient, especially when de accelerometers are connected wireless.

Detection of the movement is also possible by placing markers on the body. A camera can trace the markers and follow the movement of the body [6]. The disadvantage of this method is that the movement cannot be measured if the patient is lying under a blanket. Another problem is that if the markers come close to each other the video analysis program can accidentally switch maker points.

Logging data from the accelerometers can be useful to measure the frequency of nocturnal seizures of patients. With this information the medication of the patient can be adjusted more objectively to a more optimal treatment of the disease and raise the quality of life of the patient. Another possible use of the data is to detect a seizure and give a signal to alarm the nursing staff. The systems used today are often audio triggered and their performance is very poor [5]. An alarm system based on accelerometer data can be an improvement.

Different methods to gather accelerometer data are already carried out. First it is important to distinguish real movement of body parts from noise produced by respiration or arterial pulsation [7]. Afterwards the seizures must be separated from non-seizure movements.

In our setup we monitored the movement of pediatric patients. All patients suffer from severe epilepsy and were monitored during the night while they were asleep.

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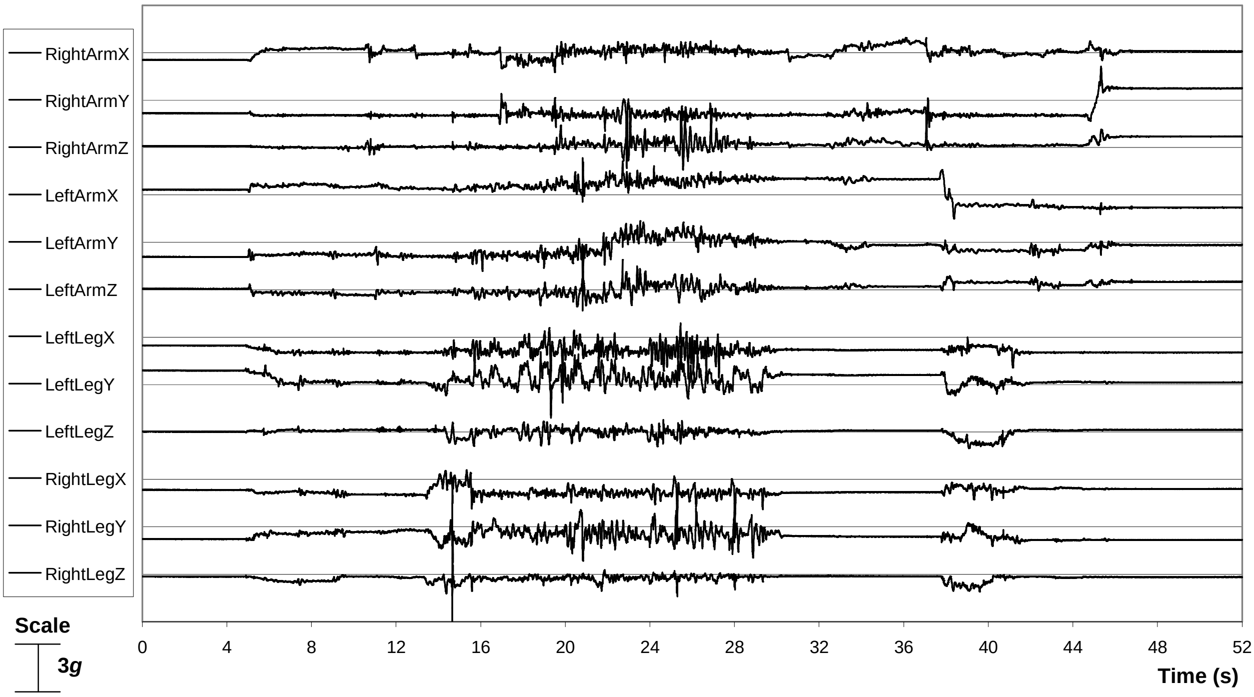

Fig. 3.1. Accelerometer signals at nocturnal acquisition.

II. MATERIAL AND METHODS

A. Setup

1) The accelerometer

To convert the physical measurement (acceleration) to an electrical measurement (voltage) we use the ADXL330 accelerometer. The ADXL330 is a small, low power, 3-axis acceleration measurement system on a single monolithic IC. It has a range of at least –3.0 g to 3.0 g, and a typical range of –3.6 g to 3.6 g. With an applied voltage supply of 3.3 V, the ADXL330 delivers an output voltage of approximately 1.6 V by 0 g acceleration. This voltage increases or decreases with 320 mV per +1 g respectively –1 g.

For each output channel, a 32 kΩ resistor is integrated. The purpose of this resistor is to set the bandwidth by an external capacitor. In our setup, a 100 nF capacitor is used. This results into a bandwidth of 50 Hz. The filtering improves measurement resolution and helps preventing aliasing.

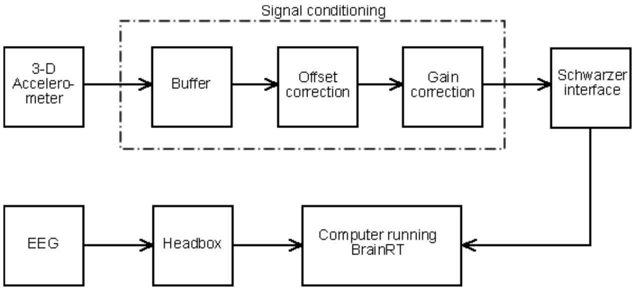

Fig. 2.1. Block diagram of data acquisition circuit.

2) Acquisition circuit block diagram

Fig. 2.1 illustrates a block diagram of the data acquisition circuit used. The 3-D accelerometer’s output voltage contains an offset and a low voltage deviation per g, as described above.

The buffer converts the relative high impedance of the accelerometer output to an impedance of only a few Ohms. This prevents linearity errors due to a limited input impedance of the following block.

The offset correction eliminates the 1.6 V offset on the accelerometer output signal by subtracting an adjustable DC-voltage. This results in a signal of 0 V by an acceleration of 0 g, increased or decreased by 320 mV/g.

The gain correction amplifies the signal by an adjustable factor to create a signal of 1 V/g. This results into a minimum range of –3 V to 3 V for an acceleration of –3 g to 3 g. The gain correction improves the accuracy after digitalization by the next block.

The Schwarzer interface box contains 12 analog input channels with a range of –5.5 V to 5.5 V and a 12-bit analog-to-digital converter with a resolution of 2.7 mV and a maximum sample rate of 1 kHz. The interface box sends the acquired data to BrainRT (OSG soft) which also gathers the EEG and video data. In this way we log our accelerometer data synchronous with our EEG and video data, the Golden Standard data.

B. Patients

In our setup we focused our attention on pediatric patients as their seizure patterns may still vary. The measuring was executed in Pulderbos revalidation and epilepsy centre for children and youth. The registrations are performed during sleep as seizures occur more or less in a controlled reproducible manner, without too much noise sources such as voluntary movement. The first patient we monitored suffered from myoclonic seizures. Another ten year old patient had unclassified epileptic seizures. Although our first goal is to detect a single type of seizure, this patient's data was useful because of the intensity of the motor symptoms during the seizures.

In the future datasets from different patients will be set up with both EEG signals and video data. This way different types of epileptic seizures [8] can be examined by children with different ages, from the age of 2 years to 14 years, as the seizures often change with the age.

III. RESULTS

Fig. 3.1 illustrates the accelerometer data of the epileptic seizure from the ten year old patient who suffers from unclassified but intense seizures. Signals 1-3 are from the three axis of the right arm, and signals 4-6 are from the left arm. Signals 7-9 are from the left leg, and 10-12 from the right leg. We can clearly notice the transient activity in the signals. The seizure starts at second 13 and lasts till second 38. The activity is visible in the accelerometer data. The activity between second 46 and second 50 is normal nocturnal movement.

IV. CONCLUSION

A measuring system which simultaneously acquires several accelerometer signals and video/EEG signals is built. It is our intention to set up a database with datasets of both the accelerometer data and the EEG/video data. With this large database the different detection algorithms can be tested and validated. The ultimate goal is to monitor patients on a daily basis only with accelerometers not only in a controlled environment such as a hospital setting but also at home.

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