Fast Data Processing for Multi Electrode Arrays

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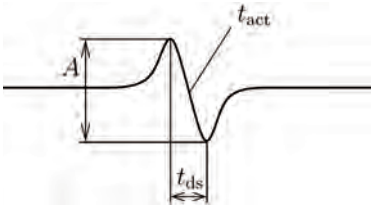
Multi electrode arrays (MEAs) provide a powerful interface to stimulate and/or sense the activity in biological tissue e.g. in medical research. Often it is crucial to reduce the huge amount of recorded data as early as possible in the acquisition process, especially if real-time visualization of the recordings is needed. The group of Prof. Dr. med. Stephan Rohr in the Department of Physiology at the University of Bern is presently using 64-channel MEAs with cultivated heart cells to record spontaneous or stimulated activity. A future MEA, currently being developed at the University of Neuchâtel and the École Polytechnique Fédérale de Lausanne (EPFL), has 16 times more electrodes.

Objective

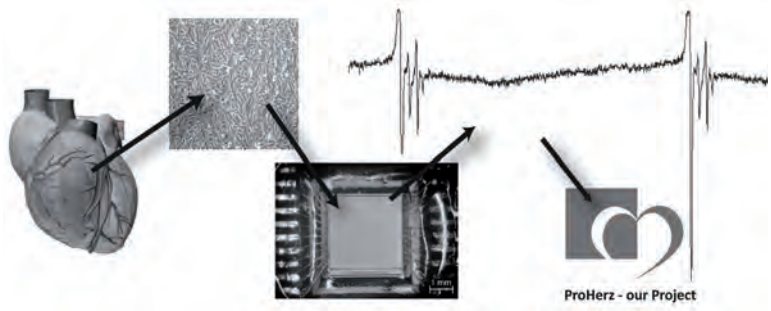
With a 1024-channel MEA, the amount of data to be processed will increase dramatically. Whenever software solutions prove to be insufficient, hardware solutions are a powerful alternative. The aim of this project is to realize the extraction of the relevant parameters from signals of such multi-channel MEAs. A hardware algorithm to detect and process action potentials for a single electrode signal has been developed during the precedent project work. This algorithm is able to detect occurring action potentials, to extract the most relevant parameters and to send them to the computer. The main focus of this work lies on processing not only one, but up to 1024 multiplexed signals. Therefore a highly integrated and fully optimized hardware algorithm, as well as a sophisticated analog signal circuit for acquisition and live viewing purposes had to be developed.



Actionpotential and parameters to be extracted. Amplitude (A), downstroke time (t_{ds}), activation time (t_{act}).

The System

A GECKO3main board, a FPGA (field programmable gate array) development kit of the BFH, is hooked up onto a self made circuit board. The incoming, multiplexed data stream is A/D-converted for processing by the FPGA. With the analog circuit developed, it is possible to attach up to four oscilloscope channels for live viewing of single electrode signals.



Heart Cell Measuring with Multi Electrode Array

The Hardware Algorithm

The algorithm is implemented in a Spartan3 FPGA on the GECKO3-main board. The incoming signals are filtered and occurring action potentials are detected by both calculating the strength and matching the shape of the signal. Recognized action potentials are then measured to extract the desired parameters, moreover a data window is stored. After that, all this information is submitted to a PC. For this application, a complex and fast signal processing approach comes into operation. Such a dedicated design outperforms any PC solution.

Outlook

The system being developed will not only help researchers at the University of Bern to understand how exactly heart arrhythmia emerges, but it also could be used for other applications as the investigation of neuronal tissue. Furthermore, it can be customized and extended to meet the various demands of the researchers.

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