Analysis of high-speed data from excitable tissues

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To elucidate and further understand the electrical signalling in networks of excitable cells like cardiomyocytes and neurons, state of the art experimental techniques permitting to assess membrane potential fluctuations with high spatio-temporal resolution are indispensable. Such experiments are based on the use of voltage sensitive dyes which report membrane potential variations by changing their fluorescence properties. The resulting light intensity changes are captured by high-speed devices that are fast enough to follow electrical activation, i.e., the spread of action potentials (Fig. 1).

Whereas the acquisition of data works very well with these systems, available software solutions for data analysis are rudimentary and barely meet the specialized demands of researchers. In particular, they fail to calculate parameters describing the network behaviour of the excitable tissues under investigation. A solution to accomplish the task of processing cardiac mapping data is described in this thesis.

Raw mapping data from high-speed cameras and other sources like multi-electrode arrays can be processed using various approaches. Pre-implemented filters and analysis plug-ins allow the extraction of desired characteristics of recorded signals and the generation of different feature maps (e.g., activation-, speed- and upstroke velocity maps, Fig.2). Moreover, the detection and tracking of phase singularities, the clustering of propagating wave fronts, the creation of velocity profiles or the tracking of activation paths are implemented in the software. For this, several new algorithms have been developed, like the tracing of activation waves based on the fast marching method.

The new software drastically reduces the evaluation time of cardiac mapping data and also improves the general handling during this phase of analysis. It is now possible to process data in an intuitive way by the graphical user interface that offers direct feedback, rather than manually writing code for data analysis. The software enables scientists to obtain a comprehensive analysis of the experiments in short time which enables them to focus on the understanding and treatment of the causes of heart diseases.
(Original Title: Analysis of opto-biological data from excitable tissues)

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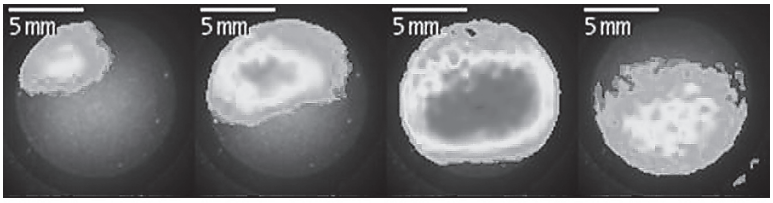

Fig.1, Propagating excitation wave on cardiac tissue, captured by the Micam Ultima high-speed camera and filtered for display by the developed software.

The data analysis tool developed in this study provides basic data conditioning and processing functionalities as well as advanced feature extraction capabilities to statistically analyse the network behaviour of excitable cells. Recorded data is processed in both the spatial and the temporal domain. The software is based on a plug-in strategy that allows seamless integration of new data processing functionalities without the need of remodelling the whole architecture.

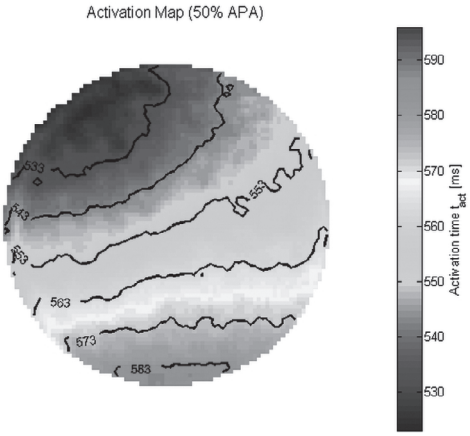

Fig.2, Example activation map (of the wavefront shown in fig1) displaying the color-coded action potential activation times (APA=Action potential amplitude).