# In-Silico Comparison of Phase Maps Based on Action Potential and Extracellular Potential

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The phase mapping is a widespread method of signal processing and data visualization, which is usually applicable to action potential (AP) records (optical mapping) and to extracellular potential (EP) records (unipolar and bipolar electrogram, non-invasive EP reconstruction). In our study, we compared phase maps based on AP and EP under different conditions.

Our study was performed with finite element myocardium simulations with the following properties: the bidomain model of the tissue, ten Tusscher et al., 2006 cellular model, a slab and a personalized 3D geometry, focal and reentrant (spiral wave) excitation pattern. Phase maps were calculated and processed according to Kuklik et al., 2015 approach and Vijayakumar et al., 2016 approach.

Phase fronts for the phase maps based on AP and the phase maps based on EP matched to each other if we took extracellular potential with the minus sign. The phase front matched to action potential upstroke and the intrinsic deflection of an unipolar electrogram. Therefore, the position of the phase singularity did not completely match to each other and to the definition of spiral wave tips, which is used in the spiral wave theory. The difference reached 3.5 mm on the surface of a myocardial slab. Also, we observed that phase map based on the extracellular electrogram was more sensitive to artifacts, which can be caused by boundary effects and repolarization fronts (Fig. 1).

In this study, we demonstrate that excitation fronts provided by AP phase mapping, EP phase mapping, and AP upstroke detection are good correlated. The observed differences in phase singularities positions and spiral wave tip positions are not valuable in clinical practice. However, these do not match perfectly, and the observed difference may be important in basic research.

The study was supported by UrFU (Act No. 211 of 16/03/2013), IIP (AAAA-A18-118020590030-1), RFBR (#18-31-00401).

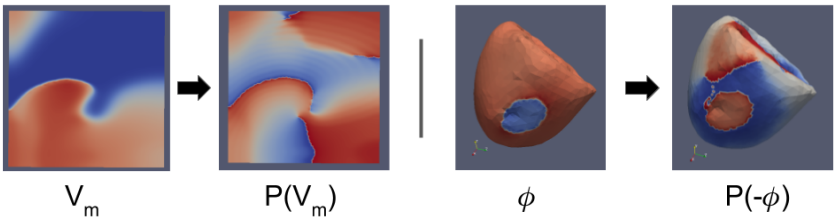


Figure 1. Some artifacts of the phase maps. Left side: AP map and AP based phase map, slab geometry. Right side: EP map and EP phase map, personalized 3D geometry.