Real-time detection of sharp wave ripples through spatial filtering

Empowered by imec, KU Leuven and VIB

Master's thesis	Promotors	Supervisors	
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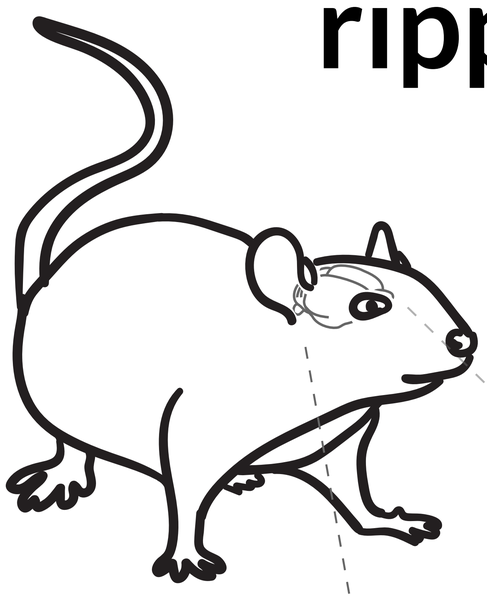
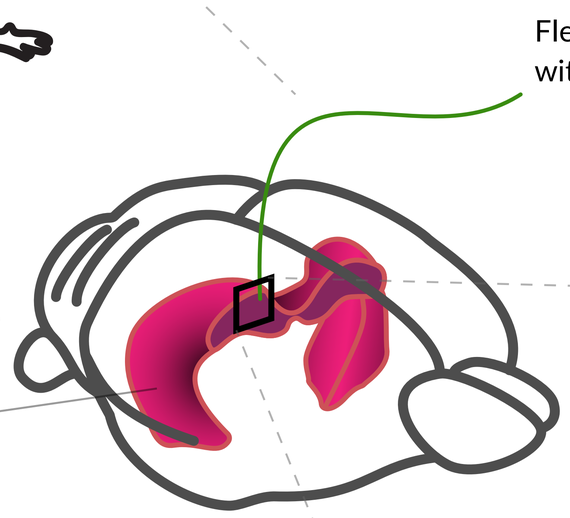
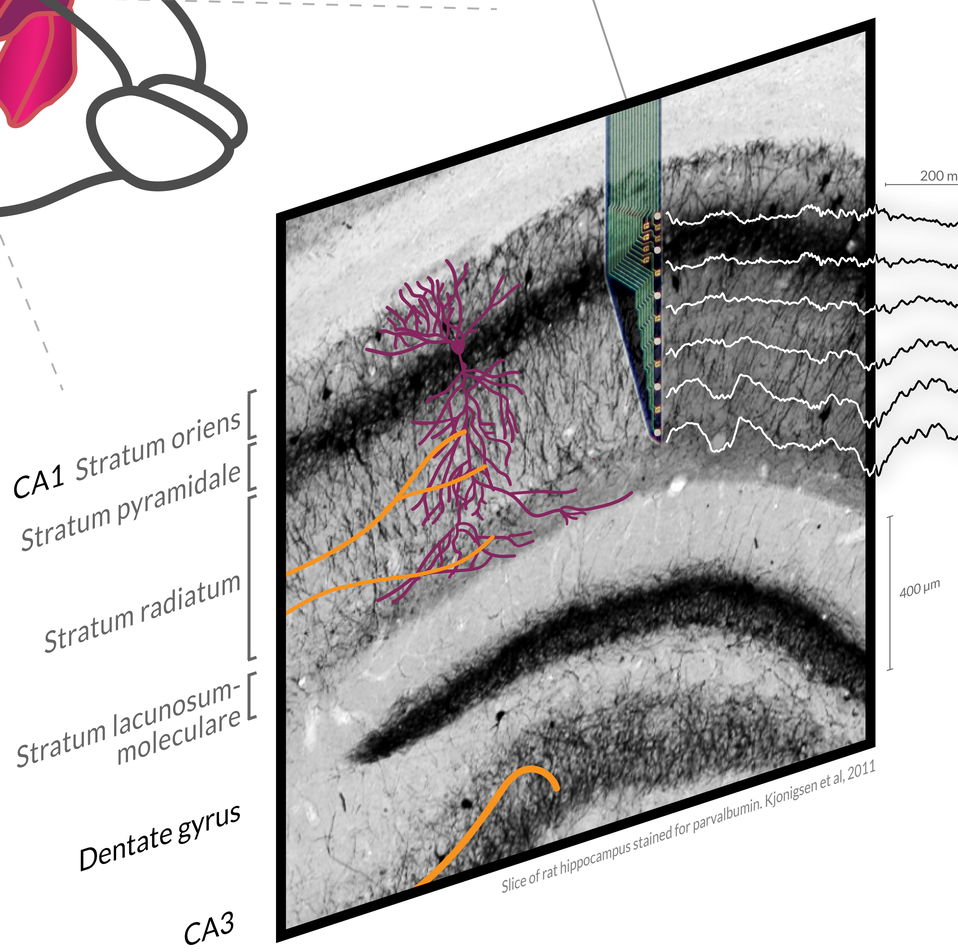




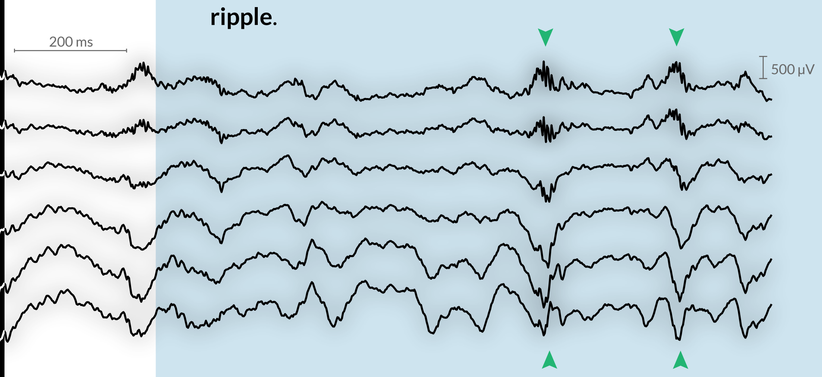


Sharp wave ripples

SWR's for short. A pattern in the extracellular electric field of the mammalian hippocampus

Axon branches originating in the CA3 region of the hippocampus (called **Schaffer collaterals**) synapse onto the apical dendrites of **CA1 pyramidal neurons**.

The resulting neuron depolarisations are reflected extracellularly as a voltage drop in the stratum radiatum: the **sharp wave**. The excitatory PSP's trigger a 100-200 Hz oscillation in the pyramidal cell body layer: the **ripple**.



SWR's are a signature of core brain mechanisms like memory retrieval and memory formation ('learning').

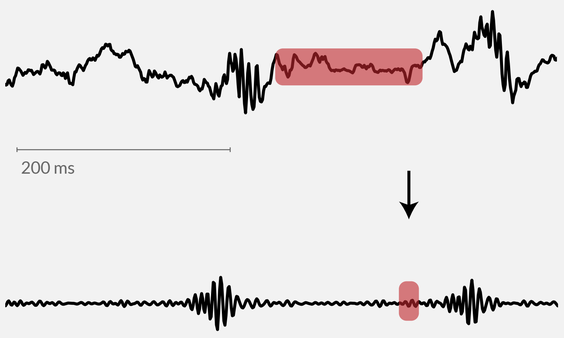
One way to better understand these mechanisms, is to perform closed-loop experiments: on detection of a relevant event (a SWR e.g.), the biological system is perturbed (by injecting a current surge into the hippocampus via the hippocampal commisure, e.g.).

This paradigm requires accurate and fast real-time detection of SWR events. This poster gives an overview of the state of the art, and a proposed improvement.

Hypothesis

Spatial filtering detects SWR's **faster** than the state-of-the-art temporal approach, with equal or better **detection performance**

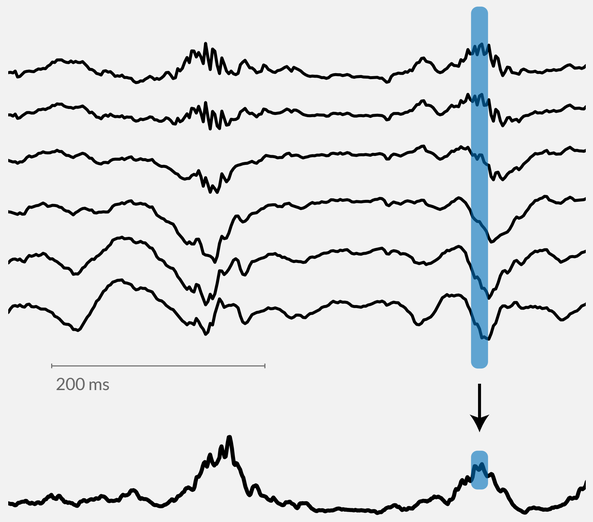
Current approach



Select one channel
Manually; in pyramidal cell body layer

Band-pass filter
A linear combination of the past few samples

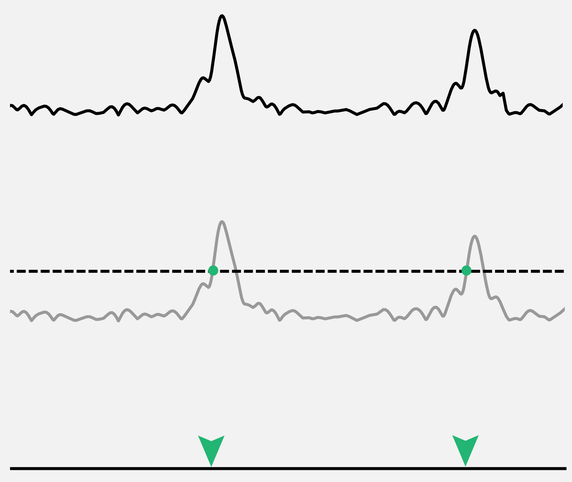
New approach



Use all channels
Without using any temporal information

Second stage of research will use both temporal and spatial information simultaneously

Spatial filter
A linear combination of present channel voltages



Envelope
Absolute value suffices in practice

Threshold
Based on envelope signal statistics

Detected SWR's

Outlook

- Quantify per algorithm: Latency? False alarms and missed detections?
- Coefficients for linear combinations can be found in many ways: investigate assumptions and merits of each method
- Spatiotemporal filtering
- Non-linear filtering (SVM, MLP); Use of NARMA models (RNN).
- Machine learning with filter outputs.
- Generative probabilistic model of SWR's to make detections via Bayesian inference
- Current analysis is done offline, using scientific Python stack and Kloosterman lab software
- Implement algorithm in C++ for real-time use in experiments; Incorporate in *"falcon"* software Ciliberti & Kloosterman, 2017

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