Chair for Cognitive Systems
Department of Electrical and Computer Engineering
Technische Universität München

Real-time sharp wave detection and stimulation.

International Neuroengineering Symposium 2022

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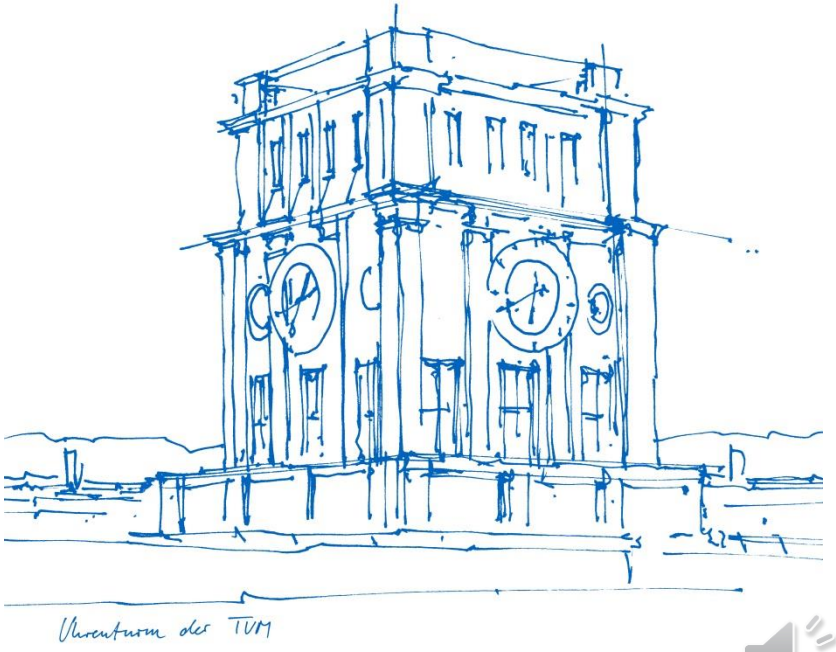


Sharp wave ripples (SWR) are brief, highly synchronous, fast oscillations observed in the CA1 region of the hippocampus

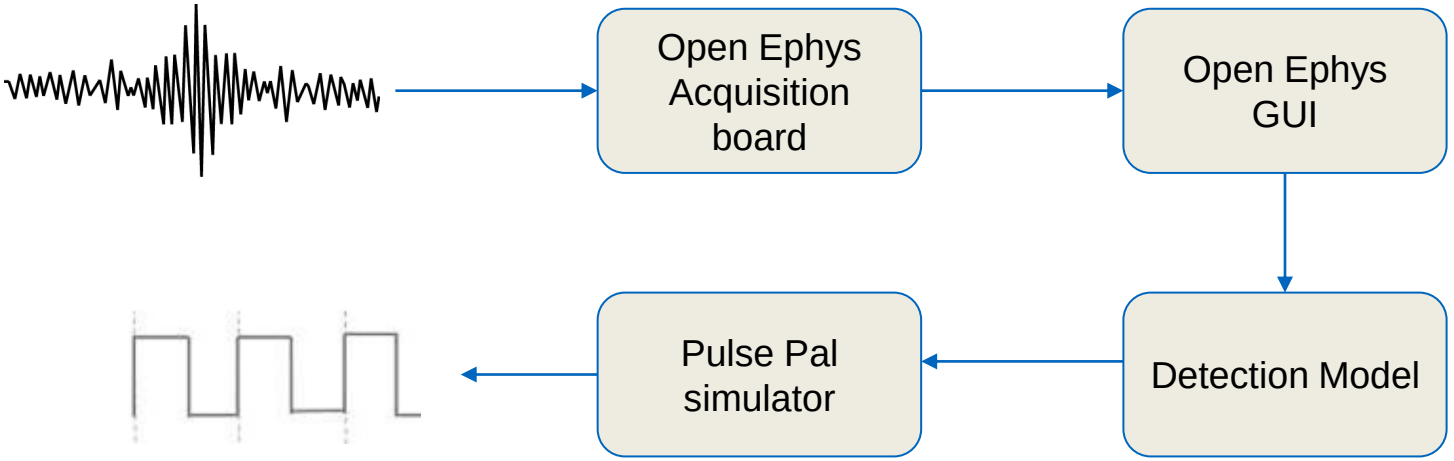
Hippocampal sharp wave ripples have been identified as key biomarkers of important brain functions such as memory consolidation and recall of episodic memory

Understanding their underlying mechanisms in healthy and pathological brain function and behavior rely on accurate SWR detection. Disruption of the SWR events by electrical stimulation of the ventral hippocampal commissure has provided the first line of evidence that the consolidation of task-related memories is linked to the SWR periods of slow-wave sleep

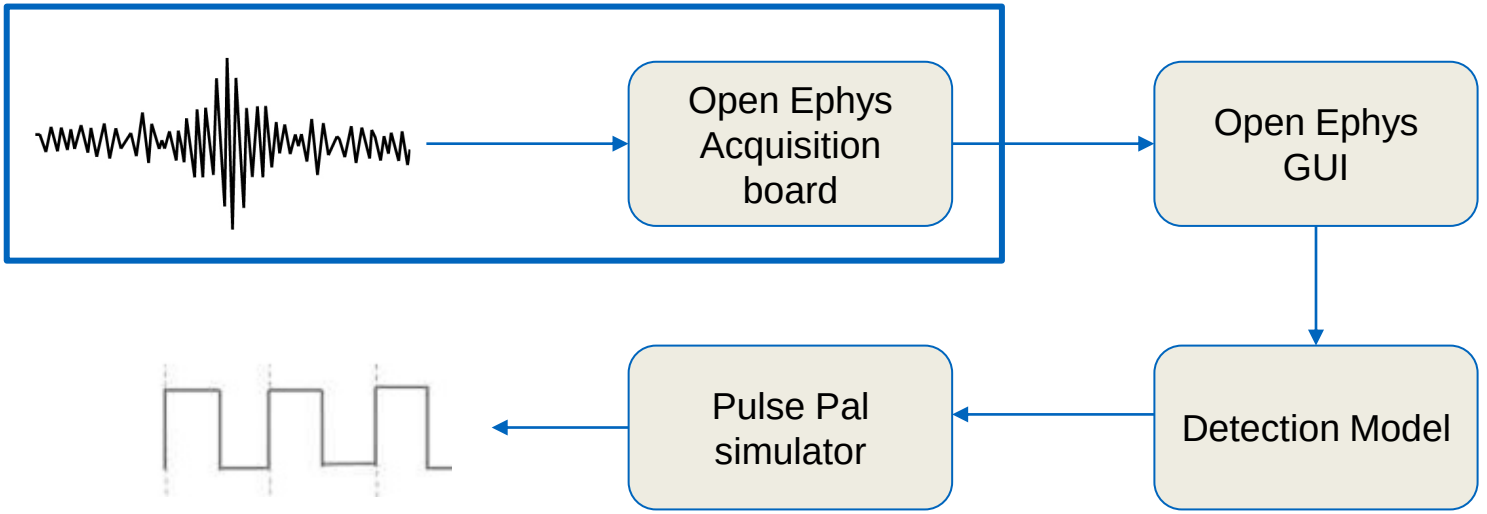
M. P. Karlsson. et al. 2009

This project is aimed at **building a real-time system for detecting sharp wave ripples** that can be used in a closed-loop perturbation of the temporally patterns of the sharp wave ripples.

Methods

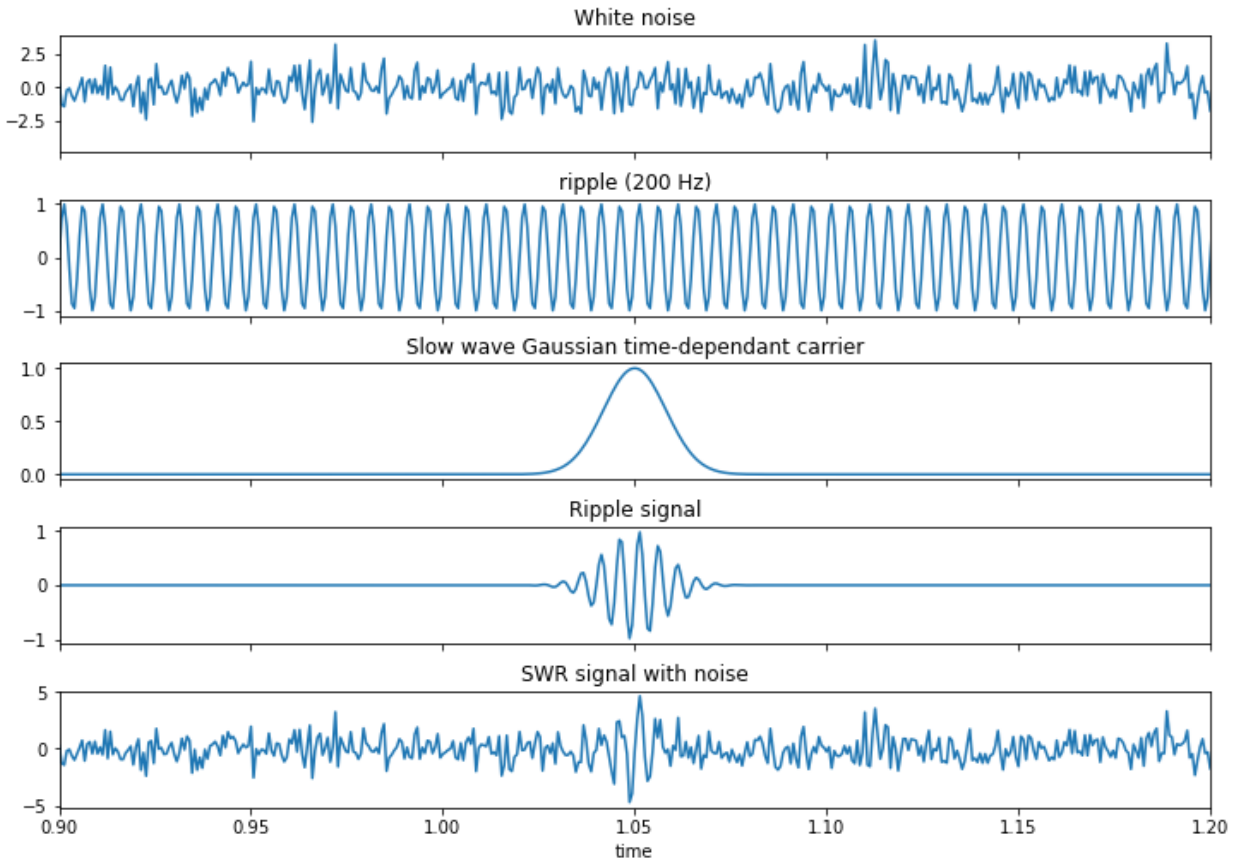

Open Ephys Acquisition board
Open Ephys GUI
Detection Model
Pulse Pal simulator

Methods

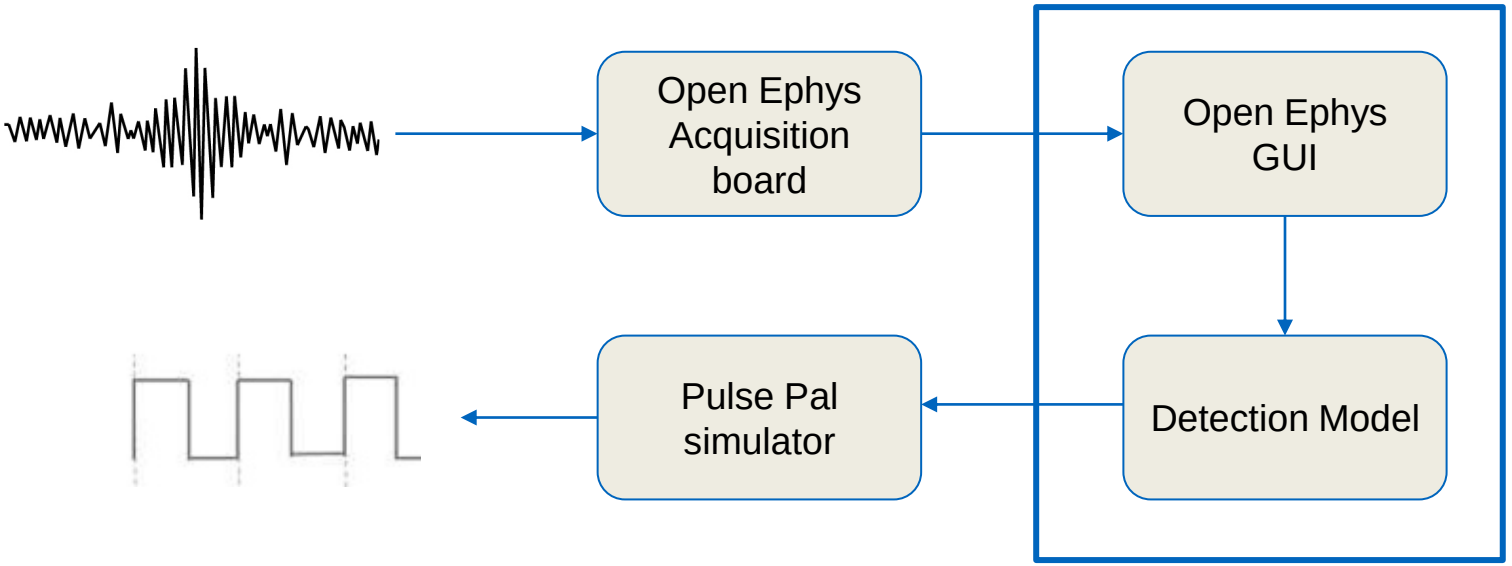


First: Coding two data-generating pipelines to be passed through the real-time system:
One for generated synthetic data, and one pseudo-experiment for a prerecorded real data.

Sharp Wave Ripple Model

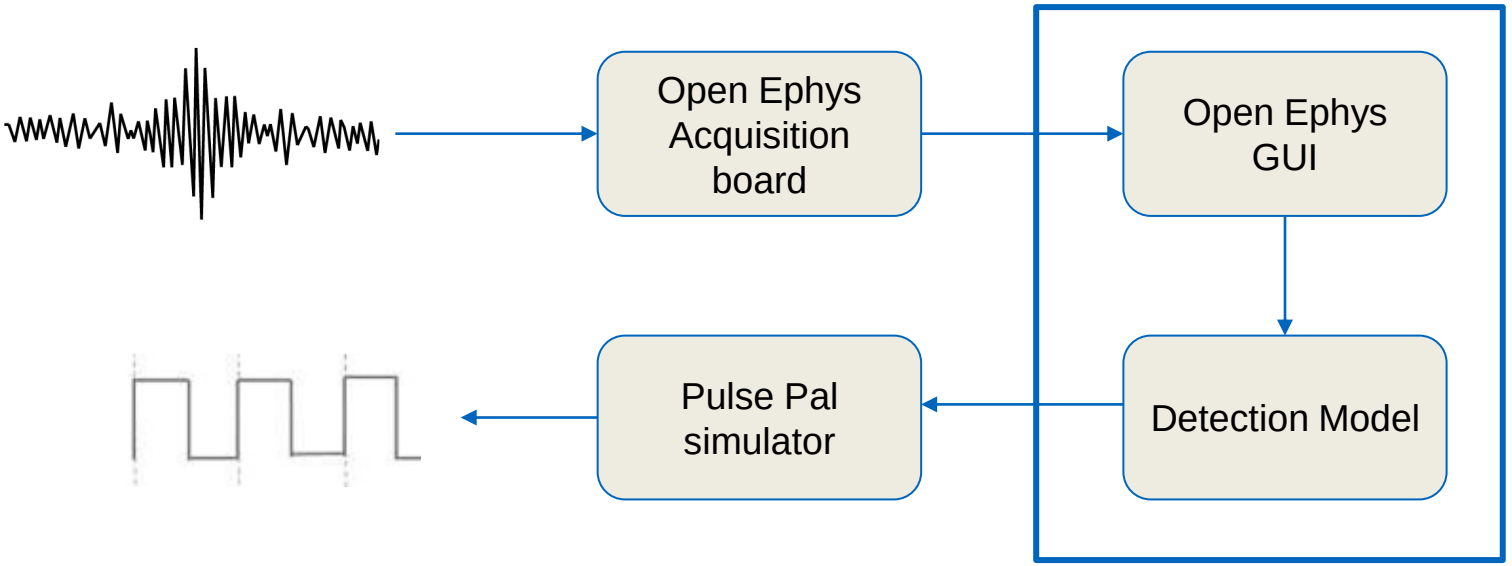


Methods



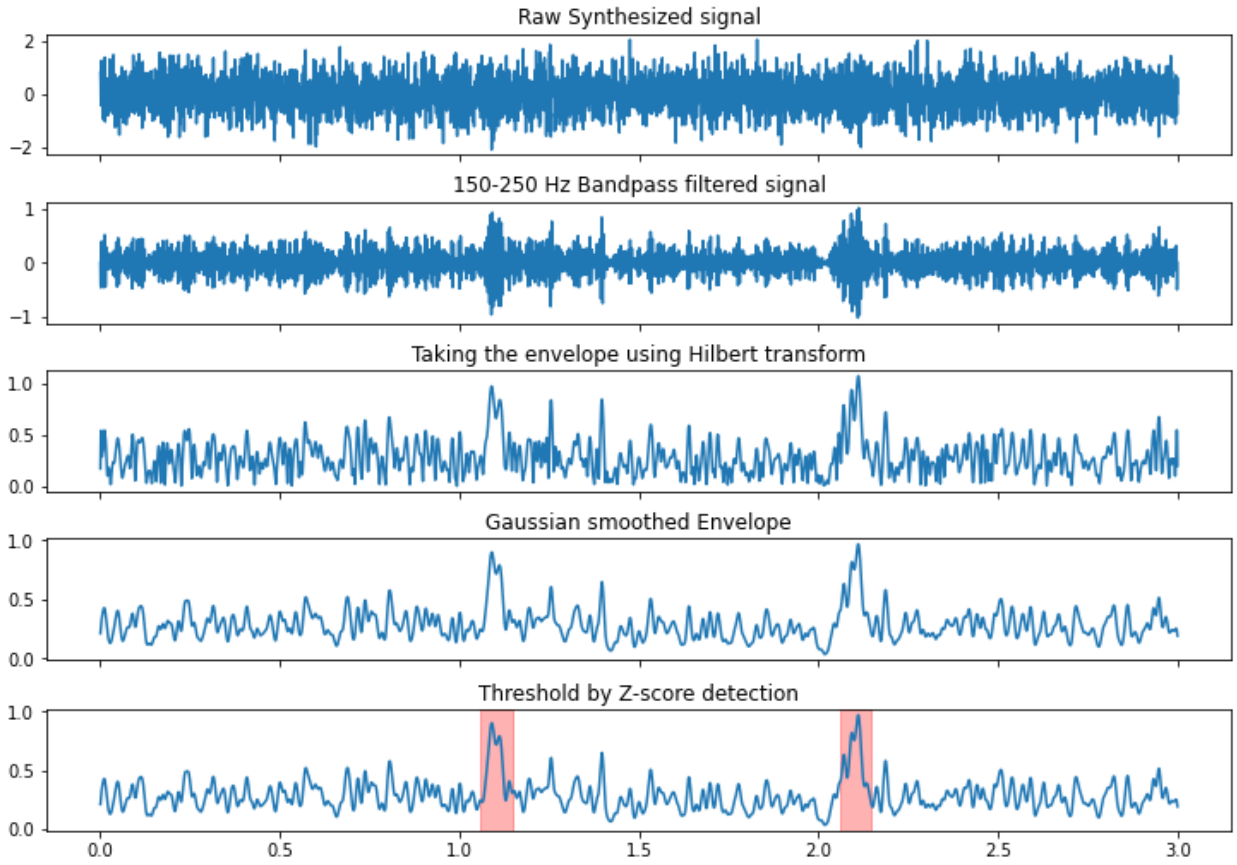
Second: Implementing the preprocessing and the detection model based on the statistical characteristics of the data.

Methods



Third: Interfacing the code with OpenEphys GUI using PythonPlugin.

Signal Processing and detection model



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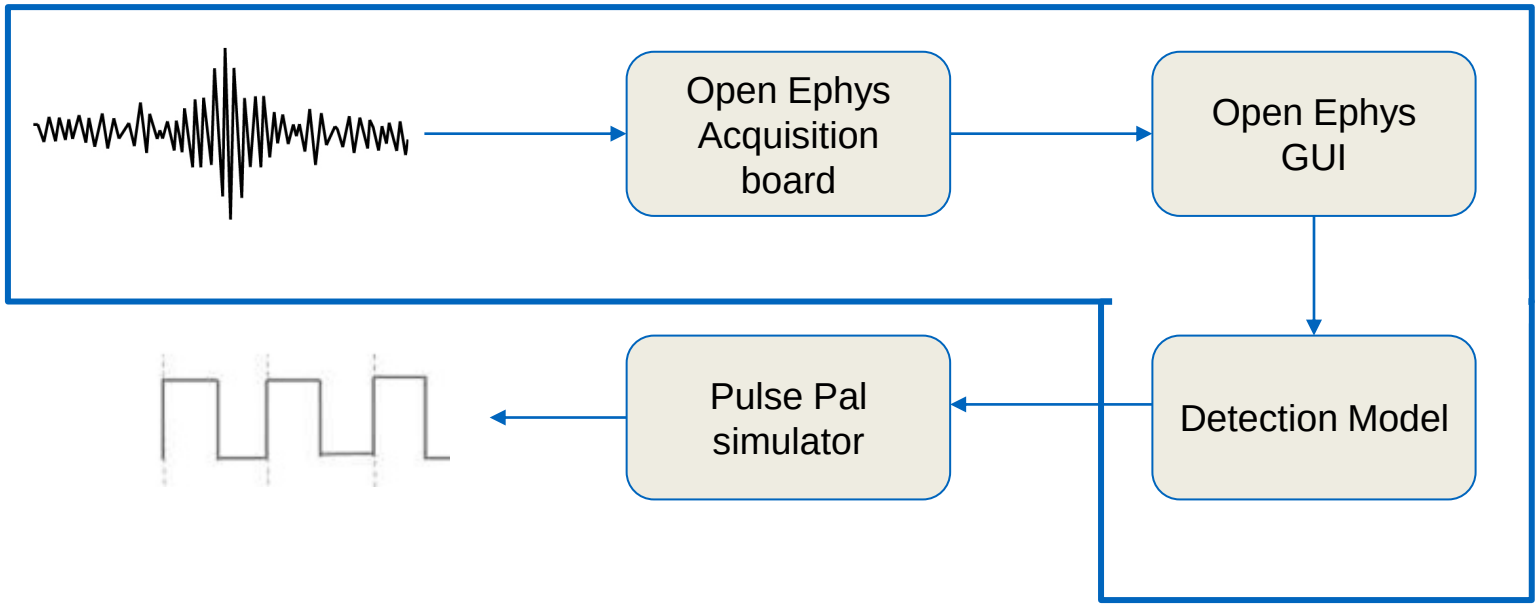
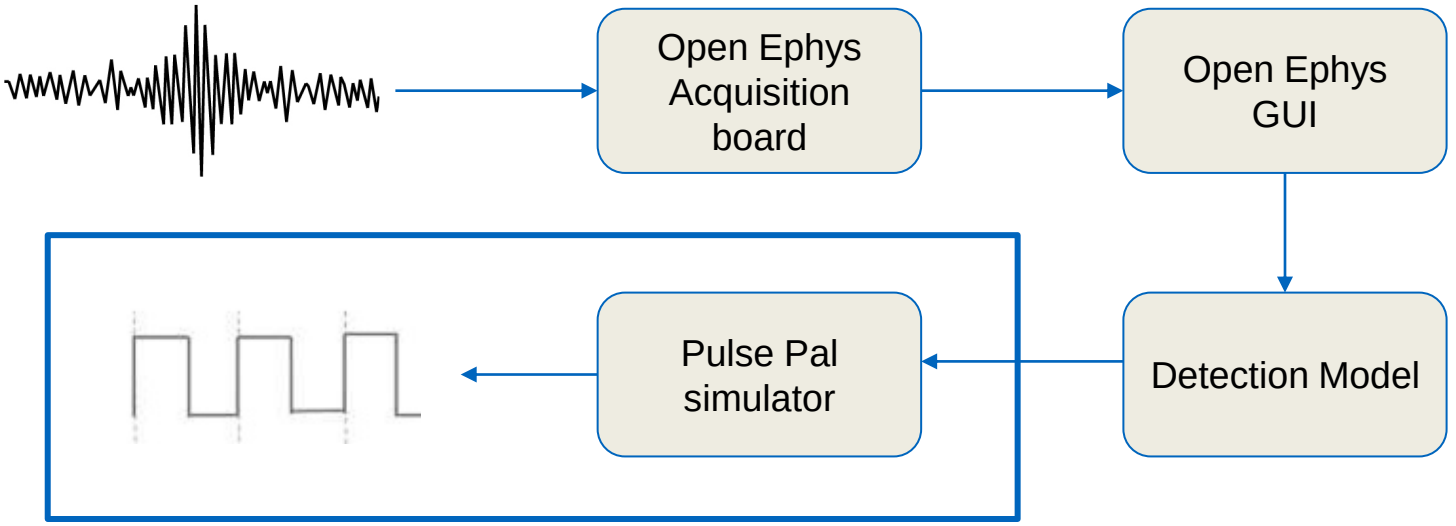


Fourth: Performing the real-time pipeline to extract a command output and executing it on the Open Ephys Acquisition Board

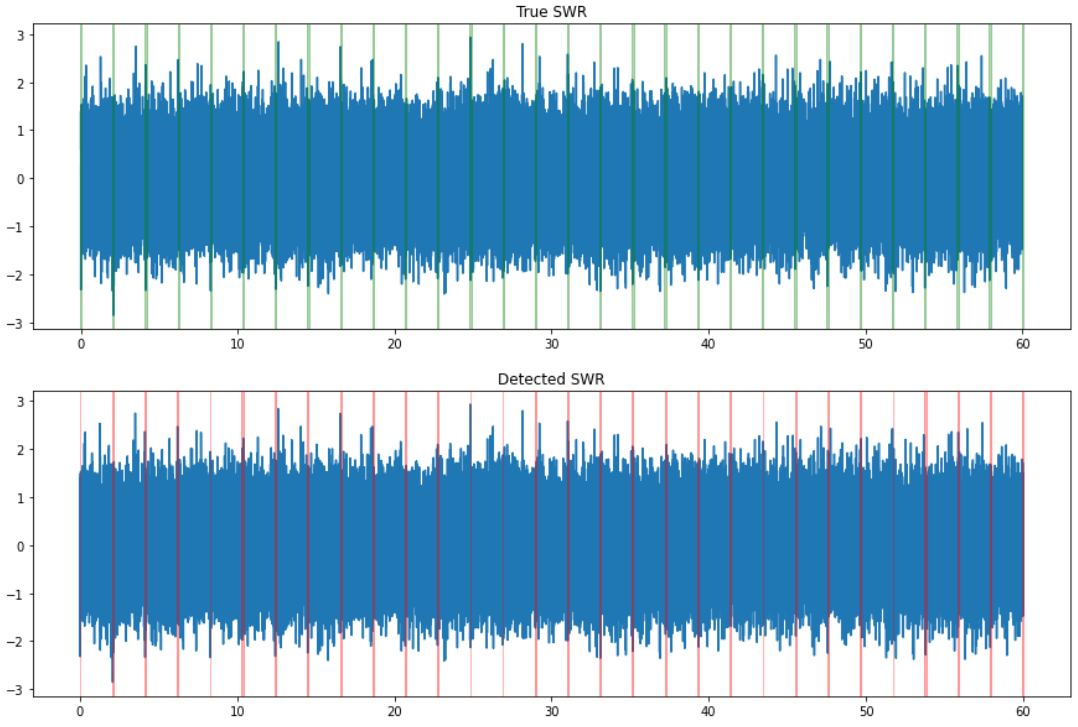
Methods



Fifth: Using the command output from open Ephys to stimulate the Fiber-coupled LED using Pulse Pal Plugin.

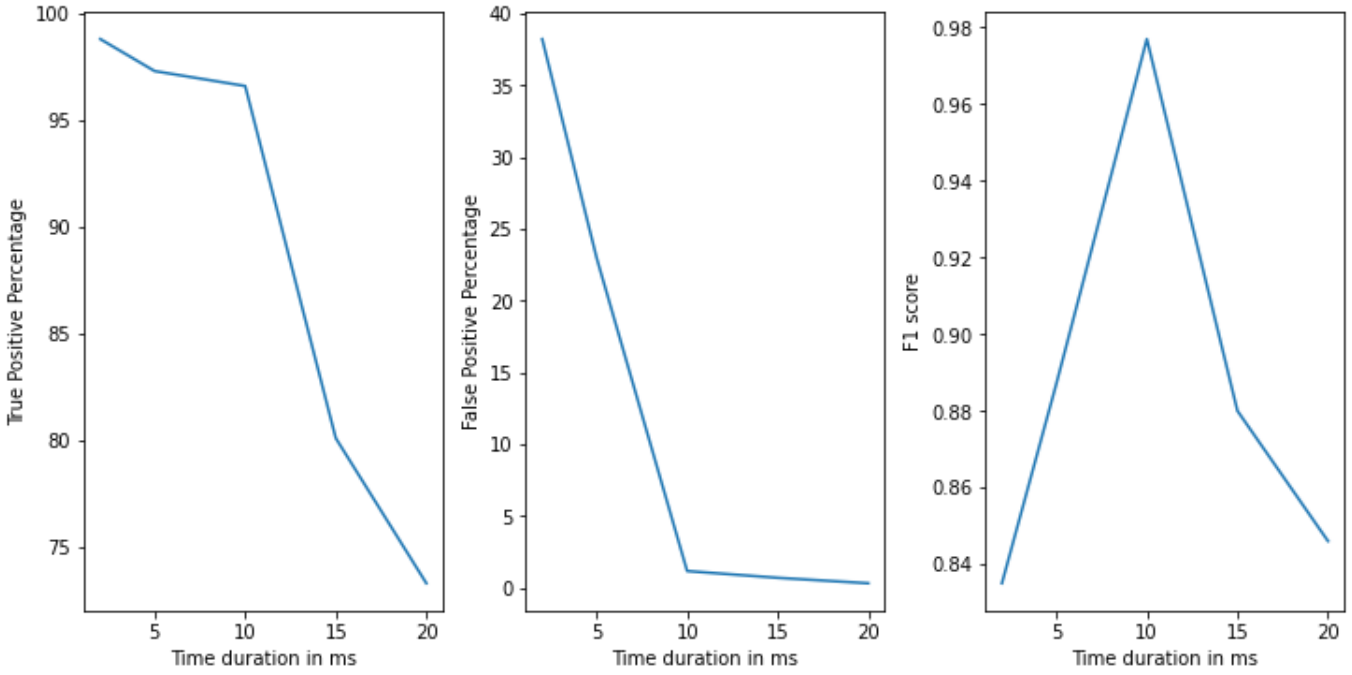
Results

- The duration time needs to be optimized; the minimum time that the signal must stay above the threshold to be detected.
- It can be different from species to species. Previous evaluation is done mostly on rat data.
- New investigation has to be done on Zebra Finch
- 15 minutes of the dataset injected randomly with 450 SWR signals.



Results

Quantifying the best parameter			
Parameter	TP%	FP%	F1 score
2ms	98.8 %	38.2 %	0.835
5ms	97.3%	22.98%	0.887
10ms	96.66%	1.16%	0.977
15ms	80.1%	0.69%	0.88
20ms	73.3%	0.31%	0.846



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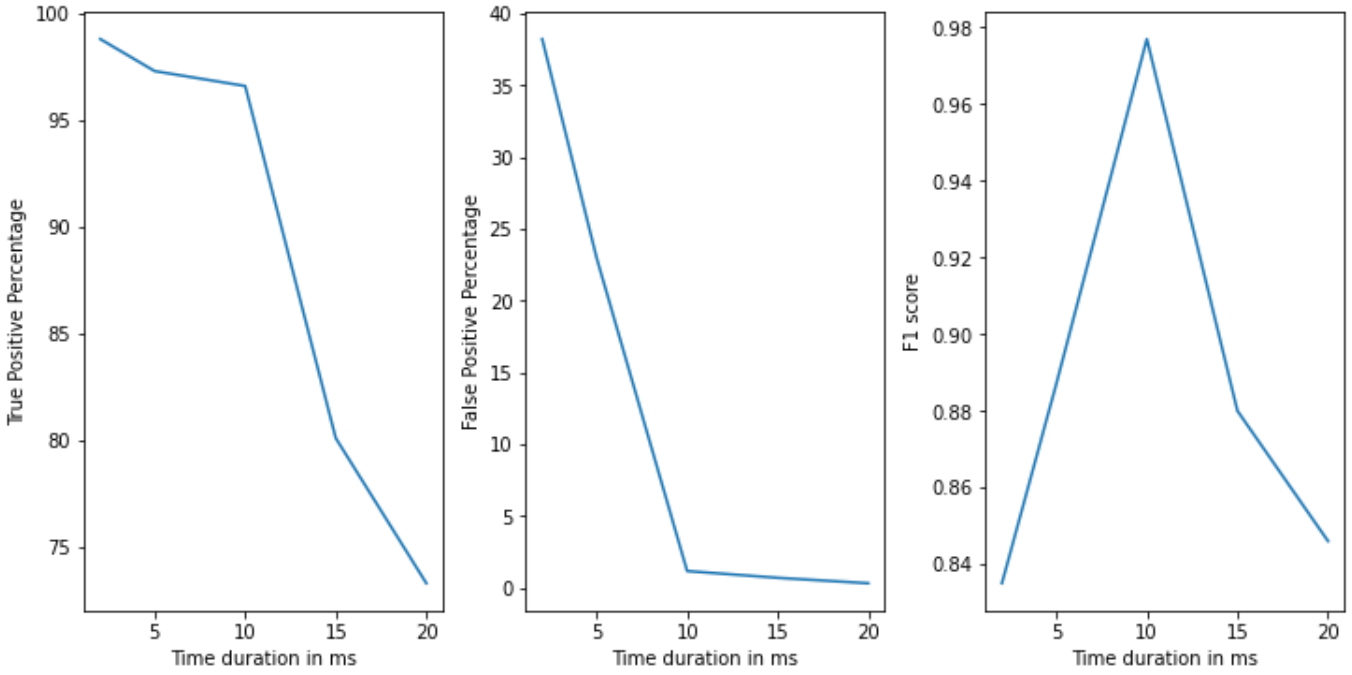

Discussion and conclusion:

- The results shows that **10ms** is the optimum duration time.
- The detection model performed 5 false positive from the 15 minutes. (0.3 FP per minute) and it performed 15 false negative out of 450 SWR in 15 minutes recording.
- Less than **<20ms latency**, which less than the speed duration of the signal, and around **97% accuracy** makes it a reliable model to be implemented in the closed-loop system.

Thank you

See you in the poster session