

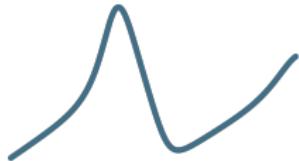


A Python toolbox for uncertainty quantification and sensitivity analysis of computational neuroscience models.

Simen Tennøe¹, Geir Halnes², Gaute Einevoll^{1,2}

¹University of Oslo, ²Norwegian University of Life Sciences

Overview of this talk

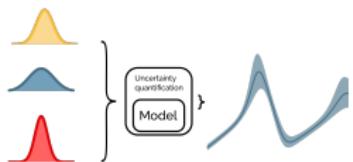


**Why we need uncertainty
quantification**

Overview of this talk



Why we need uncertainty quantification

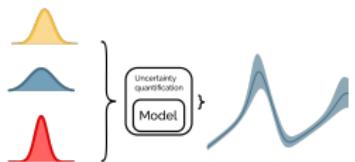


**Uncertainty quantification
and sensitivity analysis**

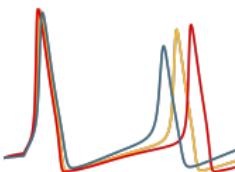
Overview of this talk



Why we need uncertainty quantification

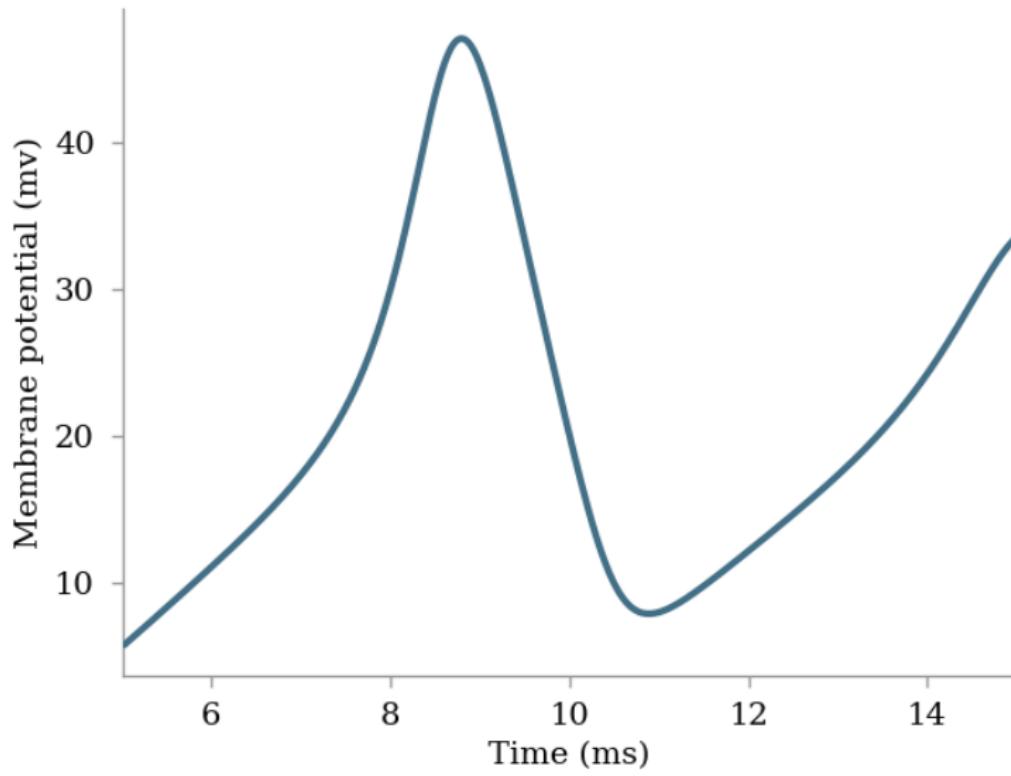


Uncertainty quantification
and sensitivity analysis



How Uncertainty is tailored
towards neuroscience

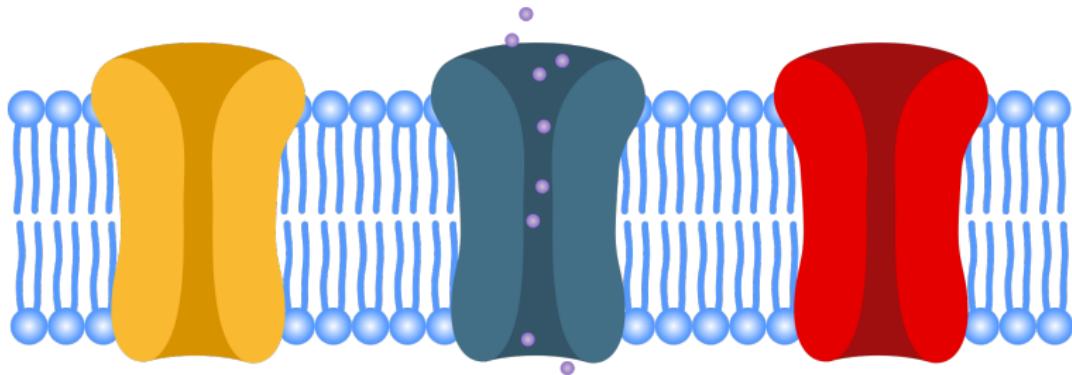
Membrane potential of the Hodgkin-Huxley model with a step current



The equation describing the Hodgkin-Huxley model

$$I = C_m \frac{dV_m}{dt} + \bar{g}_K(\dots) + \bar{g}_{Na}(\dots) + \bar{g}_L(\dots)$$

The Hodgkin-Huxley model has three types of ion channels



$$\bar{g}_{\text{Na}}$$

Potassium
conductance



$$\bar{g}_{\text{K}}$$

Sodium
conductance

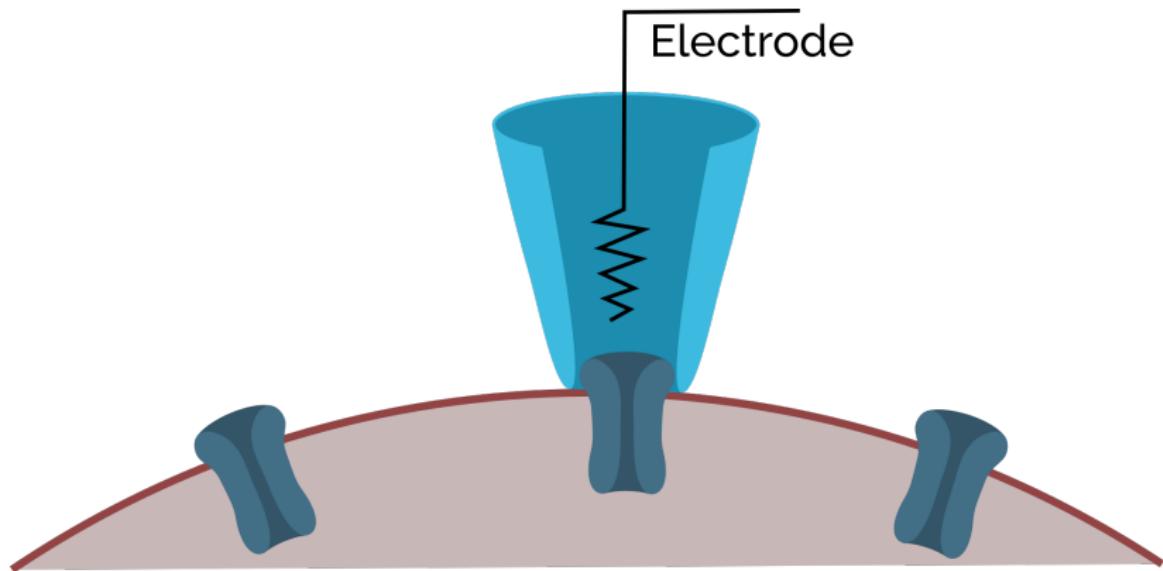


$$\bar{g}_l$$

Leak
conductance

The parameters do not have exact fixed values

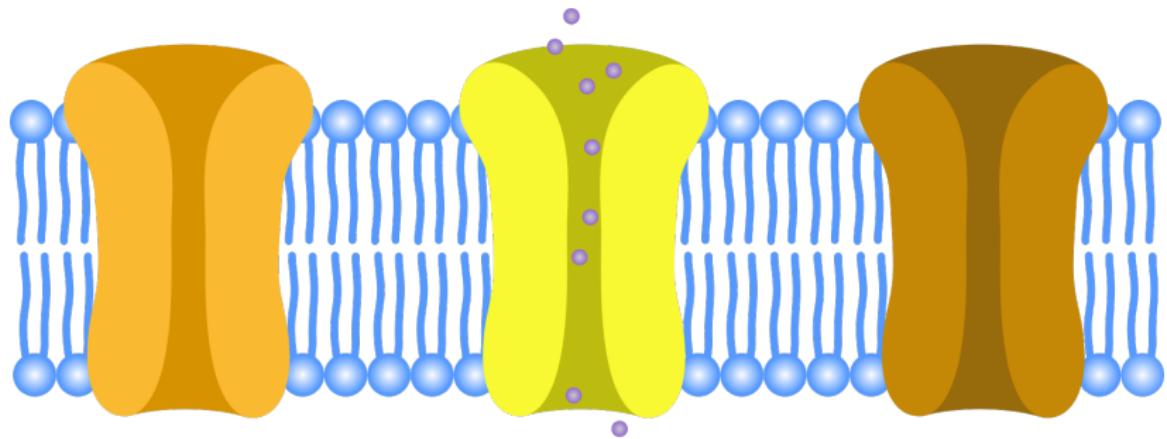
Measurement uncertainty in neuroscience



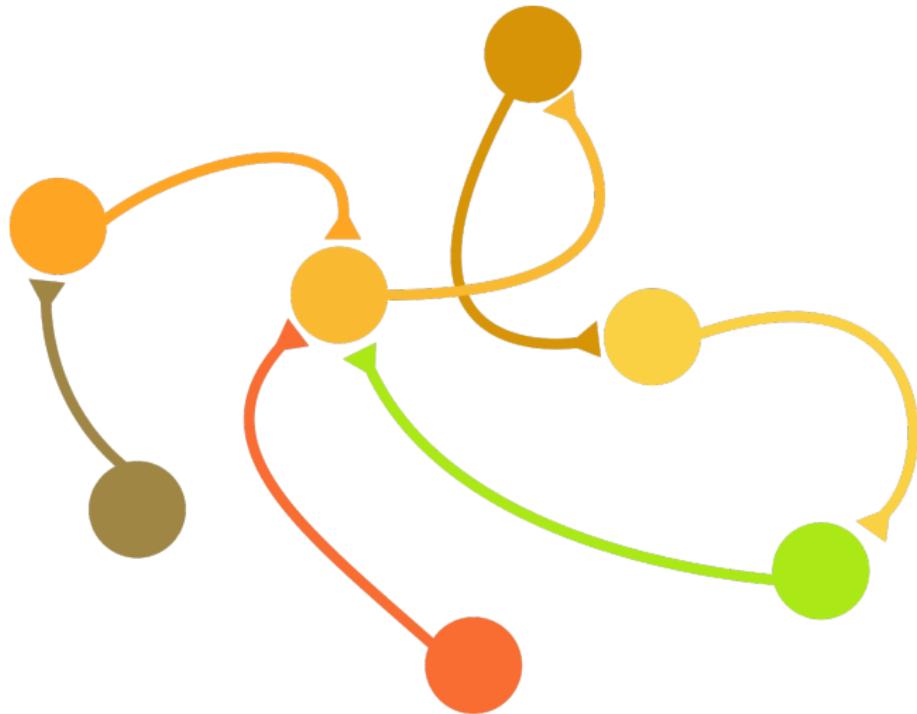
Biological variability: parameters change over time



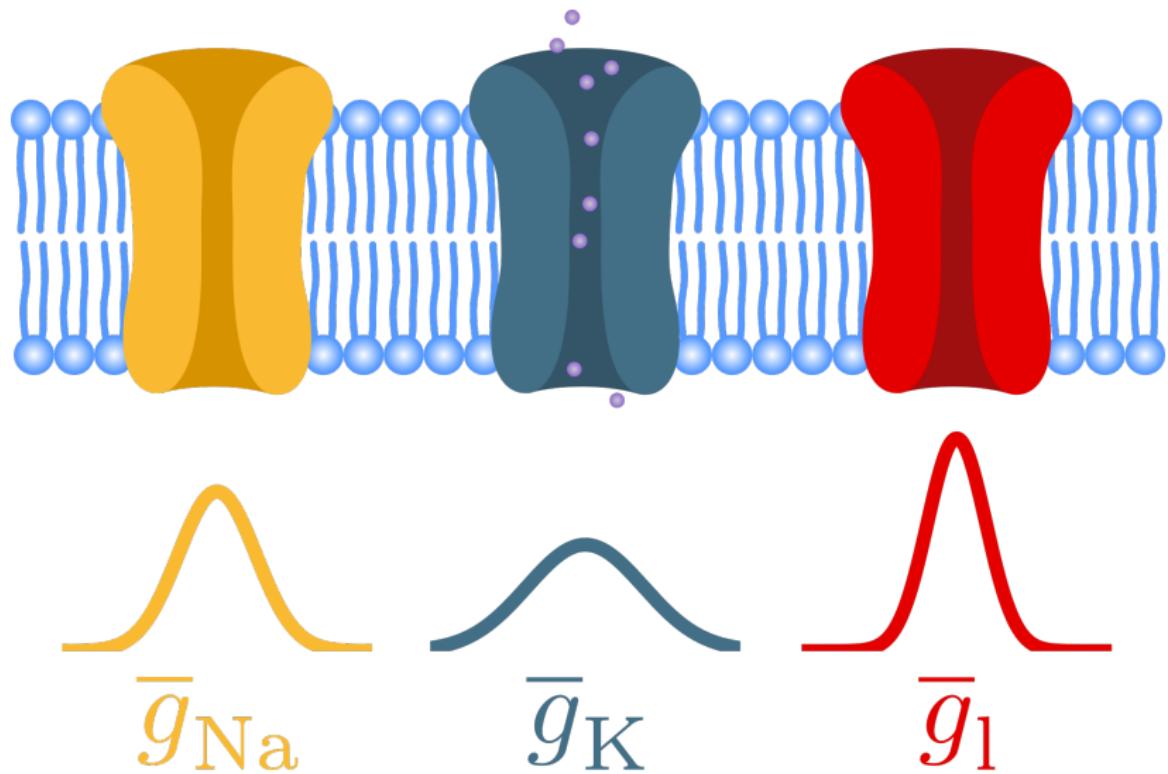
Biological variability: parameters vary within a neuron



Biological variability: parameters vary between several neurons of the same type

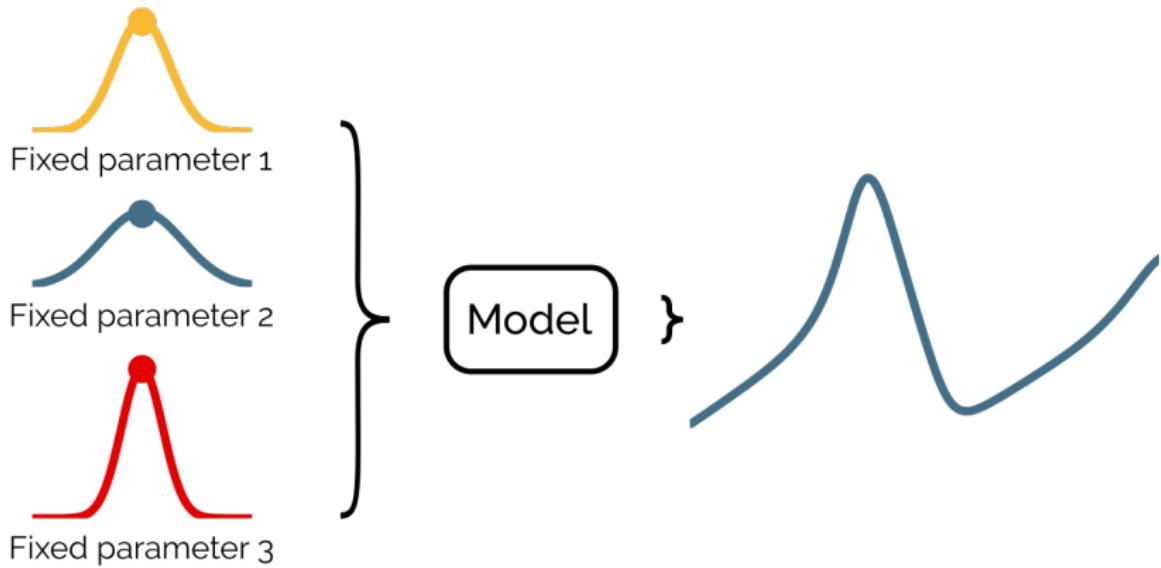


Parameters are best described by distributions

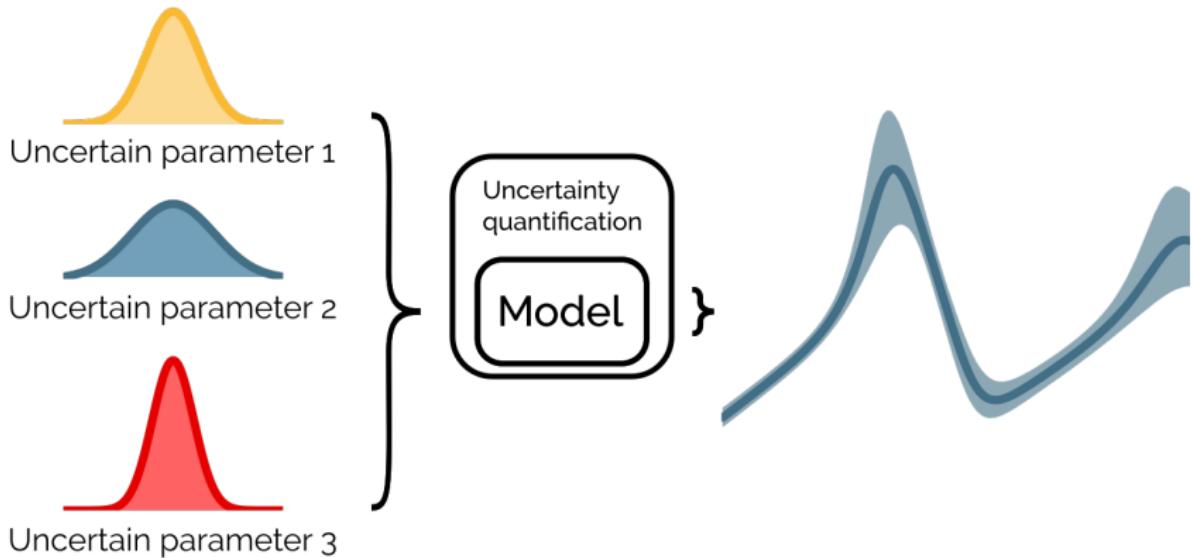


Uncertainty quantification enables us to take the effects of uncertain parameters into account

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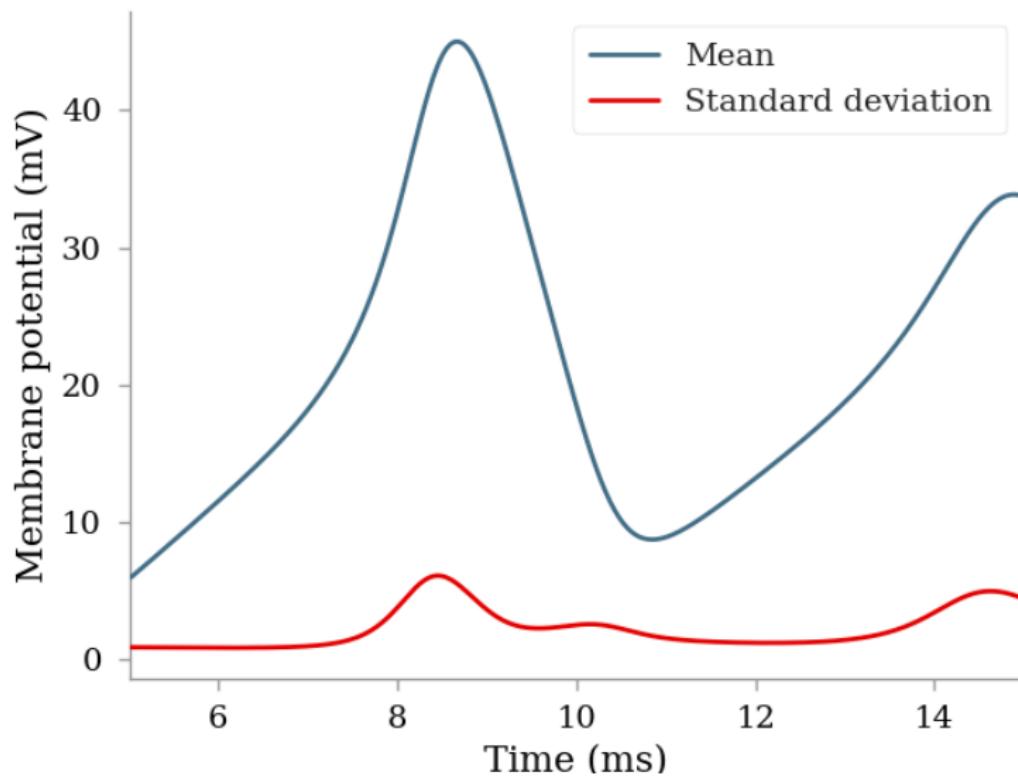


A Python toolbox for uncertainty quantification

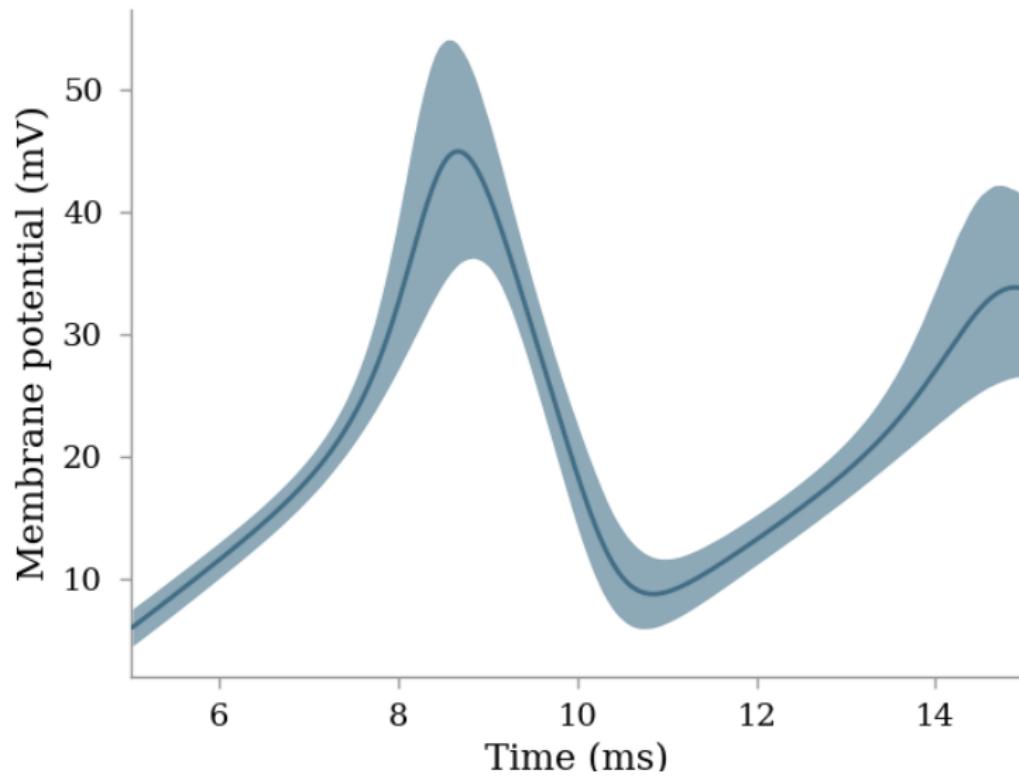
Uses both:

- ▶ Highly efficient **polynomial chaos expansions**
- ▶ Traditional **quasi-Monte Carlo methods**

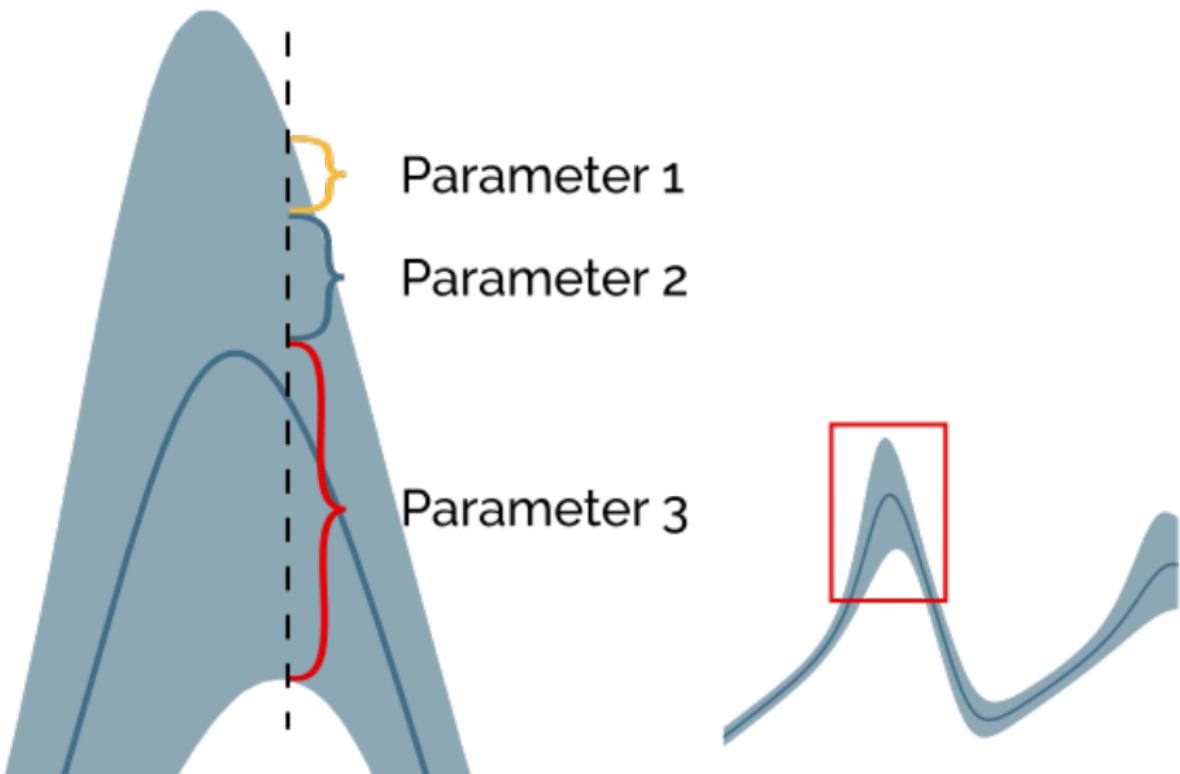
Mean and standard deviation of the Hodgkin-Huxley model with a step current



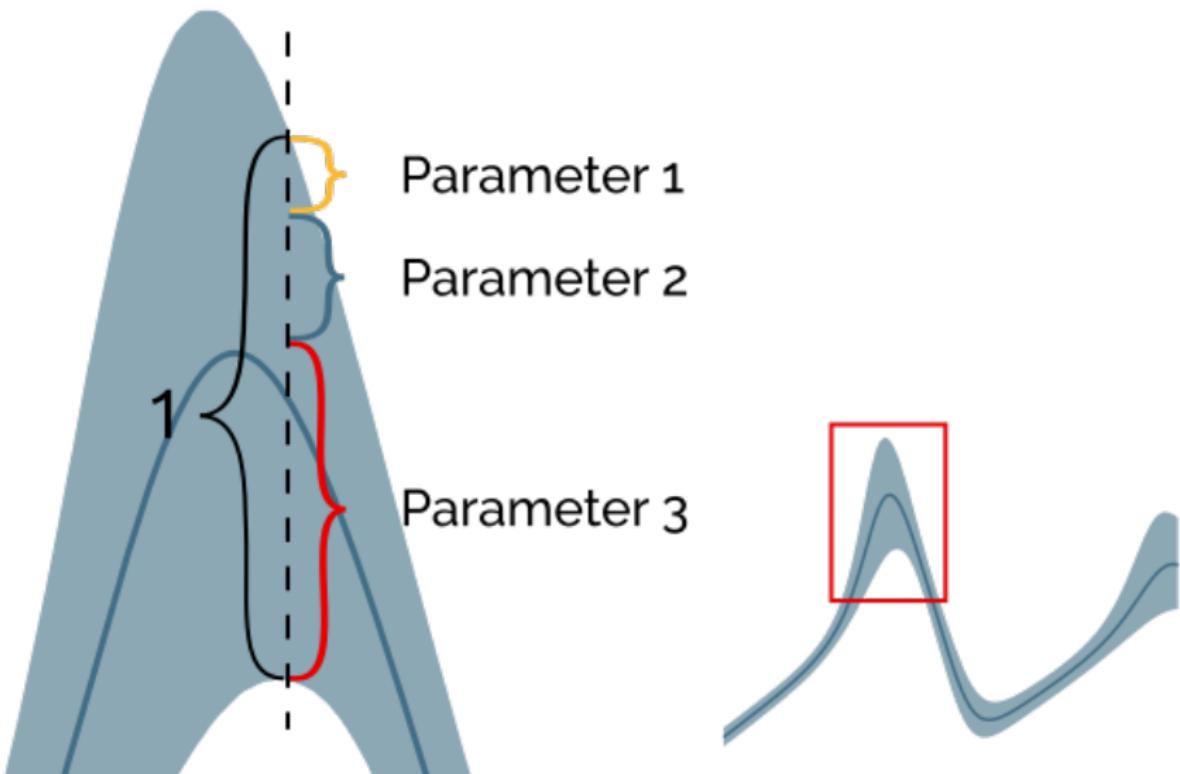
90% prediction interval of the Hodgkin-Huxley model with a step current



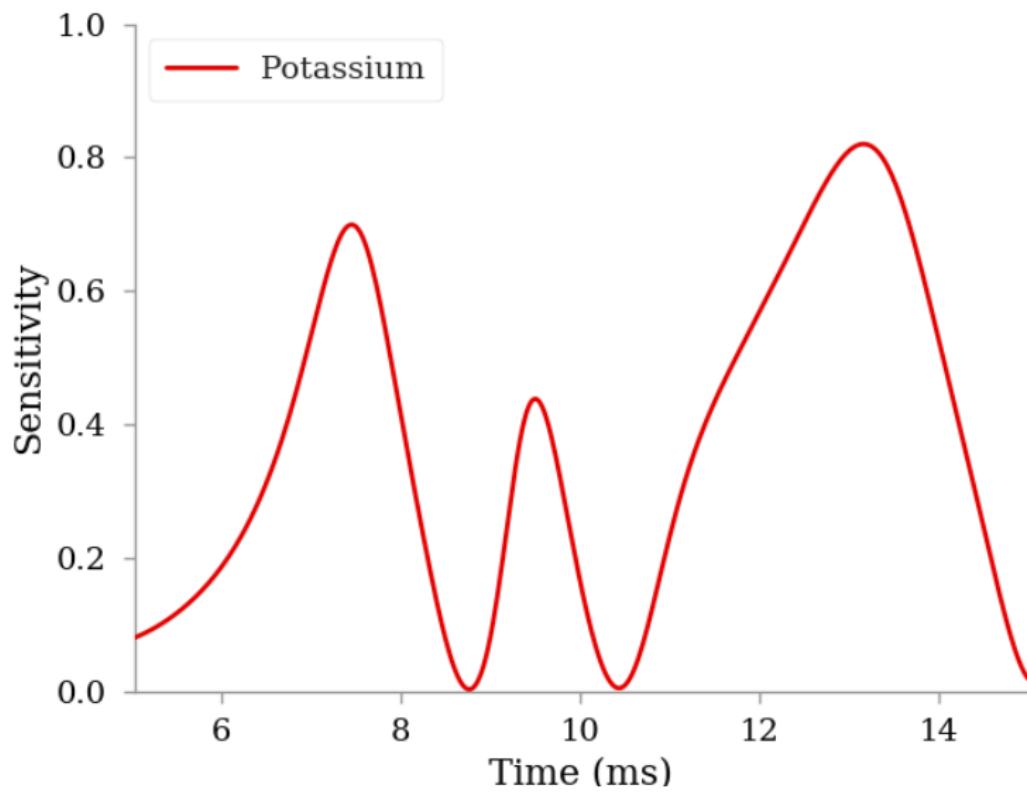
Sensitivity analysis quantifies how much of the uncertainty each parameter is responsible for



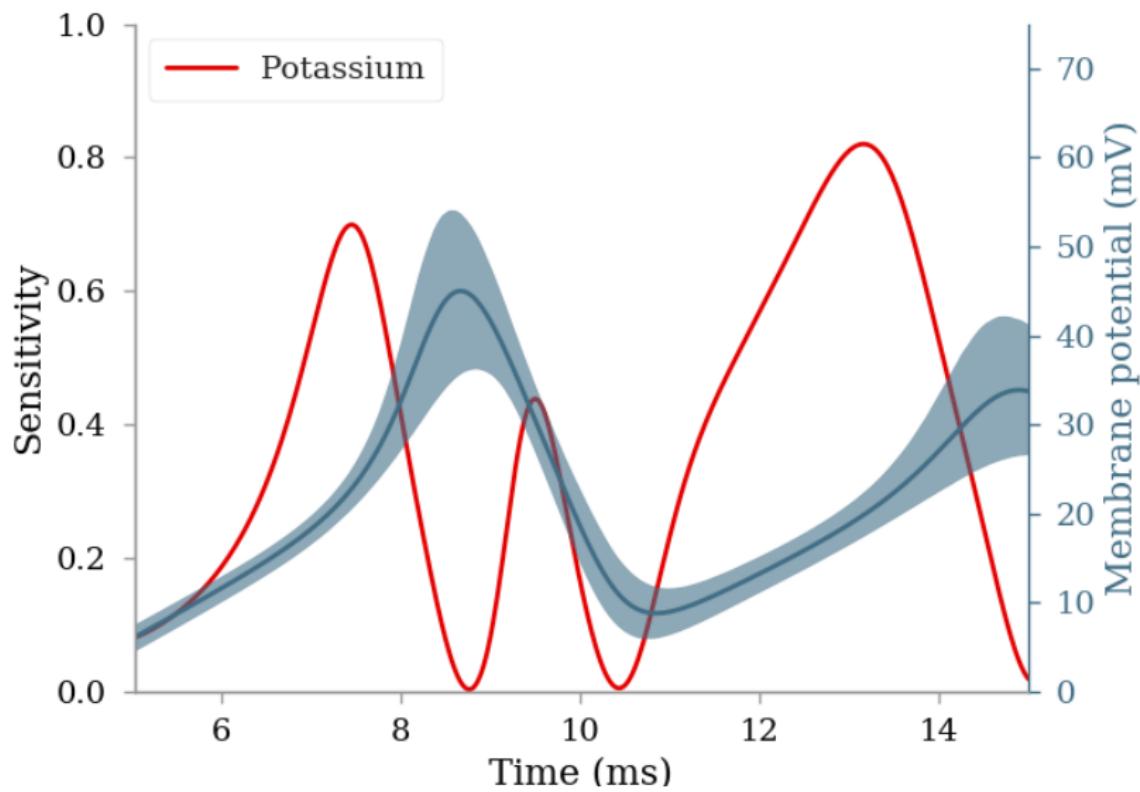
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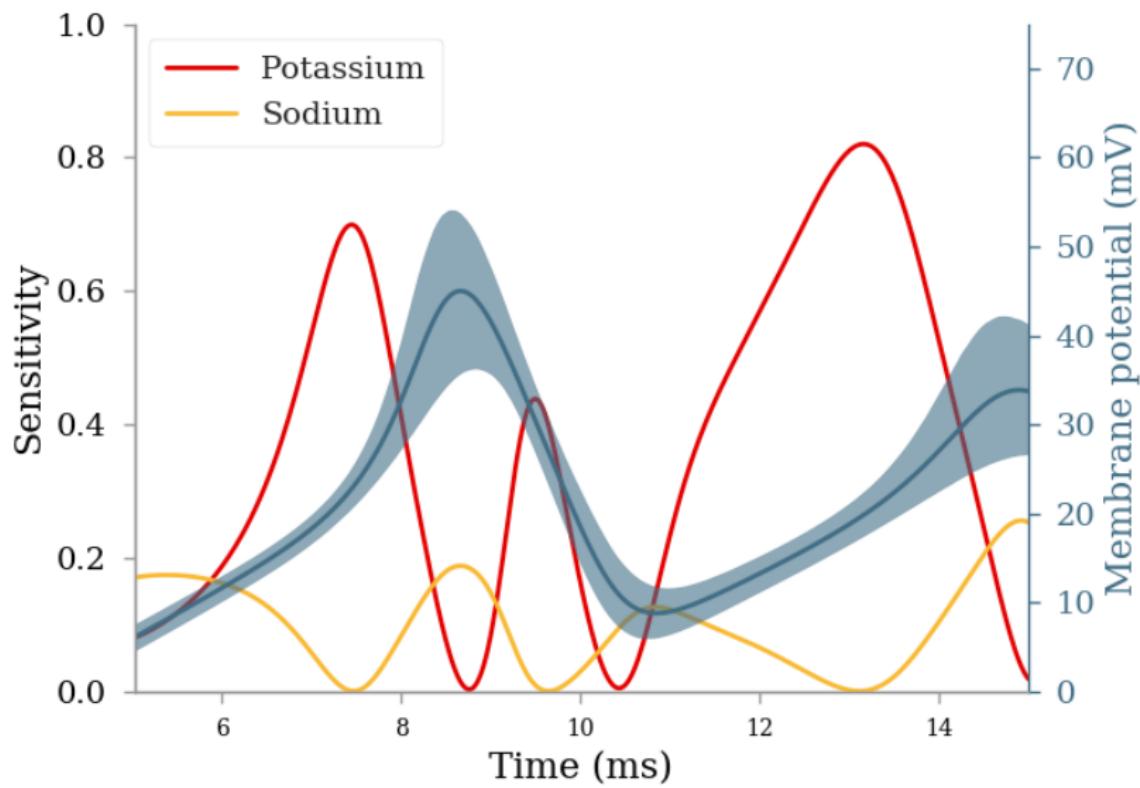
Sensitivity of the conductances in the Hodgkin-Huxley model



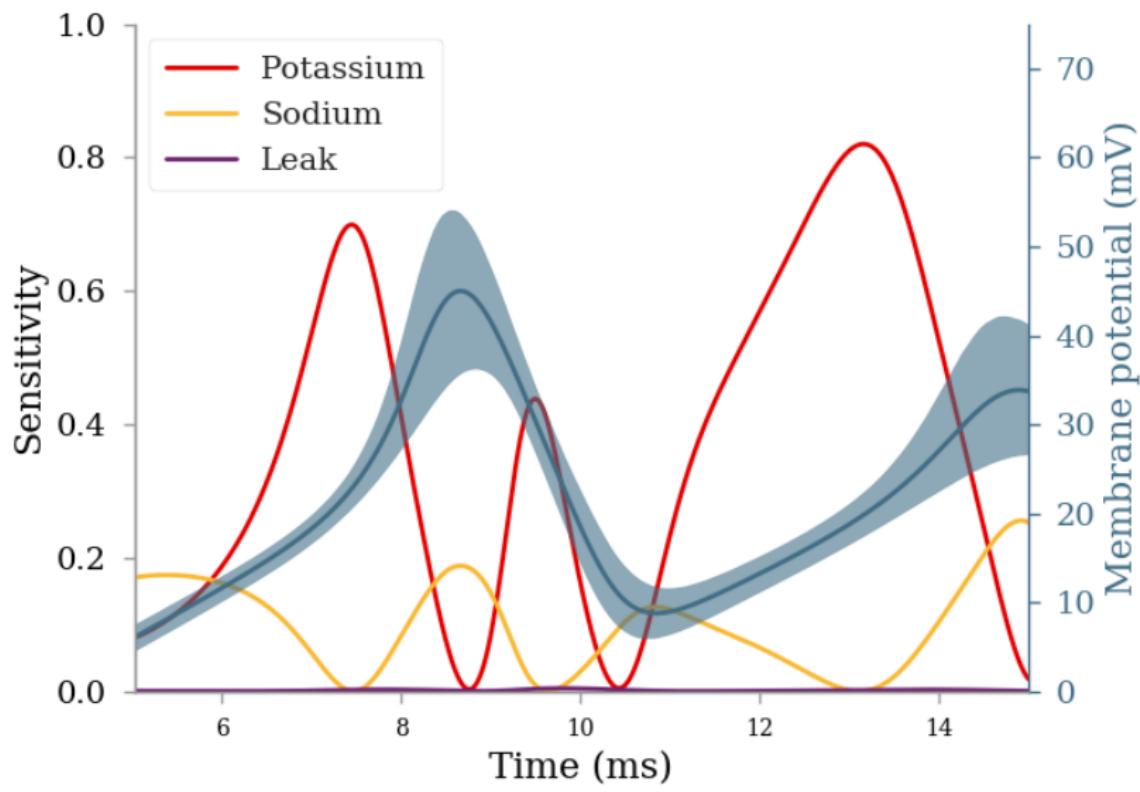
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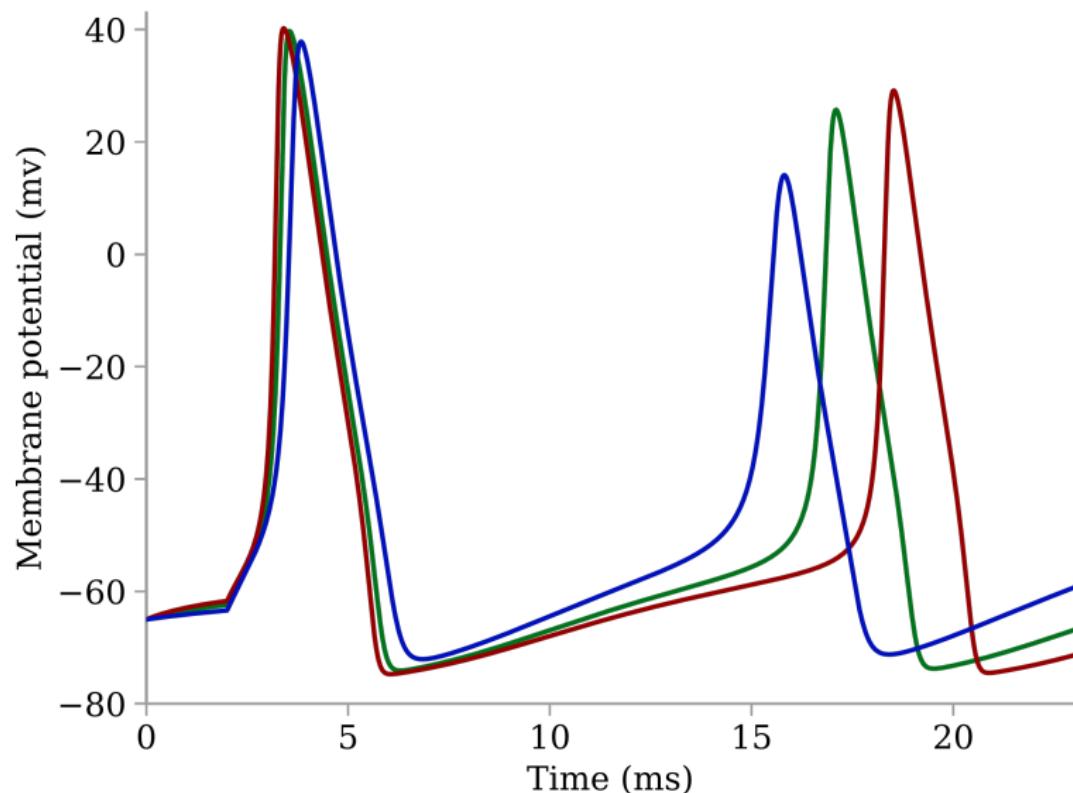
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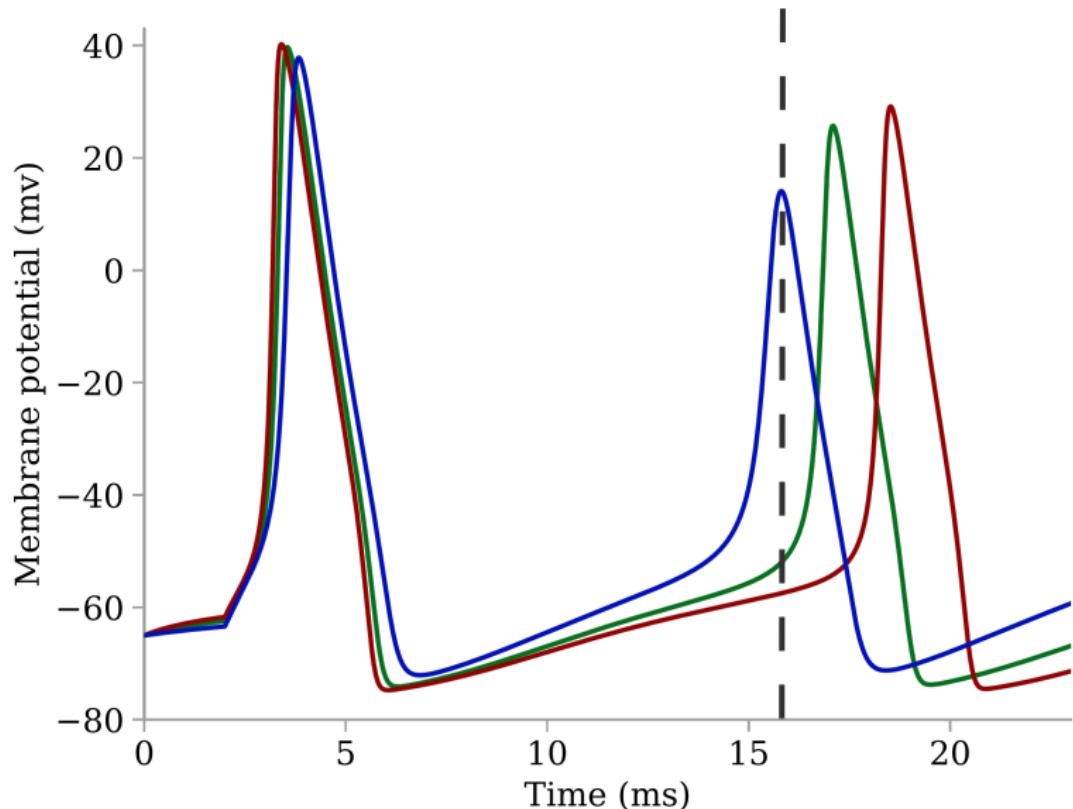
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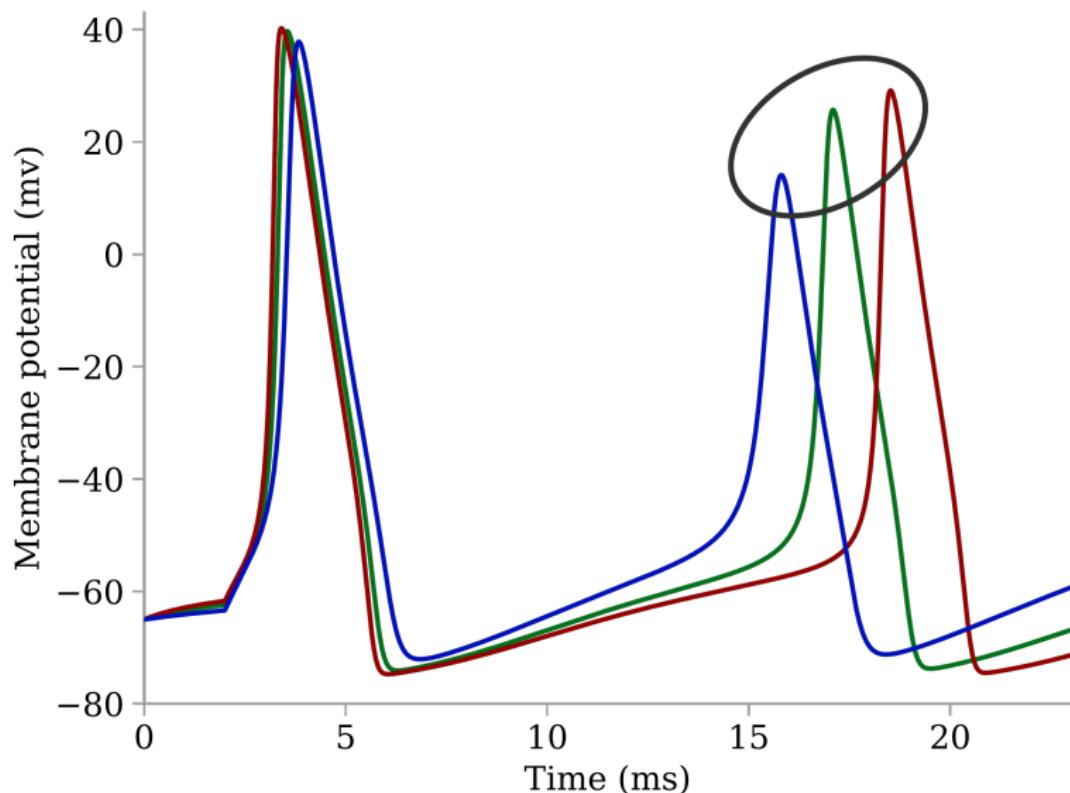
Pointwise comparison of model results give large differences due to small time shifts in spikes



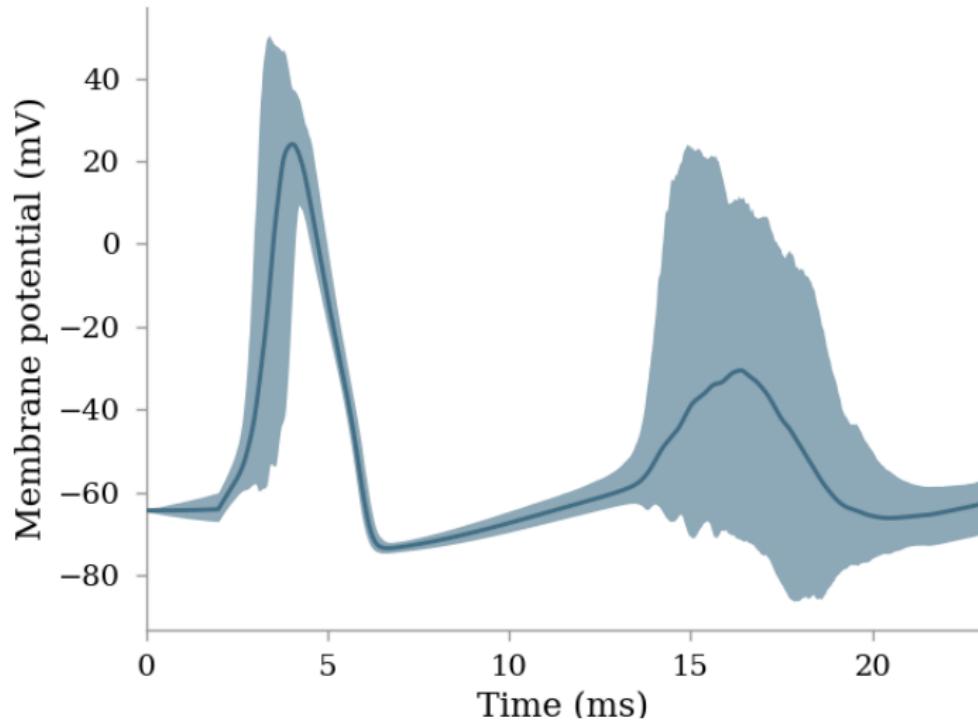
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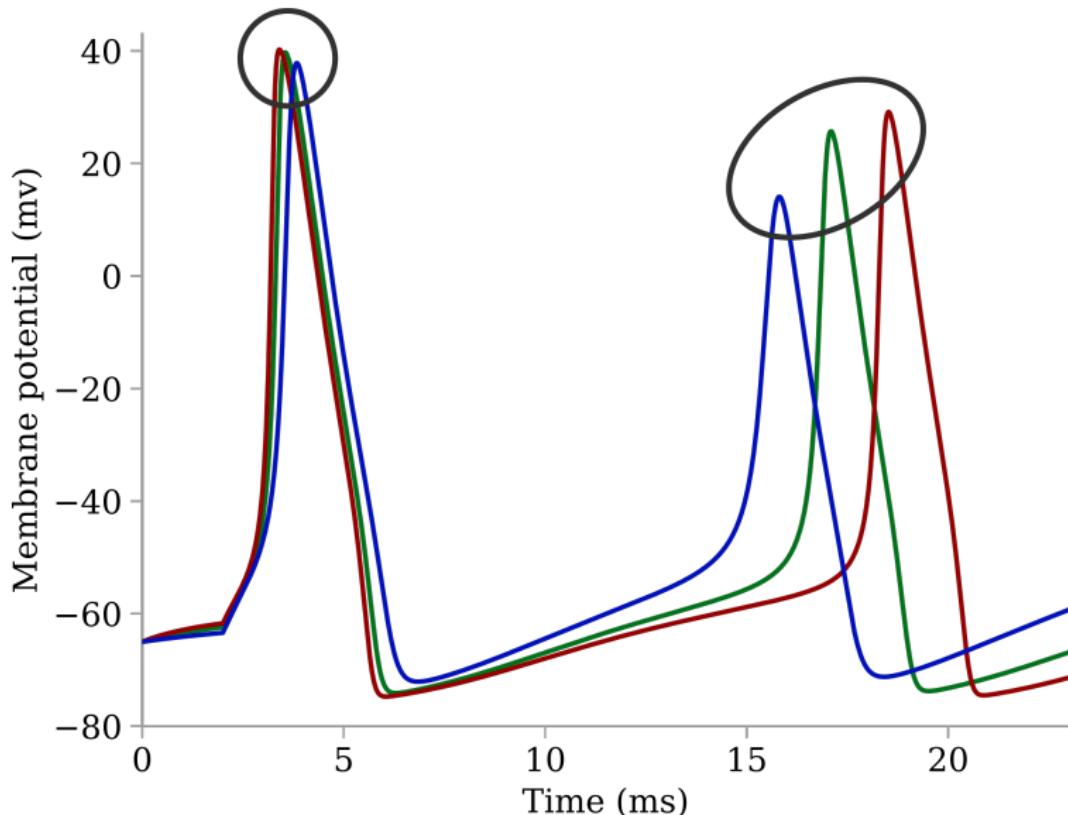
Pointwise comparison of model results give large differences due to small time shifts in spikes



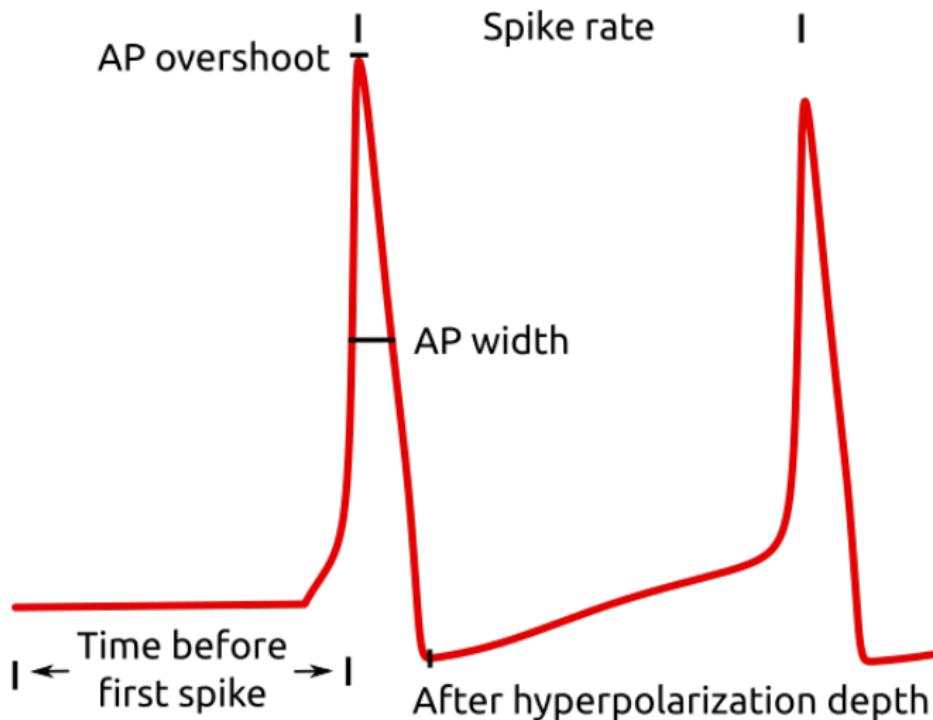
The time shifted spikes cause large variance



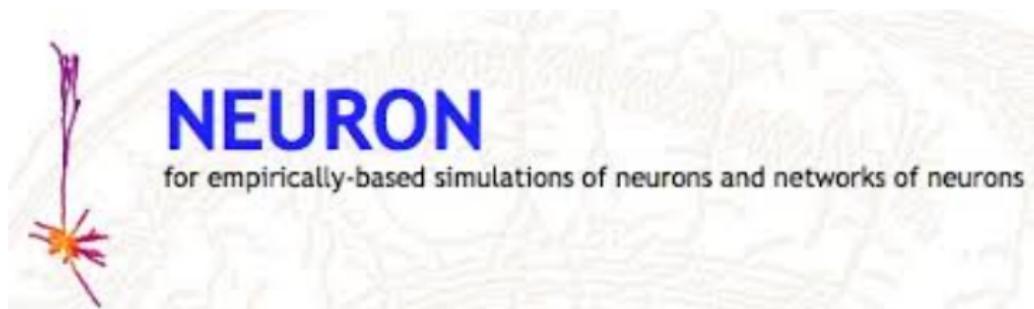
The solution is to compare features of the model, such as the number of spikes



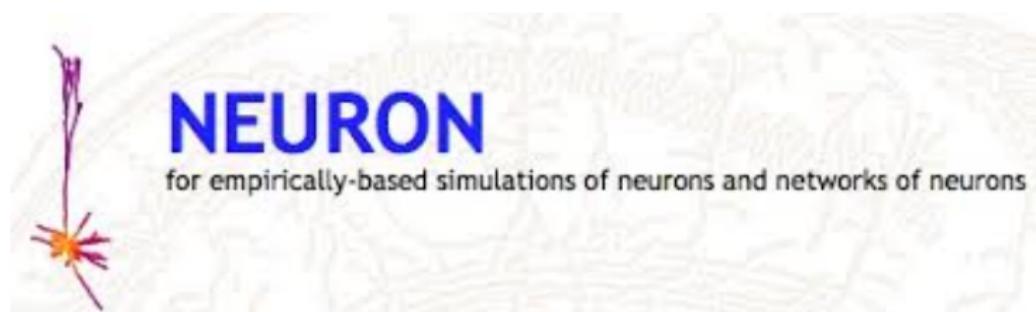
Uncertainty calculates the uncertainty for a user selected set of features of the model



Uncertainty has built-in support for
multi-compartmental models



Uncertainty has built-in support for
multi-compartmental models and network models



Summary:

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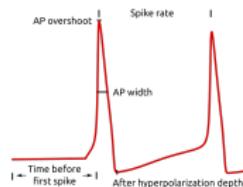
Performs all calculations without the need for detailed knowledge

Summary:

Uncertainty quantification enables us to take the effects of uncertain parameters into account



Performs all calculations without the need for detailed knowledge



Tailored towards neuroscience through the calculation of features



A Python toolbox for uncertainty quantification and sensitivity analysis

Open source:

```
github.com/simetenn/uncertainpy
```

Easy installation:

```
pip install uncertainpy
```

Extensive documentation:

```
uncertainpy.readthedocs.io
```

Article in Frontiers in Neuroinformatics



Uncertainty uses the efficient polynomial chaos expansions

