Neur(on)al networks

General description

The study of single neuron firing behavior is an essential step towards understanding the workings of the human brain. Yet, modeling the behavior of cells is notoriously complex. Detailed models explaining neuronal behavior exist on single cell level, but often require dozens of parameters to be fitted. As cellular properties vary greatly between individual neurons, not every parameter is known in detail for every cell. As a result, the predictive strength of such models often falters.

Rather than explaining neuronal behavior based on dozens of interdependent parameters and estimates, it would be interesting to see how much details one can predict based solely on observable neuronal states. Hence, to train a neural network to predict neuronal behavior (neural=artificial intelligence, neuronal=biological cells).

An experimental data set containing thousands of measurements of neuronal behavior is available. The neurons would produce so-called spiking patterns with a high (~70%) reproducibility in response to similar input signals, see Figure 1. Furthermore, the state of the neuron was measured in the form of the membrane resistance and capacitance and the membrane potential in rest.

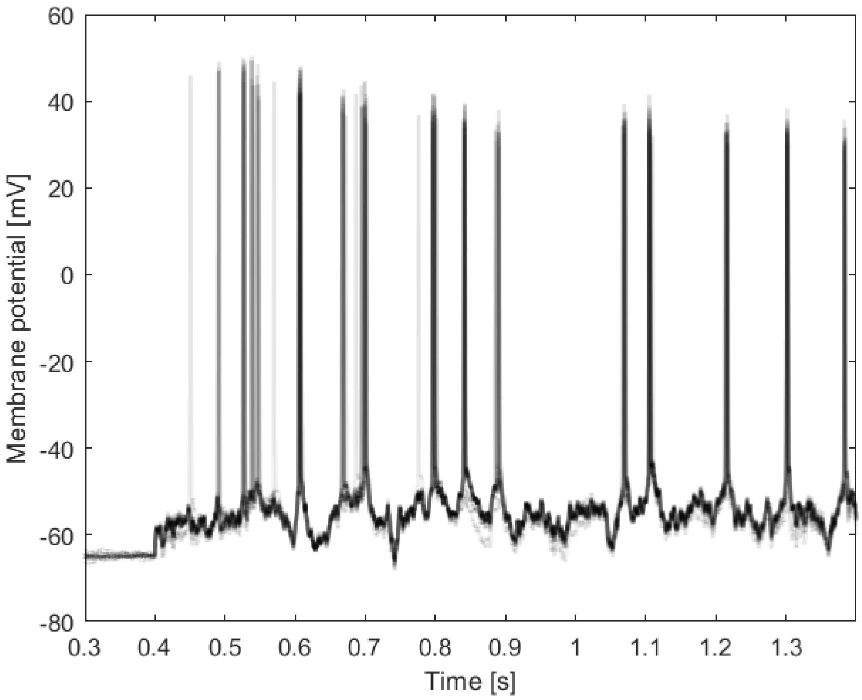

Figure 1: The spiking behavior of a neuron in response to the same input. The experiment has been rerun 18 times, and each trace is plotted with opacity 1/18. Darker areas indicate that the pattern is more reproducible at a certain time instant. While the pattern reproduces to some degree, some variation is still possible.

Student task description

The goal of this project is to investigate how well a machine learning algorithm performs when predicting neuronal activity based on observable states. The first step is to construct a neural network based on the observable properties as described in the previous section. The predictive value of the neural network should be investigated and should be compared to the performance (predictive value and computation time) of classic models, either from fits or from literature. Due to the complexity of the project, it is highly recommended to have passed at least one course focusing on artificial intelligence, machine learning, statistical signal processing, brain-related information processing or computational modeling.

Related modelling investigations regarding single neurons can be found at [1][2], and AI-driven neuronal modelling at [3]–[5]. Similar experimental work is described in [6], but please note that the experimental data set is already available.

Further information

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Sources

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