Einblicke in die Forschungsarbeit

MASTERARBEIT

„Causal Relationships in Calcium Imaging“

GUNNAR KÖNIG

Elitestudiengang Data Science

Ludwigs-Maximilian-University Munich, December 2018

Causal Relationships in Calcium Imaging

Gunnar König is an alumnus of the Elite Network Bayern graduate program Data Science at LMU. Before, he studied information systems at TU Munich. In his thesis he researched causal inference in calcium imaging of larval zebrafish with Prof. Grosse-Wentrup.

The zebrafish is an interesting model system for brain research

Studying the human brain is hard. Of course, one important reason for that is the sheer complexity of the human brain. Functions may be spatially distributed, circuits might contain complex feedback loops and alter their behavior given a small change in neural chemical mixture. Additionally, imaging the whole human brain with a high spatial and temporal resolution is still not feasible today.

Larval zebrafish combine two properties, that make it interesting for brain research. First of all, it has a developed, but still small brain that only contains about 105neurons. Secondly, its skin is transparent allowing the application of optimal imaging for brain wide monitoring. The activity of single neurons can be visualized using calcium indicators, which make use of the fact that depolarizing electrical signals are associated with Ca+ concentration. Whole brain in vivo functional imaging of zebrafish is therefore possible today.

Finding causal relationships in calcium imaging brain scans

With the advent of the new imaging techniques, a variety of researchers published studies showing how neural activity is associated with certain stimuli. However, those studies do not reveal causal relationships between the neurons or uncover the underlying neural circuits. However, this knowledge is required to be able to predict the effect of interventions.

In this work calcium imaging data was examined through a lens of causal inference. The aim is to use independencies and conditional independencies that are found in the dataset to infer knowledge about underlying causal relationships. More specifically, we are interested to find sets of neurons that can block the neural path from one selected neuron to another neuron.

This problem could be formulated as a discrete optimization problem, where all possible sets are evaluated. The size of the search space grows exponentially with the number of neurons though, making the application to the high dimensional dataset computationally infeasible. As an alternative, we state a continuous optimization problem and evaluate empirically on simulation and zebrafish data how well it solves the given problem.