

ADVANCED PROBABILISTIC CLUSTERING ALGORITHMS FOR SUPER-RESOLUTION MICROSCOPY

Supervisory Team¹

Primary Supervisor: *Clemens Heitzinger, Research Group for Machine Learning and Uncertainty Quantification, Institute for Analysis and Scientific Computing*

TU Wien project partners: *Radu Grosu and Gerhard Schütz*

External academic partners: *Name and affiliation: TBD*

External industry partners: *Name and affiliation: TBD*

Project Description

This PhD project focuses on the development of advanced probabilistic clustering algorithms to advance super-resolution microscopy. Single-molecule localization microscopy enables the recording of images at a resolution of a few nanometers, which is orders of magnitude below the diffraction-limit of light microscopy and has been considered to be impossible even a couple of years ago.

Due to the stochastic nature of the measurements, new and robust classification, localization, and reconstruction algorithms are needed in order to determine the most likely properties of single molecules, especially when they are close. Furthermore, the geometry of the lipid bilayer in which the molecules are embedded can be tried to be reconstructed.

The proposed algorithms are based on calculating the probability densities of potential candidates for clustering while taking the time dependence of the measurements into account. Bayesian learning methods will receive attention in particular.

In cooperation with world-class experts in single-resolution microscopy, the algorithms will be applied to blinking data acquired by the latest equipment and used to solve research questions of biophysical relevance.

Additionally, reinforcement-learning algorithms will be used to optimize the operation of the microscope setup.

Key Goals and Tasks

The primary aim of this PhD thesis is to develop new and reliable algorithms for the clustering of molecules in super-resolution microscopy and – in general – for extracting as much information about the molecules as possible from the images.

¹ The Early Stage Researchers (ESRs) will be accompanied during their thesis by an individual “Thesis Advisory Committee” (TAC), which will guide the ESR through the graduate studies. The TAC will consist of the thesis primary supervisor and two additional members of the Supervisory Team selected by the ESR.

Project-specific Requirements

- Completed master studies in mathematics, computer science, or a strongly related subject.
- Strong knowledge in applied mathematics and in at least one programming language such as Python or Julia.
- Experience and skills in implementing sophisticated algorithms.
- Interest in working with real-world data and solving timely real-world problems.
- Enthusiasm for solving machine-learning problems.
- Affinity for the development of algorithms.
- Willingness to travel to project meetings and scientific conferences.
- Excellent English language skills, also in the areas required above.
- Personal skills: independence, ability to work in a team, strong problem-solving skills, communication.