University of Fribourg / Faculty of Science and Medicine / Department of Mathematics

On some problems in mathematical biology around combinatorics, geometry, and probability

Linard Hoessly

Quantitative understanding of processes in nature are often based on mathematics. In particular, mathematically sound representations that can cope with the growth of available experimental data are critical to our current theoretical understanding of living systems. Three problems at the crossroads of probability, combinatorics, and biology are studied with the goal of deriving structural properties.

Dynamics of two scalings are investigated for a family of stochastic processes expressed as stochastic reaction networks by deriving product-form stationary distributions. Examples of interest from statistical mechanics and the life sciences are considered. In the non-mean field scaling, we prove the existence of condensation, enabling the study of particle systems that generalize the inclusion process.

A class of finite metric spaces is investigated via their fundamental polytopes together with a hyperplane arrangement associated to every split pseudometric. For tree-like metrics, we study the combinatorics of its underlying matroid, which decomposes as a "parallel connection", enabling explicit formulas for the face numbers of fundamental polytopes of all tree-like metrics.

Existence questions for consensus methods in phylogenetics are studied, where stability conditions can be incompatible with some basic regularity properties. We prove that such incompatibilities do arise in the cases of extension stability on binary trees and associative stability together with a Pareto property.

Jury:
Prof. Dr. Emanuele Delucchi (Thesis co-supervisor)
Prof. Dr. Christian Mazza (Thesis co-supervisor)
Prof. Dr. Enrico Bibbona (referee)
Prof. Dr. Katharina Huber (referee)