Mean-field optimal control for biological pattern formation

Lisa Maria Kreusser
University of Cambridge
lmk48@cam.ac.uk

In this talk I will discuss a class of interacting particle models with anisotropic repulsive-attractive interaction forces. These models are motivated by the simulation of fingerprint databases, which are required in forensic science and biometric applications. In existing models, the forces are isotropic and particle models lead to non-local aggregation PDEs with radially symmetric potentials. The central novelty in the models I consider is an anisotropy which can describe complex patterns accurately. I will discuss the role of anisotropic interaction in the forward models. Then, I will propose a mean-field optimal control problem for the parameter identification of a given pattern which is an inverse problem. The cost functional is based on the Wasserstein distance between the probability measures of the modeled and the desired patterns. The first-order optimality conditions corresponding to the optimal control problem are derived using a Lagrangian approach on the mean-field level. Based on these conditions we propose a gradient descent method to identify relevant parameters such as angle of rotation and force scaling which may be spatially inhomogeneous. We discretize the first-order optimality conditions in order to employ the algorithm on the particle level. Moreover, we prove a rate for the convergence of the controls as the number of particles used for the discretization tends to infinity. Numerical results for the spatially homogeneous case demonstrate the feasibility of the approach. This is joint work with M. Burger (FAU Erlangen-Nürnberg) and C. Totzeck (Wuppertal).