Macroscopic limit of kinetic equations for swarming. First steps towards estimation of interaction potentials.

Abstract

Motivated by the nonlocal movement of biological organisms such as the bacteria *E. coli* and T cells, we considerd Lévy robotic systems which combine superdiffusive random movement with emergent collective behaviour from local communication and alignment. We derived a fractional PDE from the movement strategies of the individual robots, introducing long range interactions and alignment into the analysis. The resulting kinetic model is studied at short and long time scales. Applications we study include targeting efficiency and optimal search strategies. We showed that the system allows efficient parameter studies for a search problem, addressing basic questions such as the optimal number of robots needed to cover an area.

When applying equations such as the ones derived in [1] to model real life phenomenon, a major challenge lies on the choice of the interaction potential. Previous numerical and theoretical studies typically required predetermination of terms and the goal is often to reproduce the observed dynamics qualitatively, not quantitatively. In the second part of the talk, we propose a robust variational approach to solve the inverse problem of estimating the interaction kernel from discrete observations of a single trajectory noisy data based on regularised least squares.

References

[1] G. Estrada-Rodriguez and H. Gimperlein, *Interacting particles with Lévy strategies: limits of transport equations for swarm robotic systems.* SIAM Journal on Applied Mathematics 80 (2020), 476 - 498.

[2] S. Duncan*, G. Etsrada-Rodriguez*, J. Stocek*, M. Dragone, P. Vargas and H. Gimperlein *Efficient quantitative assessment of robot swarms:coverage and targeting Lévy strategies.* Bioinspiration Biomimetics 17, no.3, 2022.