

Spontaneous Particle Aggregation with Memory

Jan Haskovec

King Abdullah University of Science and Technology, 23955 Thuwal, KSA
JAN.HASKOVEC@KAUST.EDU.SA

Abstract

We present a nonlinear and nonlocal model of spontaneous biological aggregation. On the microscopic scale it is represented as an agent-based stochastic model where each individual modulates its random movement based on the perceived local density of its neighbours. Memory is introduced via a chain of internal variables, allowing agents to retain past environmental information. With appropriate parameter settings the model exhibits emergent formation of particle clusters. We present results of systematic stochastic simulations, showing that short-term memory promotes cluster coarsening, while long-term memory disrupts aggregation, increasing the number of outliers and instances with no clustering. Statistical analysis shows that memory inhibits the particles' responsivity to environmental cues, specifically the perceived density of their neighbours, explaining the reduced clustering tendency at higher values of the memory length. To gain deeper insights into the formation and shape of particle clusters, we derive the Fokker-Planck equation in the macroscopic limit, characterize its steady states and provide results of numerical simulations.

References

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