Quantifying and Tracing Information Cascades in Swarms

X. Rosalind Wang (1), Jennifer M. Miller (2), Joseph T. Lizier (1,3), Mikhail Prokopenko (1), Louis F. Rossi (2)

1 CSIRO Information and Communication Technologies Centre, Marsfield, New South Wales, Australia,

2 Department of Mathematical Sciences, University of Delaware, Newark, Delaware, United States of America,

3 Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany

Abstract

Following [1, 2], we investigate a novel, information-theoretic, characterisation of cascades within the spatiotemporal dynamics of swarms, explicitly measuring the extent of collective communications. This is complemented by dynamic tracing of collective memory, as another element of distributed computation, which represents capacity for swarm coherence. The approach deals with both global and local information dynamics, ultimately discovering diverse ways in which an individual's spatial position is related to its information processing role. It also allows us to contrast cascades that propagate conflicting information with waves of coordinated motion. Most importantly, our simulation experiments provide the first direct information-theoretic evidence (verified in a simulation setting) for the long-held conjecture that the information cascades occur in waves rippling through the swarm.

Our experiments also exemplify how features of swarm dynamics, such as cascades' wavefronts, can be filtered and predicted. We observed that maximal information transfer tends to follow the stage with maximal collective memory, and principles like this may be generalised in wider biological and social contexts.

References

[1] X. R. Wang, J. M. Miller, J. T. Lizier, M. Prokopenko, L. F. Rossi, Quantifying and Tracing Information Cascades in Swarms, *PLoS ONE*, 7(7): e40084, 2012.

[2] X. R. Wang, J. M. Miller, J. T. Lizier, M. Prokopenko and L. F. Rossi, Measuring Information Storage and Transfer in Swarms, *Proceedings of The Eleventh European Conference on the Synthesis and Simulation of Living Systems (ECAL 2011), Paris, 2011*, *Advances in Artificial Life, ECAL 2011*, Massachusetts Institute of Technology, 838-845, 2011.