Geometric Principles of Individual and Collective Decision-Making

Keynote Talk

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ABSTRACT

In 1905 the biologist Edmund Selous wrote of his wonderment when observing a flock of starlings flying overhead "they circle; now dense like a polished roof, now disseminated like the meshes of some vast all-heaven-sweeping net…wheeling, rending, darting…a madness in the sky". He went on to speculate "They must think collectively, all at the same time, or at least in streaks or patches — a square yard or so of an idea, a flash out of so many brains". While the field of neuroscience has emerged to study the computational capabilities within an organism, far less is known about how social interactions connect brains together—and thus how sensing and information processing arises in such organismal collectives. Using new experimental technologies, including 'holographic' virtual reality for freely-moving animals, bio-mimetic robotics and artificial intelligence, I will present evidence that there exist fundamental geometric principles of spatiotemporal computation that transcend scales of biological organization; from neural dynamics to individual decision-making, and from individual decision-making to that at the scale of animal collectives. I will also show how this discovery may impact human-engineered systems, demonstrating that the evolved controller exhibits close-to-optimal performance in autonomous vehicle (terrestrial, airborne and watercraft) control, while requiring minimal sensing/computation and no system-specific tuning or optimization.

Keywords

collective decision making; neuroscience; technology

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BIOGRAPHY

Iain Couzin is Director of the Max Planck Institute of Animal Behavior and Speaker of the Excellence Cluster "Centre for the Advanced Study of Collective Behaviour" at the University of Konstanz, Konstanz, Germany. Previously he was an Assistant- and then Full-Professor in the Department of Ecology and Evolutionary Biology at Princeton University, and prior to that a Royal Society University Research Fellow in the Department of Zoology, University of Oxford, and a Junior Research Fellow in the Sciences at Balliol College, Oxford.

His work aims to reveal the fundamental principles that underlie evolved collective behavior, and consequently his research includes the study of a wide range of biological systems, from neural collectives to insect swarms, fish schools and primate groups. In recognition of his research he has been recipient of the Searle Scholar Award in 2008, top 5 most cited papers of the decade in animal behavior research 1999-2010, the Mohammed Dahleh Award in 2009, Popular Science's "Brilliant 10" Award in 2010, National Geographic Emerging Explorer Award in 2012, the Scientific Medal of the Zoological Society of London in 2013, a Web of Science Global Highly Cited Researcher since 2018, the Lagrange Prize in 2019, and the Falling Walls Life Sciences Award and Leibniz Prize (Germany's highest research honor) in 2022.