

Workshop IV: Modeling Multi-Scale Collective Intelligences



NOVEMBER 18 - 22, 2024

Scientific Overview

All known intelligent systems are collectives. Individual organisms are collectives of cells, which develop, heal, sense, and act. Groups of human and non-human animals use a range of mechanisms to coordinate their behavior across space and time, from flocks and swarms to organizations, institutions, and cultural traditions. The brain is a collective of highly coupled and dynamic excitable cells. Deep learning—the dominant approach to artificial intelligence—gains its power from combining simple units into complex architectures; many contemporary architectures combine multiple learners, and multi-agent settings are a critical frontier for AI, especially settings that integrate human and artificial agents.

These examples imply that a scientific understanding of intelligence must grapple with collective intelligence—in a much broader sense than typical usage of the term would suggest. A variety of mathematical and computational models have been developed to explain and design intelligent behavior in particular collectives. Several mathematical fields provide the ideas behind these models, from dynamical systems, statistical mechanics, network science, and random matrix theory to information theory, optimization, Bayesian statistics, theories of self-assembly and self-organization, game theory, and category theory.

This workshop will bring together leading experts in the mathematical modeling of collective intelligence. While the workshop will explore collective intelligence in many different systems, substrates (both natural and artificial), and scales, it will focus on three broadly applicable modeling frameworks: dynamical systems, which have been applied to systems as various as brains and insect swarms; statistical physics, which has illuminated the behavior of flocking birds and deep learning architectures; and game theory, which has been applied to animal, human, and AI collectives. The collective intelligence domain cultivates the further development of formal tools for treating compositionality; the emergence of new capacities and collective degrees of freedom at multiple scales; and the higher-level institutions that coordinate the intelligent behavior of lower-level parts.

Long Program Schedule

This workshop is part of the long program Mathematics of Intelligences.

- Mathematics of Intelligences Opening Day : September 9, 2024
- Mathematics of Intelligences Tutorials : September 10-13, 2024
- Workshop I: Analyzing High-dimensional Traces of Intelligent Behavior : September 23-27, 2024
- Workshop II: Theory and Practice of Deep Learning : October 14-18, 2024
- Workshop III: Naturalistic Approaches to Artificial Intelligence : November 4-8, 2024
- **Workshop IV: Modeling Multi-Scale Collective Intelligences : November 18-22, 2024**
- Mathematics of Intelligences Culminating Workshop at Lake Arrowhead : December 8-13, 2024

Participation

Additional information about this workshop including links to register and to apply for funding, can be found on the web page listed below. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission, and we welcome their applications.

Organizers

Iain Couzin (Max Planck Institute of Animal Behavior),
Pranab Das (Elon University),
Jessica Flack (Santa Fe Institute),
Govind Menon (Brown University),
Orit Peleg (University of Colorado Boulder).

Speakers

Blaise Agüera y Arcas (Google)
Robert Batterman (University of Pittsburgh)
Daniel Blair (Georgetown University)
Lindsay Caplan (Brown University)
Bernard Chazelle (Princeton University)
Daniel Cohen (Princeton University)
Jim Crutchfield (University of California, Davis (UC Davis))
Pranab Das (Elon University)
Ahmed El Hady (University of Konstanz)
Nikta Fakhri (Massachusetts Institute of Technology)
Vishwesh Guttal (Indian Institute of Science)
Conor Heins (Verses)
Albert Kao (University of Massachusetts Boston)
Adria LeBoeuf (University of Cambridge)
Santosh Manicka (Tufts University)
Richard Mann (University of Leeds)
Govind Menon (Brown University)
Danai Papageorgiou (Max Planck Institute of Animal Behavior)
Rebecca Schulman (Johns Hopkins University)
Alice Schwarze (Dartmouth College)
Joshua Vogelstein (Johns Hopkins University)
Sara Walker (Arizona State University)

