SOE 16: Collective Dynamics in Animal and Human Societies

Time: Thursday 11:00–12:15 Location: ZEU 260

SOE 16.1 Thu 11:00 ZEU 260

Individual bias and fluctuations in collective decision making: from algorithms to Hamiltonians — •Mariana Krasnytska[1,2,3], Petro Sarkanych[1,2], Luis Gómez-Nava[4,5], Abel Jonen[4], Pawel Romanczuk[4,5], and Yurij Holovatch[1,2,6] — [1]ICMP, NAS of Ukraine, Lviv, Ukraine — [2]L4 Collaboration Leipzig-Lorraine-Lviv-Coventry — [3]Université de Lorraine, Nancy, France — [4]Humboldt Universität zu Berlin, Germany — [5]Research Cluster of Excellence "Science of Intelligence", Berlin, Germany — [6]Coventry University, UK

We reconsider the spin model suggested recently to understand some features of collective decision making among higher organisms [A.T. Hartnett et al., Phys. Rev. Lett. 116 (2016) 038701]. Within the model, the state of an agent is described by the pair of variables corresponding to its opinion and a bias towards any of the opposing opinions. Collective decision making is interpreted within the non-linear voter model subject to social pressure. Here, we push such physical analogy further and give the statistical physics interpretation of the model via explicit calculation of its partition function. In such interpretation, the temperature serves as a measure of fluctuations that were not taken into account within the original formulation. We find exact solutions for the thermodynamics and dynamics of the model on the complete graph. We discuss the advantages and flaws of such an approach as well as its utility in understanding the impact of population heterogeneity, type of local interaction and fluctuations in collective decision making.

SOE 16.2 Thu 11:15 ZEU 260

Following the information footprint of firms — •Edward Lee[1], Alan Kwan[2], Rudolf Hanel[1], Anjali Bhatt[3], and Frank Neffke[1] — [1]Complexity Science Hub Vienna, Austria — [2]Hong Kong University, China — [3]Harvard Business School, Boston, USA

What a firm does is more revealing than how much it makes, but firms are often described with metrics for economic size. Instead, we characterize what firms know in terms of what they read, the information footprint, using a data set of hundreds of millions of records of news articles accessed by employees in millions of firms. We discover that the reading habits of firms are of limited diversity. This observation suggests that information constraints act on firms. To understand how, we relate a firm's information footprint with economic variables, showing that the former grows superlinearly with the latter. This exaggerates the classic Zipf's law inequality in the economic size of firms and reveals an economy of scale with respect to information. Second, we reconstruct the topic space firms inhabit, finding that the space resembles a tangled "hairball" with a few dense knots of topics and many specialized strands sticking out. Some of the topics are ubiquitous, indicating inescapable demand regardless of firm size. Finally, we connect these pieces in a model of how firms grow in the space of topics. We show that diversity in firm reading habits can be explained by a mixed strategy of local exploration and recurrent exploitation on the topic graph. This shows that the constraints that the space of ideas imposes on firm growth provide a useful and new perspective on firm development.

SOE 16.3 Thu 11:30 ZEU 260

Influence of confirmation biases on collective decision-making in fluctuating environments — •Clémence Bergerot[1,2], Wolfram Barfuss[3], and Pawel Romanczuk[2,4] — [1]Charité - Universitätsmedizin Berlin, Einstein Center for Neurosciences Berlin, Germany — [2]Humboldt Universität zu Berlin, Germany — [3]Tübingen AI Center, University of Tübingen, Germany — [4]Research Cluster of Excellence "Science of Intelligence", Berlin, Germany

In experimental studies of decision-making, it is now established that human agents tend to update confirmatory information with a higher weight than disconfirmatory information. This confirmation bias has been modeled within a reinforcement learning framework, using asymmetric updating of prediction errors. Interestingly, such a bias has been suggested to enhance individual performance in a wide range of multi-armed bandit tasks. However, little is known about the impact of the confirmation bias on collective performance. In order to characterize the circumstances that make this bias beneficial or detrimental to collective decision-making, we develop a multiagent model in which reinforcement learning agents can observe others' actions and rewards, and update this information asymmetrically. With agent-based simulations, we seek to understand how the confirmation bias affects collective performance in changing environments, and how network topology modulates this effect. We also study our multiagent system in the deterministic limit [W. Barfuss et al., Phys. Rev. E, 99(4) (2016) 043305], which allows us to gain an analytical understanding of the biased learning dynamics.

SOE 16.4 Thu 11:45 ZEU 260

Population waves in sessile organisms — •Niraj Kushwaha and Edward Lee — Complexity Science Hub Vienna, Josefstädter Straße 39, 1080 Vienna, Austria

The mathematical laws of life manifest scaling regularities such as the relationship between mass and metabolism for the smallest to the largest organisms on Earth. These laws lack essential components representing interaction between organisms while sharing limited resources. Once accounted for, these components can bring significant variation to the predicted demographic laws using just metabolic scaling theory and can give mathematical descriptions for observed ecological phenomena. The oscillations in population number, where spikes in the number of organisms of a specific size propagate from small to large organisms is an example of such a phenomena. Here, we incorporate spatial competition and resource variation in a differential equation model for the population dynamics of sessile organisms. We use analytic and numerical tools to solve the corresponding equations and to characterize the form of instabilities that generate the oscillations, which we use to identify hidden mechanisms that may drive instabilities in ecological systems such as forests. As a result, we may be able to identify the most significant factors that affect the stability of an ecosystem corresponding to resource fluctuations that may become more prominent with climate change.

SOE 16.5 Thu 12:00 ZEU 260

The role of escape angle in predator-prey interactions: the emergence of fountain effect — •Palina Bartashevich[1,2] and Pawel Romanczuk[1,2] — [1]Institute for Theoretical Biology, Humboldt-Universität zu Berlin, 10115 Berlin, Germany — [2]Excellence Cluster Science of Intelligence, Technische Universität Berlin, 10587 Berlin, Germany

Empirical studies of fish schooling widely described the variety of ways in which fish escape to reduce the chances of being caught by a predator while trying at the same time to stay in a group. The "fountain effect" is one such evasion maneuver that allows small fish to outmaneuver the fast-moving predator by swimming away at a constant angle determined by the rear limit of the visual cone [1]. Our spatially-explicit agent-based numerical simulations recover the same optimal prey-fleeing angle as confirmed by empirical studies. Moreover, our results show that the fleeing angle not only minimizes the distance to the predator but creates a sequence of information flows that best facilitates the information propagation throughout the collective. This finding highlights the direct role of social interaction in the emergence of the fountain effect which was not addressed before. We also address the questions of how the stimulus characteristics such as the initial predator angle of attack and distance to the first responders affect the response as a whole, allowing us to make biological predictions.

[1] Hall SJ, Wardle CS and MacLennan DN 1986. Predator evasion in a fish school: test of a model for the fountain effect. Mar. Biol. 91: 143-148.