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From Ants to Query Complexity

Abstract:

I will talk about my recent adventures with ants. Together with biologists we study P. longicornis ants as they collaboratively transport a large food item to their nest. This collective navigation process is guided by pheromones which are laid by individual ants. Using a new methodology to detect scent marks, we identify a new kind of ant trail characterized by very short and dynamic pheromone markings and highly stochastic navigation response to them. We argue that such a trail can be highly beneficial in conditions in which knowledge of individual ants regarding the underlying topological structure is unreliable. This gives rise to a new theoretical search model on graphs under unreliable guiding instructions, which is of independent computational interest. To illustrate the model, imagine driving a car in an unknown country that is in the aftermath of a major hurricane which has randomly flipped a certain small fraction of the road-signs. Under such conditions of unreliability, how can you still reach your destination fast? I will discuss the limits of unreliability that allow for efficient navigation. In trees, for example, there is a phase transition phenomenon that occurs roughly around the inverse of the square root of the maximal degree. That is, if noise is above this threshold then any algorithm cannot avoid finding the target in exponential time (in the original distance), while below the threshold we identify an optimal, almost linear, walking algorithm. Finally, I will discuss algorithms that under such a noisy model aim to minimize the number of queries to find a target (rather than the number of moves).

This talk is based on joint works with biologists from the Weizmann Institute: Ofer Feinerman, Udi Fonio, and others, and with CS researchers: Lucas Bockowski, Adrian Kosowski, and Yoav Rodeh.