Contribution ID: **103** Type: **oral**

Second order optimization may lead to Lévy walks

Friday, 8 September 2017 09:50 (15 minutes)

Most living organisms perform two different types of search: a directed search (taxis) and a random search. The former is observed when the environment provides cues to guide the motion towards targets, whereas the latter may not involve any memory and information processing and can be modeled by random walks. There is a large body of experimental results showing that the random walk adopted by many organisms is described well by Lévy walks, which raises questions about the reasons and underlying mechanisms of such a behavior. Here we show that Lévy walks may emerge from a directed gradient based search, which bridges the gap between the two modes of a search. For a wide range of scenarios our model reproduces the tail index $\alpha = 1$, in line with previous experimental observations in foraging organisms and predictions based on optimality considerations for sparse targets. Moreover, the model predicts specific relations between features of the search and the curvature of the optimized function, which can be tested experimentally.

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Session Classification: Session 12