CBS Forum

Biological mechanisms and advantages of Lévy walks emerging near a critical point

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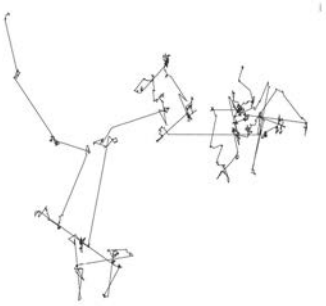

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Abstract:

For two decades, it has been reported that a special class of random walks, called Lévy walks, are common to the movement patterns of a wide variety of organisms, from cells, insects, fish and birds to mammals, including humans. Although this has been considered to be the result of natural selection due to the high search efficiency of Lévy walks, it has also been suggested that this may be a secondary phenomenon resulting from interactions with complex environments. Hence, why Lévy walks are found in biological movements remains unclear. In this talk, I will review the history of Lévy walks researches, and then I will talk about my recently published work on Lévy walks emerging as critical phenomena. Based on the evidence that Lévy walks are generated intrinsically in the brain, I constructed a mathematical model of nonlinear systems such as the central pattern generator and explored the functional advantages of Lévy walks near the critical point of chaotic synchronous and asynchronous states. We found that Lévy walks near the critical point maximized their sensitivity to perturbations and generated a variety of behaviors. Furthermore, the Lévy walks were found to have an optimal dynamic range for encoding information and the flexibility to switch behaviors in response to environmental conditions. These results were validated by applying nonlinear time series analysis to Drosophila larvae data published in a previous study. These results suggest that Lévy walks, which are commonly observed in biological movements, occur near the critical point and may be explained by these functional advantages.

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