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The Variational Formulation of Evolutionary Processes

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Abstract

We consider three classical models of biological evolution: (i) the Moran process, an example of a reducible Markov Chain; (ii) the Kimura Equation, a particular case of a degenerated Fokker-Planck Diffusion; (iii) the Replicator Equation, a paradigm in Evolutionary Game Theory. While these approaches are not completely equivalent, they are intimately connected, since (ii) is the diffusion approximation of (i), and (iii) is obtained from (ii) in an appropriate limit. It is well known that the Replicator Dynamics for two strategies is a gradient flow with respect to the celebrated Shahshahani distance. We reformulate the Moran process and the Kimura Equation as gradient flows and in the sequel we discuss conditions such that the associated gradient structures converge: (i) to (ii), and (ii) to (iii). This provides a geometric characterisation of these evolutionary processes and provides a reformulation of the above examples as time minimisation of free energy functionals.

Room *Sousa Pinto*
October 27, 2022 - 14:30

This seminar is supported in part by the Portuguese Foundation for Science and Technology (FCT - Fundação para a Ciência e a Tecnologia), through CIDMA - Center for Research and Development in Mathematics and Applications, within project UIDB/04106/2020.

FCT Fundação para a Ciência e a Tecnologia

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