

Dynamical Signatures of Living Systems

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One of the main challenges in modeling living systems is to distinguish a random walk of physical origin (for instance, Brownian motions) from those of biological origin, and that will constitute the starting point of the proposed approach. As conjectured in ^[1], the biological random walk must be nonlinear. Indeed, any stochastic Markov process can be described by linear Fokker-Planck equation (or its discretized version); only those types of processes have been observed in the inanimate world. However, all such processes always converge to a stable (ergodic or periodic) state, i.e., to the states of a lower complexity and higher entropy. At the same time, the evolution of living systems is directed toward a higher level of complexity if complexity is associated with a number of structural variations. The simplest way to mimic such a tendency is to incorporate a nonlinearity into the random walk; then the probability evolution will attain the features of nonlinear diffusion equation: the formation and dissipation of shock waves initiated by small shallow wave disturbances. As a result, the evolution never “dies”: it produces new different configurations which accompanied by increase or decrease of entropy (the decrease takes place during formation of shock waves, the increase-during their dissipation). In other words, the evolution can be directed “against the second law of thermodynamics” ^[6] by forming patterns outside of equilibrium in the probability space.

Due to that, a specie is not locked up in a certain pattern of behavior: it still can perform a variety of motions, and only the statistics of these motions is constrained by this pattern. It should be emphasized that such a “twist” is based upon the concept of reflection, i.e., the existence of the self-image (adopted from psychology).

The model consists of a generator of stochastic processes which represents the motor dynamics in the form of nonlinear random walks, and a simulator of the nonlinear version of the diffusion equation which represents the mental dynamics.

It has been demonstrated that coupled mental-motor dynamics can simulate emerging self-organization, prey-predator games, collaboration and competition, “collective brain,” etc.

1. M. Zak, Physical Invariants of biosignatures Physics Letters A, 1999 (in press)