

Quantifying Meaning in Biological Systems

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Abstract : The advanced computational analysis of biological systems is becoming increasingly dependent upon an understanding of the information-theoretic structure of the materials, energy and interactive processes that comprise those systems. The stability and survival of these living systems are fundamentally contingent upon their ability to acquire and process the meaning of information concerning the physical state of its biological continuum (biocontinuum). The drive for adaptive system reconciliation of a divergence from steady-state within this biocontinuum can be described by an information metric-based formulation of the process for actionable knowledge acquisition that incorporates the axiomatic inference of Kullback-Leibler information minimization driven by survival replicator dynamics. If the mathematical expression of this process is the Lagrangian integrand for any change within the biocontinuum then it can also be considered as an action functional for the living system. In the direct method of Lyapunov, such a summarizing mathematical formulation of global system behavior based on the driving forces of energy currents and constraints within the system can serve as a platform for the analysis of stability. As the system evolves in time in response to biocontinuum perturbations, the summarizing function then conveys information about its overall stability. This stability information portends survival and therefore has absolute existential meaning for the living system. The first derivative of the Lyapunov energy information function will have a negative trajectory toward a system's steady state if the driving force is dissipating. By contrast, system instability leading to system dissolution will have a positive trajectory. The direction and magnitude of the vector for the trajectory then serves as a quantifiable signature of the meaning associated with the living system's stability information, homeostasis and survival potential.

Keywords : meaning, information, Lyapunov, living systems

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