Lurching Toward Chernobyl: Dysfunctions of Real-Time Computation

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Abstract

Cognitive biological structures, social organizations, and computing machines operating in real time are subject to Rate Distortion Theorem constraints driven by the homology between information source uncertainty and free energy density. This exposes the unitary structure/environment system to a relentless entropic torrent compounded by large deviations causing increased average distortion between intent and impact, particularly as demands escalate. The phase transitions characteristic of information phenomena suggest that, rather than graceful decay under increasing load, these structures will undergo punctuated degradation akin to spontaneous symmetry breaking in physical systems. Rate distortion problems, that also affect internal structural dynamics, can become synergistic with limitations equivalent to the inattentional blindness of natural cognitive processes. These mechanisms, and their interactions, are unlikely to scale well, so that, depending on architecture, enlarging the structure or its duties may lead to a crossover point at which added resources must be almost entirely devoted to ensuring system stability -- a form of allometric scaling familiar from biological examples. This suggests a critical need to tune architecture to problem type and system demand. A real-time computational structure and its environment are a unitary phenomenon, and environments are usually idiosyncratic. Thus the resulting path dependence in the development of pathology could often require an individualized approach to remediation more akin to an arduous psychiatric intervention than to the traditional engineering or medical quick fix. Failure to recognize the depth of these problems seems likely to produce a relentless chain of the Chernobyl-like failures that are necessary, but often insufficient, for remediation under our system.

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