



Physical Invariants of Intelligence

Current research involves a quantumlike aspect of mental-to-motor feedback.

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A program of research is dedicated to development of a mathematical formalism that could provide, among other things, means by which living systems could be distinguished from non-living ones. A major issue that arises in this research is the following question: What invariants of mathematical models of the physics of systems are (1) characteristic of the behaviors of intelligent living systems and (2) do not depend on specific features of material compositions heretofore considered to be characteristic of life?

This research at earlier stages has been reported, albeit from different perspectives, in numerous previous *NASA Tech Briefs* articles. To recapitulate: One of the main underlying ideas is to extend the application of physical first principles to the behaviors of living systems. Mathematical models of motor dynamics are used to simulate the observ-

able physical behaviors of systems or objects of interest, and models of mental dynamics are used to represent the evolution of the corresponding knowledge bases. For a given system, the knowledge base is modeled in the form of probability distributions and the mental dynamics is represented by models of the evolution of the probability densities or, equivalently, models of flows of information.

At the time of reporting the information for this article, the focus of this research was upon the following aspects of the formalism: Intelligence is considered to be a means by which a living system preserves itself and improves its ability to survive and is further considered to manifest itself in feedback from the mental dynamics to the motor dynamics. Because of the feedback from the mental dynamics, the motor dynamics attains quantumlike properties: The trajectory

of the physical aspect of the system in the space of dynamical variables splits into a family of different trajectories, and each of those trajectories can be chosen with a probability prescribed by the mental dynamics.

From a slightly different perspective, the mechanism of decision-making is feedback from the mental dynamics to the motor dynamics, and this mechanism provides a quantumlike collapse of a random motion into an appropriate deterministic state, such that entropy undergoes a pronounced decrease. The existence of this mechanism is considered to be an invariant of intelligent behavior of living systems, regardless of the origins and material compositions of the systems.

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Rocket-Plume Spectroscopy Simulation for Hydrocarbon-Fueled Rocket Engines

Enhanced simulation includes code for new electronic bands in the 300-to-850-nm spectral bands.

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The UV-Vis spectroscopic system for plume diagnostics monitors rocket engine health by using several analytical tools developed at Stennis Space Center (SSC), including the rocket plume spectroscopy simulation code (RPSSC), to identify and quantify the alloys from the metallic elements observed in engine plumes. Because the hydrocarbon-fueled rocket engine is likely to contain C₂, CO, CH, CN, and NO in addition to OH and H₂O, the relevant electronic bands of these molecules in the spectral range of 300 to 850 nm in the RPSSC have been included.

SSC incorporated several enhancements and modifications to the original line-by-line spectral simulation com-

puter program implemented for plume spectral data analysis and quantification in 1994. These changes made the program applicable to the Space Shuttle Main Engine (SSME) and the Diagnostic Testbed Facility Thruster (DTFT) exhaust plume spectral data. Modifications included updating the molecular and spectral parameters for OH, adding spectral parameter input files optimized for the 10 elements of interest in the spectral range from 320 to 430 nm and linking the output to graphing and analysis packages. Additionally, the ability to handle the non-uniform wavelength interval at which the spectral computations are made was added. This allowed a precise superposition of wave-

lengths at which the spectral measurements have been made with the wavelengths at which the spectral computations are done by using the line-by-line (LBL) code.

To account for hydrocarbon combustion products in the plume, which might interfere with detection and quantification of metallic elements in the spectral region of 300 to 850 nm, the spectroscopic code has been enhanced to include the carbon-based combustion species of C₂, CO, and CH. In addition, CN and NO have spectral bands in 300 to 850 nm and, while these molecules are not direct products of hydrocarbon-oxygen combustion systems, they can show up if nitrogen or a nitrogen compound is