Information Sciences

Parameterized Linear Longitudinal Airship Model

NASA's Jet Propulsion Laboratory, Pasadena, California

A parameterized linear mathematical model of the longitudinal dynamics of an airship is undergoing development. This model is intended to be used in designing control systems for future airships that would operate in the atmospheres of Earth and remote planets.

Heretofore, the development of linearized models of the longitudinal dynamics of airships has been costly in that it has been necessary to perform extensive flight testing and to use system-identification techniques to construct models that fit the flight-test data. The present model is a generic one that can be relatively easily specialized to approximate the dynamics of specific airships at specific operating points, without need for further system identification, and with significantly less flight testing.

The approach taken in the present development is to merge the linearized dynamical equations of an airship with techniques for estimation of aircraft stability derivatives, and to thereby make it possible to construct a linearized dynamical model of the longitudinal dynamics of a specific airship from geometric and aerodynamic data pertaining to that airship. (It is also planned to develop a model of the lateral dynamics by use of the same methods.) All of the aerodynamic data needed to construct the model of a specific airship can be obtained from wind-tunnel testing and computational fluid dynamics.

This work was done by Eric Kulczycki, Alberto Elfes, David Bayard, Marco Quadrelli, and Joseph Johnson of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45346

Physics of Life: A Model for Non-Newtonian Properties of Living Systems

New analytical tools focus on the geometry and kinematics of behavior of living things.

NASA's Jet Propulsion Laboratory, Pasadena, California

This innovation proposes the reconciliation of the evolution of life with the second law of thermodynamics via the introduction of the First Principle for modeling behavior of living systems. The structure of the model is quantum-inspired: it acquires the topology of the Madelung equation in which the quantum potential is replaced with the information potential. As a result, the model captures the most fundamental property of life: the progressive evolution; i.e. the ability to evolve from disorder to order without any external interference.

The mathematical structure of the model can be obtained from the Newtonian equations of motion (representing the motor dynamics) coupled with the corresponding Liouville equation (representing the mental dynamics) via information forces. All these specific non-Newtonian properties equip the model with the levels of complexity that matches the complexity of life, and that makes the model applicable for description of behaviors of ecological, social, and economical systems.

Rather than addressing the six aspects of life (organization, metabolism, growth, adaptation, response to stimuli, and reproduction), this work focuses only on "biosignature"; i.e. the mechanical invariants of life, and in particular, the geometry and kinematics of behavior of living things. Living things obey the First Principles of Newtonian mechanics. One main objective of this model is to extend the First Principles of classical physics to include phenomenological behavior on living systems; to develop a new mathematical formalism within the framework of classical dynamics that would allow one to capture the specific properties of natural or artificial living systems such as formation of the collective mind based upon abstract images of the selves and non-selves; exploitation of this collective mind for communications and predictions of future expected characteristics of evolution; and for making decisions and implementing the corresponding corrections if the expected scenario is different from the originally planned one. This approach postulates that even a primitive living species possesses additional, non-Newtonian properties that are not included in the laws of Newtonian or statistical mechanics. These properties follow from a privileged ability of living systems to possess a self-image (a concept introduced in psychology) and to interact with it.

The proposed mathematical system is based on the coupling of the classical dynamical system representing the motor dynamics with the corresponding Liouville equation describing the evolution of initial uncertainties in terms of the probability density and representing the mental dynamics. The coupling is implemented by the information-based supervising forces that can be associated with self-awareness. These forces fundamentally change the pattern of the probability evolution, and therefore, lead to a major departure of the behavior of living systems from the patterns of both Newtonian and statistical mechanics.

This innovation is meant to capture the signature of life based only on observable behavior, not on any biochemistry. This will not prevent the use of this model for developing artificial living systems, as well as for studying some general properties of behavior of natural, living systems.

This work was done by Michail Zak of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-44903