Books & Reports

Simulation of Stochastic Processes by Coupled ODE-PDE

A document discusses the emergence of randomness in solutions of coupled, fully deterministic ODE-PDE (ordinary differential equations-partial differential equations) due to failure of the Lipschitz condition as a new phenomenon. It is possible to exploit the special properties of ordinary differential equations (represented by an arbitrarily chosen, dynamical system) coupled with the corresponding Liouville equations (used to describe the evolution of initial uncertainties in terms of joint probability distribution) in order to simulate stochastic processes with the proscribed probability distributions. The important advantage of the proposed approach is that the simulation does not require a random-number generator.

This work was done by Michail Zak of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). *NPO-45241*

Cluster Inter-Spacecraft Communications

A document describes a radio communication system being developed for exchanging data and sharing data-processing capabilities among spacecraft flying in formation. The system would establish a high-speed, low-latency, deterministic loop communication path connecting all the spacecraft in a cluster. The system would be a wireless version of a ring bus that complies with the Institute of Electrical and Electronics Engineers (IEEE) standard 1393 (which pertains to a spaceborne fiber-optic data bus enhancement to the IEEE standard developed at NASA's Jet Propulsion Laboratory). Every spacecraft in the cluster would be equipped with a ring-bus radio transceiver. The identity of a spacecraft would be established upon connection into the ring bus, and the spacecraft could be at any location in the ring communication sequence.

In the event of failure of a spacecraft, the ring bus would reconfigure itself, bypassing a failed spacecraft. Similarly, the ring bus would reconfigure itself to accommodate a spacecraft newly added to the cluster or newly enabled or re-enabled. Thus, the ring bus would be scalable and robust. Reliability could be increased by launching, into the cluster, spare spacecraft to be activated in the event of failure of other spacecraft.

This work was done by Brian Cox of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-45379, volume and number of this NASA Tech Briefs *issue, and the page number.*

Genetic Algorithm Optimizes Q-LAW Control Parameters

A document discusses a multi-objective, genetic algorithm designed to optimize Lyapunov feedback control law (Q-law) parameters in order to efficiently find Pareto-optimal solutions for low-thrust trajectories for electronic propulsion systems. These would be propellant-optimal solutions for a given flight time, or flight time optimal solutions for a given propellant requirement. The approximate solutions are used as good initial solutions for high-fidelity optimization tools. When the good initial solutions are used, the high-fidelity optimization tools quickly converge to a locally optimal solution near the initial solution.

Q-law control parameters are represented as real-valued genes in the genetic algorithm. The performances of the Q-law control parameters are evaluated in the multi-objective space (flight time vs. propellant mass) and sorted by the non-dominated sorting method that assigns a better fitness value to the solutions that are dominated by a fewer number of other solutions. With the ranking result, the genetic algorithm encourages the solutions with higher fitness values to participate in the reproduction process, improving the solutions in the evolution process. The population of solutions converges to the Pareto front that is permitted within the Q-law control parameter space.

This work was done by Seungwon Lee, Paul von Allmen, Anastassios Petropoulos, and Richard Terrile of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-44489.

Low-Impact Mating System for Docking Spacecraft

A document describes a low-impact mating system suitable for both docking (mating of two free-flying spacecraft) and berthing (in which a robot arm in one spacecraft positions an object for mating with either spacecraft). The low-impact mating system is fully androgynous: it mates with a copy of itself, i.e., all spacecraft and other objects to be mated are to be equipped with identical copies of the system. This aspect of the design helps to minimize the number of unique parts and to standardize and facilitate mating operations. The system includes a closed-loop feedback control subsystem that actively accommodates misalignments between mating spacecraft, thereby attenuating spacecraft dynamics and mitigating the need for precise advance positioning of the spacecraft.

The operational characteristics of the mating system can be easily configured in software, during operation, to enable mating of spacecraft having various masses, center-of-gravity offsets, and closing velocities. The system design provides multi-fault tolerance for critical operations: for example, to ensure unmating at a critical time, a redundant unlatching mechanism and two independent pyrotechnic release subsystems are included.

This work was done by James L. Lewis and Brandan Robertson of Johnson Space Center and Monty B. Carroll, Thang Le, and Ray Morales of Lockheed Martin Corp. Further information is contained in a TSP (see page 1).

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be ad-

dressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23933-1.

This work was done by Betsy Pugel of Goddard Space Flight Center. Further information is contained in a TSP (see page 1).GSC-15338-1

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Refer to NPO-44997, volume and number of this NASA Tech Briefs *issue, and the page number.*

Non-Destructive Evaluation of Materials via Ultraviolet Spectroscopy

A document discusses the use of ultraviolet spectroscopy and imaging for the non-destructive evaluation of the degree of cure, aging, and other properties of resin-based composite materials. This method can be used in air, and is portable for field use. This method operates in reflectance, absorbance, and luminescence modes.

The ultraviolet source is used to illuminate a composite surface of interest. In reflectance mode, the reflected response is acquired via the imaging system or via the spectrometer. The spectra are analyzed for organic compounds (conjugated organics) and inorganic compounds (semiconducting band-edge states; luminescing defect states such as silicates, used as adhesives for composite aerospace applications; and metal oxides commonly used as thermal coating paints on a wide range of spacecraft). The spectra are compared with a database for variation in conjugation, substitution, or length of molecule (in the case of organics) or band edge position (in the case of inorganics).

This approach is useful in the understanding of material quality. It lacks the precision in defining the exact chemical structure that is found in other materials analysis techniques, but it is advantageous over methods such as nuclear magnetic resonance, infrared spectroscopy, and chromatography in that it can be used in the field to assess significant changes in chemical structure that may be linked to concerns associated with weaknesses or variations in structural integrity, without disassembly of or destruction to the structure of interest.

Gold-on-Polymer-Based Sensing Films for Detection of Organic and Inorganic Analytes in the Air

A document discusses gold-on-polymer as one of the novel sensor types developed for part of the sensor development task. Standard polymer-carbon composite sensors used in the JPL Electronic Nose (ENose) have been modified by evaporating 15 nm of metallic gold on the surface. These sensors have been shown to respond to alcohols, aromatics, ammonia, sulfur dioxide, and elemental mercury in the parts-per-million and parts-per-billion concentration ranges in humidified air.

The results have shown good sensitivity of these films operating under mild conditions (operating temperatures 23–28 ºC and regeneration temperature up to 40 ºC). This unique sensor combines the diversity of polymer sensors for chemical sensing with their response to a wide variety of analytes with the specificity of a gold sensor that shows strong reaction/binding with selected analyte types, such as mercury or sulfur.

This work was done by Kenneth Manatt of Santa Barbara Research and Margie Homer, Margaret Ryan, Adam Kisor, Abhijit Shevade, April Jewell, and Hanying Zhou of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Quantum-Inspired Maximizer

A report discusses an algorithm for a new kind of dynamics based on a quantum-classical hybrid-quantum-inspired maximizer. The model is represented by a modified Madelung equation in which the quantum potential is replaced by different, specially chosen "computational" potential. As a result, the dynamics attains both quantum and classical properties: it preserves superposition and entanglement of random solutions, while allowing one to measure its state variables, using classical methods. Such optimal combination of characteristics is a perfect match for quantum-inspired computing. As an application, an algorithm for global maximum of an arbitrary integrable function is proposed. The idea of the proposed algorithm is very simple: based upon the Quantum-inspired Maximizer (QIM), introduce a positive function to be maximized as the probability density to which the solution is attracted. Then the larger value of this function will have the higher probability to appear.

Special attention is paid to simulation of integer programming and NP-complete problems. It is demonstrated that the problem of global maximum of an integrable function can be found in polynomial time by using the proposed quantum-classical hybrid. The result is extended to a constrained maximum with applications to integer programming and TSP (Traveling Salesman Problem).

This work was done by Michail Zak of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).
NPO-45458