

ous experiences, and that will enable it to recombine its known behaviors in such a way as to solve related, but novel, task problems with apparent creativity. The approach is to combine sensory-motor data association and dimensionality reduction to learn navigation and manipulation tasks as sequences of basic behaviors that can be implemented with a small set of closed-loop controllers. Over time, the aggregate of behaviors and their transition probabilities form a stochastic network. Then given a task, the robot finds a path in the network that leads from its current

state to the goal.

The SES provides a short-term memory for the cognitive functions of the robot, association of sensory and motor data via spatio-temporal coincidence, direction of the attention of the robot, navigation through spatial localization with respect to known or discovered landmarks, and structured data sharing between the robot and human team members, the individuals in multi-robot teams, or with a C3 center.

*This work was done by Katherine Achim Fleming and Richard Alan Peters II of Vanderbilt University for Johnson Space Center.*

*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 MSC-24363-1, volume and number of this NASA Tech Briefs issue, and the page number.*

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## ▶ HyDE Framework for Stochastic and Hybrid Model-Based Diagnosis

**It uses hybrid models built by the users and sensor data from the system to deduce the state of the system over time.**

*Ames Research Center, Moffett Field, California*

Hybrid Diagnosis Engine (HyDE) is a general framework for stochastic and hybrid model-based diagnosis that offers flexibility to the diagnosis application designer. The HyDE architecture supports the use of multiple modeling paradigms at the component and system level. Several alternative algorithms are available for the various steps in diagnostic reasoning. This approach is extensible, with support for the addition of new modeling paradigms as well as diagnostic reasoning algorithms for existing or new modeling paradigms.

HyDE is a general framework for stochastic hybrid model-based diagnosis of discrete faults; that is, spontaneous changes in operating modes of components. HyDE combines ideas from consistency-based and stochastic approaches to model-based diagnosis using discrete and continuous models to create a flexible and extensible architecture for stochastic and hybrid diagnosis. HyDE supports the use of multiple paradigms and

is extensible to support new paradigms.

HyDE generates candidate diagnoses and checks them for consistency with the observations. It uses hybrid models built by the users and sensor data from the system to deduce the state of the system over time, including changes in state indicative of faults.

At each time step when observations are available, HyDE checks each existing candidate for continued consistency with the new observations. If the candidate is consistent, it continues to remain in the candidate set. If it is not consistent, then the information about the inconsistency is used to generate successor candidates while discarding the candidate that was inconsistent.

The models used by HyDE are similar to simulation models. They describe the expected behavior of the system under nominal and fault conditions. The model can be constructed in modular and hierarchical fashion by building component/subsystem models (which

may themselves contain component/subsystem models) and linking them through shared variables/parameters. The component model is expressed as operating modes of the component and conditions for transitions between these various modes. Faults are modeled as transitions whose conditions for transitions are unknown (and have to be inferred through the reasoning process).

Finally, the behavior of the components is expressed as a set of variables/parameters and relations governing the interaction between the variables. The hybrid nature of the systems being modeled is captured by a combination of the above transitional model and behavioral model. Stochasticity is captured as probabilities associated with transitions (indicating the likelihood of that transition being taken), as well as noise on the sensed variables.

*This work was done by Sriram Narasimhan and Lee Brownston of Ames Research Center. Further information is contained in a TSP (see page 1). ARC-15570-1*

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## ▶ IMAGESEER — IMAGEs for Education and Research

**Web portal shares image data with research institutions.**

*Goddard Space Flight Center, Greenbelt, Maryland*

IMAGESEER is a new Web portal that brings easy access to NASA image data for non-NASA researchers, educators,

and students. The IMAGESEER Web site and database are specifically designed to be utilized by the university community,

to enable teaching image processing (IP) techniques on NASA data, as well as to provide reference benchmark data to

validate new IP algorithms. Along with the data and a Web user interface front-end, basic knowledge of the application domains, benchmark information, and specific NASA IP challenges (or case studies) are provided.

Working with project scientists and engineers, four types of IP techniques have been identified as corresponding to Earth Science needs; these are gap filling/in-painting, cloud detection, image registration, and map cover/classification. For each of these challenges, corresponding data were selected from four different geographic regions: mountains (Colorado), urban (Los Angeles), water coastal area (Chesapeake Bay), and agriculture (Illinois). Satellite images have been collected for these areas from several satellite instruments, then georegistered, and finally converted to common image formats (GeoTIFF and raw). Along with the original data, associated benchmarks (or validation data) have been acquired or generated, including cloud cover masks and assessments, georegistered scenes, and

classification maps from the National Land Cover Data (NLCD) database gathered in 1992 and 2001 by the Multi-Resolution Land Characteristics Consortium (MRLC).

IMAGESEER provides a modern and graphically-rich Web site (<http://imageseer.nasa.gov>) for easily browsing and downloading all of the selected datasets, benchmarks, and tutorials. Using a paradigm common on commercial Web sites, users can restrict their searches by selectively filtering by data source (project, mission, and instrument), region of interest, desired image processing technique, and time period. By deliberately focusing on only a subset of NASA data, continuously emphasizing ease-of-use, providing common file formats, and supplying the “answers” as well as the questions to NASA IP challenges, IMAGESEER provides an easily navigable and usable Web site for non-NASA researchers, educators, and students. On the backend, automated Python scripts convert the NASA data, generate thumbnails and

benchmarks, and populate the IMAGESEER database. The database and the IMAGESEER Web site were developed using a MySQL database and HyperText PreProcessor (PHP).

IMAGESEER currently focuses on Earth Science data, but is designed to be straightforwardly extended to planetary and exploration data, and in fact, planetary-specific challenges, such as automated crater counting and boulder counting, have already been identified. IMAGESEER is ideal for helping educators and students learn IP techniques needed for and with actual NASA data and for helping researchers develop new algorithms or adapt existing algorithms to NASA data and challenges. It provides a focused set of NASA-centric data for education and research, hopefully engendering further interest in NASA careers and research.

*This work was performed by Jacqueline Le Moigne, Thomas Grubb, and Barbara Milner for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15967-1*