pared to a manual process, this script reduces human error and saves considerable man-hours by automating and streamlining the mission planning and sequencing task for the GRAIL mission.

This work was done by Jared A. Call, John H. Kwok, and Forest W. Fisher of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice @jpl.nasa.gov.

This software is available for commercial licensing. Please contact Dan Broderick at Daniel.F.Broderick@jpl.nasa.gov. Refer to NPO-48658.

Real-Time Multimission Event Notification System for Mars Relay

NASA's Jet Propulsion Laboratory, Pasadena, California

As the Mars Relay Network is in constant flux (missions and teams going through their daily workflow), it is imperative that users are aware of such state changes. For example, a change by an orbiter team can affect operations on a lander team. This software provides an ambient view of the real-time status of the Mars network.

The Mars Relay Operations Service (MaROS) comprises a number of tools to coordinate, plan, and visualize various aspects of the Mars Relay Network. As part of MaROS, a feature set was developed that operates on several levels of the software architecture. These levels include a Web-based user interface, a back-end "ReSTlet" built in Java, and databases that store the data as it is received from the network. The result is a real-time event notification and management system, so mission teams can track and act upon events on a moment-by-moment basis.

This software retrieves events from MaROS and displays them to the end user. Updates happen in real time, i.e., messages are pushed to the user while logged into the system, and queued when the user is not online for later viewing. The software does not do away with the e-mail notifications, but augments them with in-line notifications. Further, this software expands the events that can generate a notification, and allows user-generated notifications.

Existing software sends a smaller subset of mission-generated notifications via email. A common complaint of users was that the system-generated e-mails often "get lost" with other e-mail that comes in. This software allows for an expanded set (including user-generated) of notifications displayed in-line of the program. By separating notifications, this can improve a user's workflow.

This work was done by Michael N. Wallick, Daniel A. Allard, Roy E. Gladden, Paul Wang, and Franklin H. Hy of Caltech; and Corey L. Peterson for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This software is available for commercial licensing. Please contact Dan Broderick at Daniel.F.Broderick@jpl.nasa.gov. Refer to NPO-48288.

SIM_EXPLORE: Software for Directed Exploration of Complex Systems

NASA's Jet Propulsion Laboratory, Pasadena, California

Physics-based numerical simulation codes are widely used in science and engineering to model complex systems that would be infeasible to study otherwise. While such codes may provide the highest-fidelity representation of system behavior, they are often so slow to run that insight into the system is limited. Trying to understand the effects of inputs on outputs by conducting an exhaustive grid-based sweep over the input parameter space is simply too time-consuming. An alternative approach called "directed exploration" (see figure) has been developed to harvest information from numerical simulators more efficiently. The basic idea is to employ active learning and supervised machine learning to choose cleverly at each step which simulation trials to run next based on the results of previous trials.

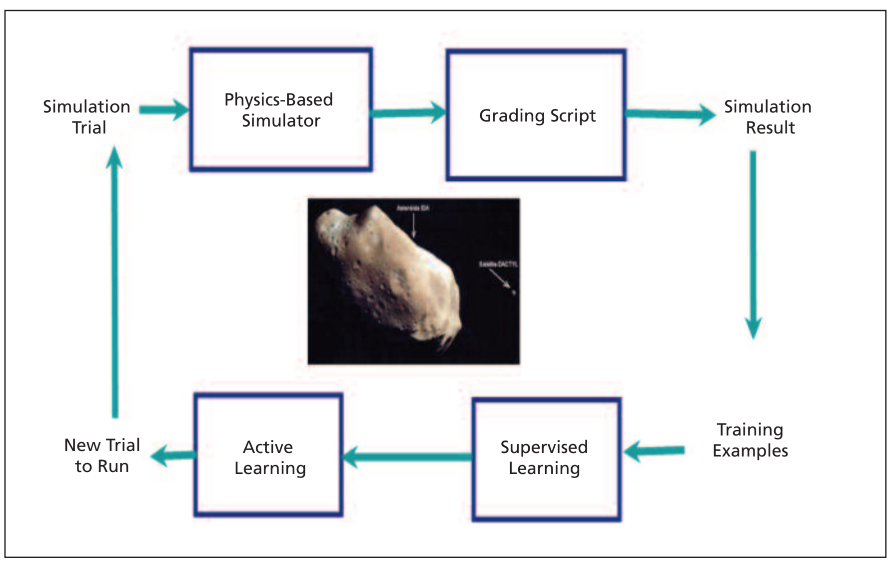

Illustration of the **Directed Exploration** approach in an asteroid collision application. The central image shows the Ida-Dactyl asteroid pair observed serendipitously by the Galileo spacecraft. Planetary scientists are interested in understanding how such systems form and more generally in how asteroid families form. Physics-based numerical simulations offer a means to gain insight into such systems; however, the simulations are so slow to run that a *directed exploration* strategy is required.

SIM_EXPLORE is a new computer program that uses directed exploration to explore efficiently complex systems represented by numerical simulations. The software sequentially identifies and runs simulation trials that it believes will be most informative given the results of previous trials. The results of new trials are incorporated into the software's model of the system behavior. The updated model is then used to pick the next round of new trials. This process, implemented as a closed-loop system wrapped around existing simulation code, provides a means to improve the speed and efficiency with which a set of simulations can yield scientifically useful results.

The software focuses on the case in which the feedback from the simulation trials is binary-valued, i.e., the learner is only informed of the success or failure of the simulation trial to produce a desired output. The software offers a number of choices for the supervised learning algorithm (the method used to model the system behavior given the results so far) and a number of choices for the active learning strategy (the method used to choose which new simulation trials to run given the current behavior model). The software also makes use of the LEGION distributed computing framework to leverage the power of a set of compute nodes. The approach has been demonstrated on a planetary science application in which numerical simulations are used to study the formation of asteroid families.

This work was done by Michael Burl and Esther Wang of Caltech, and Brian Enke and William J. Merline of SWRI for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

This software is available for commercial licensing. Please contact Dan Broderick at Daniel.F.Broderick@jpl.nasa.gov. Refer to NPO-47919.

Mobile Timekeeping Application Built on Reverse-Engineered JPL Infrastructure

NASA's Jet Propulsion Laboratory, Pasadena, California

Every year, non-exempt employees cumulatively waste over one man-year tracking their time and using the timekeeping Web page to save those times. This app eliminates this waste.

The innovation is a native iPhone app. Libraries were built around a reverse-engineered JPL API. It represents a punch-in/punch-out paradigm for timekeeping. It is accessible natively via iPhones, and features ease of access.

Any non-exempt employee can natively punch in and out, as well as save and view their JPL timecard. This app is built on custom libraries created by reverse-engineering the standard timekeeping application. Communication is through custom libraries that re-route traffic through BrowserRAS (remote access service).

This has value at any center where employees track their time.

This work was done by Robert J. Witoff of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This software is available for commercial licensing. Please contact Dan Broderick at Daniel.F.Broderick@jpl.nasa.gov. Refer to NPO-48449.

Advanced Query and Data Mining Capabilities for MaROS

NASA's Jet Propulsion Laboratory, Pasadena, California

The Mars Relay Operational Service (MaROS) comprises a number of tools to coordinate, plan, and visualize various aspects of the Mars Relay network. These levels include a Web-based user interface, a back-end "ReSTlet" built in Java, and databases that store the data as it is received from the network. As part of MaROS, the innovators have developed and implemented a feature set that operates on several levels of the software architecture.

This new feature is an advanced querying capability through either the Web-based user interface, or through a back-end REST interface to access all of the data gathered from the network. This software is not meant to replace the REST interface, but to augment and expand the range of available data. The current REST interface provides specific data that is used by the MaROS Web application to display and visualize the information; however, the returned information from the REST interface has typically been pre-processed to return only a subset of the entire information within the repository, particularly only the information that is of interest to the GUI (graphical user interface). The new, advanced query and data mining capabilities allow users to retrieve the raw data and/or to perform their own data processing. The query language used to access the repository is a restricted subset of the structured query language (SQL) that can be built safely from the Web user interface, or entered as freeform SQL by a user. The results are returned in a CSV (Comma Separated Values) format for easy exporting to third-party tools and applications that can be used for data mining or user-defined visualization and interpretation. This is the first time that a service is capable of providing access to all cross-project relay data from a single Web resource.

Because MaROS contains the data for a variety of missions from the Mars network, which span both NASA and ESA, the software also establishes an access control list (ACL) on each data record in the database repository to enforce user access permissions through a multi-layered approach.

This work was done by Paul Wang, Michael N. Wallick, Daniel A. Allard, Roy E. Gladden, and Franklin H. Hy of Caltech for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Dan Broderick at Daniel.F.Broderick@jpl.nasa.gov.
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