tion to images created by satellites, the exact whereabouts of the aerobot can be pinpointed. This is crucial for scientific understanding of an area as it allows scientists to piece together an accurate mosaic of a region using actual planetary latitude/longitude references. Such references can also be used to categorize and discover suitable landing sites for future missions for example.

SciSys, with the University of Wales, Aberystwyth (UK) and Joanneum Research (Austria), is currently developing and testing a vision-based software package which builds 3-D models and localises the aerobot using vision data. The project will deliver two main components, namely: an Imagery-based Localisation Package (ILP) module which will implement the on-board Digital Elevation Model (DEM) generation, image prioritisation, vision-based localisation, data storage and uplink management; and a test framework to validate and evaluate the ILP module. The test framework will include a dedicated software simulator and a real prototype balloon fitted with a comprehensive payload ie camera system, on-board computer, altimeter and wireless communications.

The ILP requires an advanced image prioritisation data management system since the aerobot would only be able to upload its data to the orbiting spacecraft at limited times. Image prioritisation is a process by which the ILP stores images which are, by a prior-agreed set of standards such as high gradient variability, judged to be of interest to the scientific community. Those which are of less interest may be compressed more substantially or simply not stored at all.

Figure 2: A proposed design for the ExoMars Rover, a future Aurora mission.

As Steve Squires, Principal Investigator for NASA's Mars Exploration Rover (MER) mission, has commented "it takes MER a day to do what a field geologist could do in 45 seconds". For a complex mission, there is a need to increase the intelligence of the On-Board Software (OBSW) so that it can perform more tasks autonomously without the need for ground assistance. There are a number of technologies from the field of Artificial Intelligence which can help out on future Mars missions. SciSys is currently carrying out research into Intelligent Planning and Scheduling (IPS) which offers engineers the prospect of having a rover which can validate their activity plans with real-time information and repair these plans autonomously should they fail. Ultimately therefore, it offers the prospect of more science.

The potential of IPS for an actual rover mission has never been demonstrated in a test environment representing ESA's Aurora programme. The Mars Mission On-board Planner and Scheduler (MMOPS) project aims to address this. SciSys, with the University of Strathclyde (UK) and Heriot-Watt University (UK), are working on a project to develop an on-board IPS application capable of mission plan validation and repair. Trials involving engineering and operations personnel will then explore the benefits and optimal trade-off between factors such as autonomy vs. complexity, risk and net benefit to a mission.

As these examples illustrate, SciSys' own experience with the complex and challenging task of robotic planetary exploration has shown that strong relationships with universities and research centres is a key element for success.

Links:
SciSys: http://www.scisys.co.uk
ESA's Aurora programme:
http://www.esa.int/SPECIALS/Aurora/

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MEXAR2 Support to Space Mission Planners

by Amedeo Cesta, Gabriella Cortellessa, Simone Fratini, Angelo Oddi and Nicola Policella

MEXAR2 is a fielded AI system in daily use at ESA since February 2005. It provides continuous support to human mission planners in synthesizing plans for downlinking on-board memory data from the MARS EXPRESS spacecraft to Earth.

A critical problem for interplanetary space missions is to maximize scientific results while guaranteeing data return to Earth. A research team of the Institute of Cognitive Science and Technology of the Italian Research Council (ISTC-CNR) has developed an AI system, named MEXAR2, currently in daily use at the European Space Agency (ESA-ESOC). MEXAR2 provides continuous support to human mission planners in synthesizing dump plans for downlinking on-board memory data from the MARS EXPRESS spacecraft to Earth.

The MARS EXPRESS mission has ambitious goals for the scientific experiments on board. The seven payloads with which the orbiter is equipped are expected to maximize their data return to take advantage of the opportunity offered by proximity to the Red Planet.

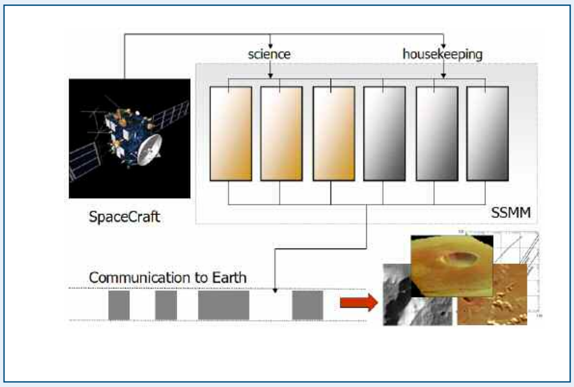

Figure 1: Bringing data from Mars to Earth.

New information from Mars is not only arriving to the space scientific community but, through the media, is also being disseminated further.

Obviously, in a deep-space mission like MARS EXPRESS, data transmission to Earth is fundamental. The space probe continuously produces a large amount of data resulting from the activities of its payloads and from on-board device monitoring and verification tasks. All data must be transferred to Earth during bounded downlink sessions. The presence of a single pointing system implies that the space-probe either points to Mars to perform payload operations, or points to Earth, to download the produced data. As a consequence, on-board data must generally be first stored in a Solid State Mass Memory (SSMM) and then transferred to Earth.

The average data production on a single day can be around 2-3 Gbit while the transmission rate of the communication channel, which varies between 45Kbs and 182Kbs, may not be sufficient. The on-board memory is subdivided into different banks, called packet stores, in which both scientific and spacecraft management data can be stored. In particular, the latter must reach Earth daily so as to allow safety checking of the different operations on board. It should be noted that each packet store assigned to science data is managed cyclically, so if new data are produced before the previous data have been dumped to Earth, the older data are overwritten and the related observation experiments have to be re-scheduled. Even if the on-board memory is about 9.4 Gbit, the irregular distribution of transmission windows, the different transmission rates of such windows and the different data rates for data production (eg, the stereo camera can produce files close to 1Gbit) may frequently create usage peaks close to the packet store capacities.

To complicate matters there is an additional uncertainty factor in data production for some instruments due to different compression algorithms. Dump plans for the on-board memory are usually computed for a nominal expected production of a certain payload activity, a POR (Payload Operation Request), but mission planners may discover that on-board data are more than expected so they have to recompute a dump plan.

The role of the software previously used to support the decision making was secondary; it was relegated to constraint checking tasks. On the contrary, by integrating Artificial Intelligence problem solving methods and Human-Computer Interaction techniques, MEXAR2 implements a proactive approach to plan synthesis while, at the same time, fostering human intervention and control during problem solving. In general, data dump generation can now be performed more quickly and with less effort and the quality of plans exceed that provided by the tools previously used.

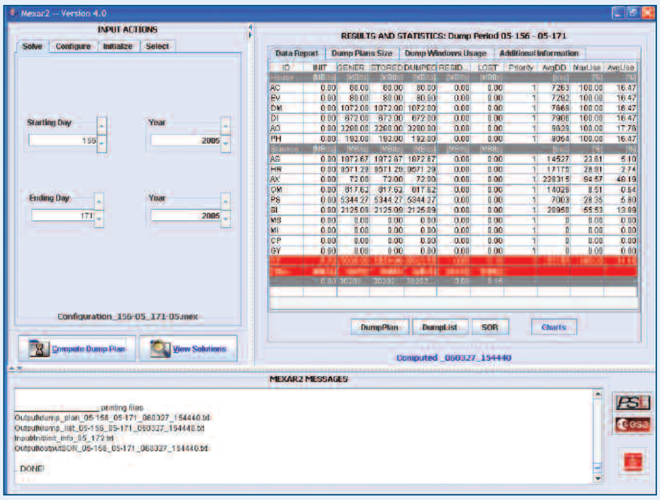

Figure 2: Mexar2 Interaction Module.

From the user standpoint, the problem of uncertainty in data production is addressed very satisfactorily and the time saved for producing plans has been estimated as up to 50%.

The ability of MEXAR2 to generate plans over multiple days very quickly, allows mission planners to consider alternative solutions in order to avoid data loss. It is worth noting that, before the introduction of MEXAR2 in the Mission Planning System, mission planners were satisfied with a single solution; MEXAR2 makes it possible to activate interesting optimizations. This allows problematic intervals in the schedule of future payload operations to be identified and an alternative allocation of the tasks involved to be negotiated with scientists thus minimizing overwrites. Additionally, users appreciate the usability and flexibility of the interface services and the fact that MEXAR2 runs on several platforms so that they can easily employ it from different machines. The previous procedure for synthesizing dump plans quite often obliged staff to work overtime; this effect has been eliminated with MEXAR2.

The scientific community has gained a number of benefits from MEXAR2: observation data are available earlier and data loss is minimized. As already said potential overwrites can be quickly detected and fed back to the scientists for science plan updates. Thanks to MEXAR2 the use of the downlink channel is optimised and more data can be downlinked. We can conclude that the use of MEXAR2 has resulted in an important increase in the scientific return from the mission.

Link:
http://pst.istc.cnr.it/

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