All of these steps are controlled by LabVIEW software, which controls 7-way, two 2-way valves, as well as a peristaltic pump. Solvents are all attached to the 7-way valve and are introduced by the peristaltic pump at flow rates on the order of 1-5 µL/min.

This work was done by Maegan K. Spencer of Stanford University, De-Ling Liu of Aerospace Corp., and Isik Kanik and Luther Beegle of Caltech for NASA's Jet Propulsion Laboratory.

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-45428, volume and number of this NASA Tech Briefs *issue, and the page number.*

Durable Tactile Glove for Human or Robot Hand

Lyndon B. Johnson Space Center, Houston, Texas

A glove containing force sensors has been built as a prototype of tactile sensor arrays to be worn on human hands and anthropomorphic robot hands. Whereas the force sensors of a prior force-sensing glove are mounted on the outside, the force sensors of this glove are mounted inside, in protective pockets; as a result of this and other design features, the present glove is more durable. The sensors, which cost only $3 apiece (2002), produce analog force readings in the range of 0 to 5 lb (0 to 22 N) at numerous locations across the hand.

To minimize false readings due to internal glove motions and/or tight fit of the glove on the hand, the pockets are constructed as recesses within modular foam inserts that are sewn into the glove. High-friction material provides good gripping surfaces for finger and palm contact areas. Textile stiffeners on the backsides of the sensors prevent deformation of the foam during motion. To ensure that forces are directed into the sensors and not channeled through the relatively stiff gripping-surface material, stiff plastic beads are sewn in place between the sensors and the outer glove fabric.

This work was done by Melissa Butzer of Oceaneering Space Systems, Myron A. Diftler of Lockheed Martin Corp., and Eric Huber of Metrica, Inc., for Johnson Space Center. Further information is contained in a TSP (see page 1).
MSC-23544-1

Robotic Arm Manipulator Using Active Control for Sample Acquisition and Transfer, and Passive Mode for Surface Compliance

NASA's Jet Propulsion Laboratory, Pasadena, California

A robotic arm that consists of three joints with four degrees of freedom (DOF) has been developed. It can carry an end-effector to acquire and transfer samples by using active control and comply with surface topology in a passive mode during a brief surface contact. The three joints are arranged in such a way that one joint of two DOFs is located at the shoulder, one joint of one DOF is located at the elbow, and one joint of one DOF is located at the wrist. Operationally, three DOFs are moved in the same plane, and the remaining one on the shoulder is moved perpendicular to the other three for better compliance with ground surface and more flexibility of sample handling. Three out of four joints are backdriveable, making the mechanism less complex and more cost effective.

Having joints of a robotic arm accomplish two different tasks is a new concept. The preliminary engineering shows this concept is workable with proper selection of actuators.

This work was done by Jun Liu, Michael L. Underhill, Brian P. Trease, and Randel A. Lindemann of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47099