proach assumes that each county contains a single canonical pixel for each crop (corn, cotton, soybean, etc.) and that the rest of the pixels in that county are noisy observations of the true one.

This work could ultimately provide automated mapping of crops that are being grown, which could save agencies such as the U.S. Department of Agriculture a significant amount of money that is currently devoted to surveying fields to produce summaries of how much of each crop is being grown. Reliable early estimates of the likely volume of production can significantly affect crop prices throughout the season.

This work was done by Kiri L. Wagstaff of Caltech and Terran Lane of the University of New Mexico for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45177

Speech Acquisition and Automatic Speech Recognition for Integrated Spacesuit Audio Systems

This interface also has applications in mobile phones, in-car devices, and home electronics and appliances.

John H. Glenn Research Center, Cleveland, Ohio

A voice-command human-machine interface system has been developed for spacesuit extravehicular activity (EVA) missions. A multichannel acoustic signal processing method has been created for distant speech acquisition in noisy and reverberant environments. This technology reduces noise by exploiting differences in the statistical nature of signal (i.e., speech) and noise that exists in the spatial and temporal domains. As a result, the automatic speech recognition (ASR) accuracy can be improved to the level at which crewmembers would find the speech interface useful. The developed speech human/machine interface will enable both crewmember usability and operational efficiency. It can enjoy a fast rate of data/text entry, small overall size, and can be lightweight. In addition, this design will free the hands and eyes of a suited crewmember.

The system components and steps include beam forming/multi-channel noise reduction, single-channel noise reduction, speech feature extraction, feature transformation and normalization, feature compression, model adaption, ASR HMM (Hidden Markov Model) training, and ASR decoding. A state-of-the-art phoneme recognizer can obtain an accuracy rate of 65 percent when the training and testing data are free of noise. When it is used in spacesuits, the rate drops to about 33 percent. With the developed microphone array speech-processing technologies, the performance is improved and the phoneme recognition accuracy rate rises to 44 percent. The recognizer can be further improved by combining the microphone array and HMM model adaptation techniques and using speech samples collected from inside spacesuits. In addition, arithmetic complexity models for the major HMM-based ASR components were developed. They can help real-time ASR system designers select proper tasks when in the face of constraints in computational resources.

This work was done by Yiteng (Arden) Huang, Jingdong Chen, and Shaoyan (Sharyl) Chen of WEVOICE, Inc. for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18534-1.

Predicting Long-Range Traversability From Short-Range Stereo-Derived Geometry

Learning-based software improves obstacle avoidance by robotic ground vehicles.

NASA's Jet Propulsion Laboratory, Pasadena, California

Based only on its appearance in imagery, this program uses close-range 3D terrain analysis to produce training data sufficient to estimate the traversability of terrain beyond 3D sensing range. This approach is called learning from stereo (LFS). In effect, the software transfers knowledge from middle distances, where 3D geometry provides training cues, into the far field where only appearance is available. This is a viable approach because the same obstacle classes, and sometimes the same obstacles, are typically present in the mid-field and the far-field. Learning thus extends the effective look-ahead distance of the sensors.

The baseline navigation software architecture in both the LAGR (Learning Applied to Ground Robotics) and MTP (Mars Technology Program) programs operates so that stereo image pairs are processed into range imagery, which is then converted to local elevation maps on a ground plane grid with cells roughly 20-cm square covering 5 to 10 m in front of the vehicle, depending on camera height and resolution. The image and the map are the two basic coordinate systems used, but only pixels with nonzero stereo disparity can be placed into the map. Geometry-based traversability analysis heuristics are used to produce local, grid-based, 'traversability-cost' maps over the local map area, with a real number representing traversability in each map cell. The local elevation and cost maps are accumulated in a global map as the robot drives. Path planning algorithms for local obstacle avoidance and global route planning are applied to the global map. The resulting path is used to derive steering commands sent to the motor controllers.

The software (training set selection, classifier training, and image classification) runs in real time at about 3 Hz on a 2-GHz processor, and the type of "image appearance features" is user-configurable. Basic RGB (red-green-blue) features, or their powers, or separable textures or within-patch color histograms can be used in any combination. All of these methods run in real time. The software can work in two modes: purely on-line or by using a fixed, previously-learned classifier. To learn the classifier, a cumulative-training mode is built in which training data across an entire run accumulates, learns a model at the end of the run, and saves the model to a reusable configuration file. The cumulative training mode can run alongside the online classification mode. One of two classification modes can be used: A linear discriminant (LDA)-based method, or a linear support vector machine (SVM) classifier.

This work was done by Michael Turmon, Benyang Tang, Andrew Howard, and Max Bajracharya of Caltech for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-45146.

Browser-Based Application for Telemetry Monitoring of Robotic Assets

NASA's Jet Propulsion Laboratory, Pasadena, California

AEGSE Virtuoso Charting is an application that enables animated, real-time charting of telemetry streams of data from a rover. These automatically scaled charts are completely interactive, and allow users to choose the variables that they want to monitor. The charts can process data from streams with many variables. This application allows for the simultaneous viewing of up to four individually configured charts on a small touch-screen laptop.

The charting application has been tested and found to be extremely robust during long operations. It was left running overnight, with incoming telemetry at 100 Hz, and it did not experience any signs of lost functionality or memory leaks. This robustness is critical for an application that will be used to support vital tests for the Mars Science Laboratory rover.

The charting component also provides an interactive interface that allows the engineers to decide how many charts they want on their screen, and which attributes should be plotted on each chart. The application is optimized to make the charts on display take up as much of the available space as possible to maximize the use of the screen real estate. Engineers are also able to plot multiple attributes on the same chart, which enables them to observe the correlation between various attributes.

This work was done by Kelly S. Breed, Mark W. Powell, Khawaja S. Shams, and Richard D. Petras 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 Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-46348.