Signal Processing, Inc.

A Pattern Recognition Company

www.signalpro.net

A leading provider to solve challenging problems in Machine Learning and Pattern Recognition

Mission

Signal Processing, Inc. researches, develops, licenses and supports proprietary machine learning and pattern recognition software for government and commercial markets. We offer feasibility studies, consulting services, custom made solutions and software, development of high-end algorithms for challenging pattern recognition problems, and R&D cooperation and partnership. SPI performs research and development in the areas of image/video processing, speech processing, signal processing, fault diagnostics and health monitoring, prognostics, explosive detection, chemical and biological agent detection, and health monitoring and control applications.

Core competencies

All employees of Signal Processing have advanced degrees and extensive experiences in algorithm design and implementation, hardware implementation, and real-time system integration. Employees of SPI are active in the research community, especially in the area of speech processing, pattern recognition, diagnostics and prognostics, condition based maintenance, health monitoring, signal/image processing, and real-time controls.

Partnerships

We have close collaborations with many universities and companies, including Texas A&M University, West Virginia University, Carnegie Mellon University, University of Maryland at College Park, Virginia Polytechnic Institute and State University, University of Missouri at Columbia, University of Delaware, Arizona State University, University of Texas at Arlington, UT Pan American, U. Colorado at Boulder, U. Calgary, U. Tennessee, Johns Hopkins U., Ohio State U., Lockheed Martin, General Electric, BAE Systems, SAIC, and Raytheon

Invention Disclosures

1. "A Novel and High Performance Framework for Chemical/Biological Agent Detection and Classification Using Fluctuation Enhanced Sensing," 2007.
2. "Enhanced Partial Fingerprint Recognition Using Feature Level Fusion," 2007.
3. "Condition Based Maintenance Using Wireless Sensors," 2008.
4. "Chemical Agent Fingerprinting Using Zero-Crossing Patterns," 2008.
5. "Multi-thread multi-core processing architecture for real-time applications," 2009.
6. "Fast and novel nonlinear change detection algorithms for hyperspectral image processing," 2009
7. "Novel system to reduce inbound and outbound signal interactions in helmet," 2010
8. "Fast arcing fault localization system," 2011
9. "Novel matrix completion algorithm," 2011
10. "High performance lossy and lossless compression algorithms," 2012
11. "Multiple pixel size target tracking," 2012
12. "Super-resolution algorithm for hyperspectral images," 2012

Patents

1. "Knowledge learning system and process for fingerprint verifications," Patent # 8295561, issued 10/23/2012.
2. "Fast algorithms for signal enhancement in noisy environments," pending.
3. "Novel Approach to generating high resolution hyperspectral images from low resolution images," to be filed.

Company Background

Signal Processing, Inc. (SPI) is located in Rockville, MD and has been in business since April 2006. SPI is an active award winner in SBIR/STTR and MIPS (a Maryland state funded grant).

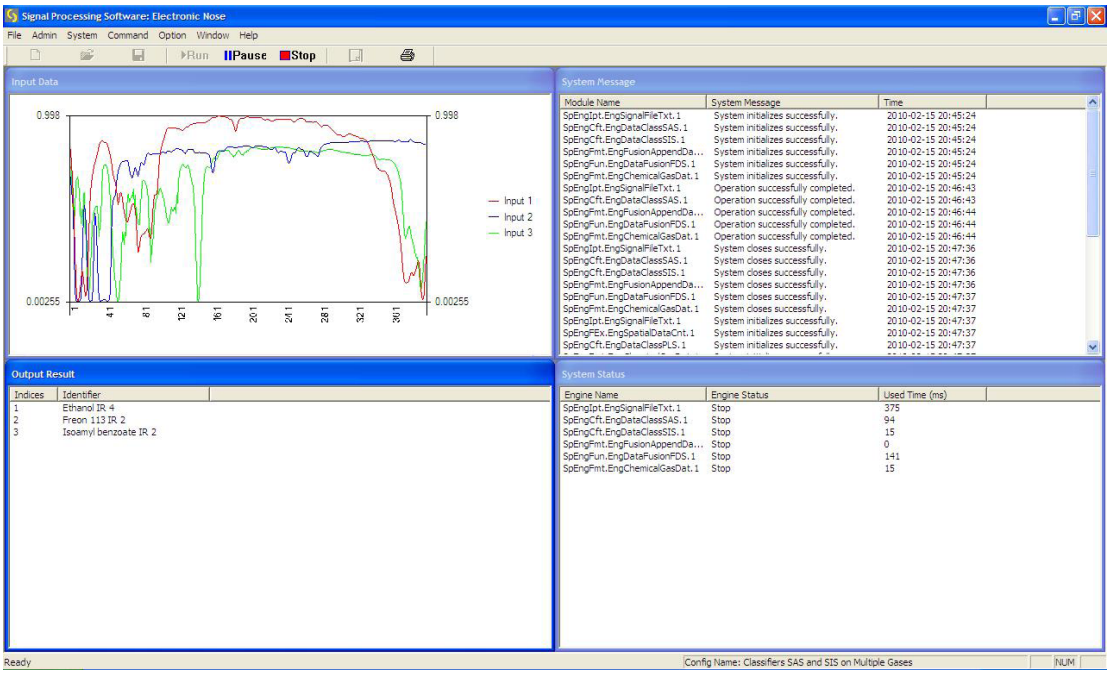
Management

The president and founder of Signal Processing, Inc. is Dr. Chiman Kwan. Dr. Chiman Kwan worked in the Beam Instrumentation Department of the SSC (Superconducting Super Collider Laboratory) in Dallas, Texas, from April 1991 to February 1994, where he was heavily involved in the modeling, simulation and design of modern digital controllers and signal processing algorithms for the beam control and synchronization system. He received an invention award for his work at SSC. Between March 1994 and June 1995, he joined the Automation and Robotics Research Institute in Fort Worth, where he applied neural networks and fuzzy logic to the control of power systems, robots, and motors. From July 1995 to March 2006, he was the Vice President of Intelligent Automation, Inc. and served as Principal Investigator/Program Manager for more than 65 different projects, with total funding exceeding 20 million dollars.

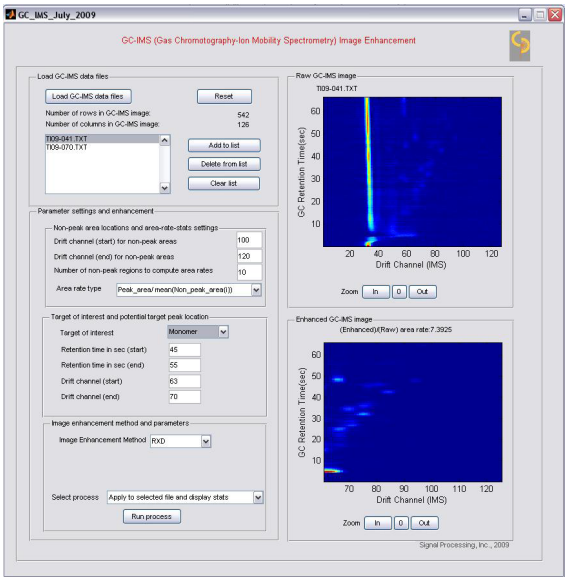
Products

By using Phase I and Phase II awards from federal government agencies, SPI has successfully created the following products:

CAC-CET™ | CAC-CET™ is a new software tool that can classify and estimate concentrations of different chemical agents. The tool is modular, flexible, and suitable for real-time chemical agent classification applications, including conventional and nano-sensors. It is low cost and independent of commercial software packages such as Matlab, Labview, etc.

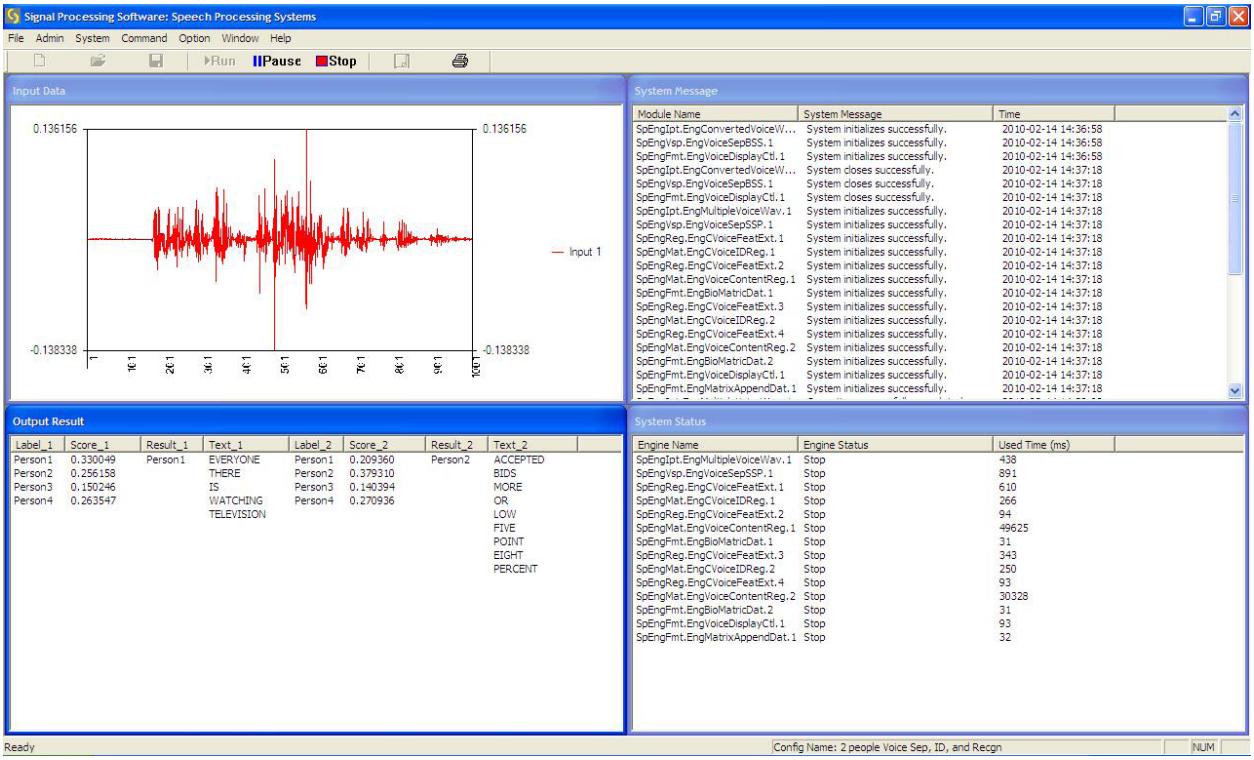


Chemical Concentration Estimation Tool for Gc-Ims | We developed a software tool for the Army. The tool enhances the detection performance in a portable Army GC-IMS (Gas Chromatography Ion Mobility Analyzer). The tool is user-friendly and enhances the state-of-the-art in chemical agent detection and concentration estimation in GC-IMS.



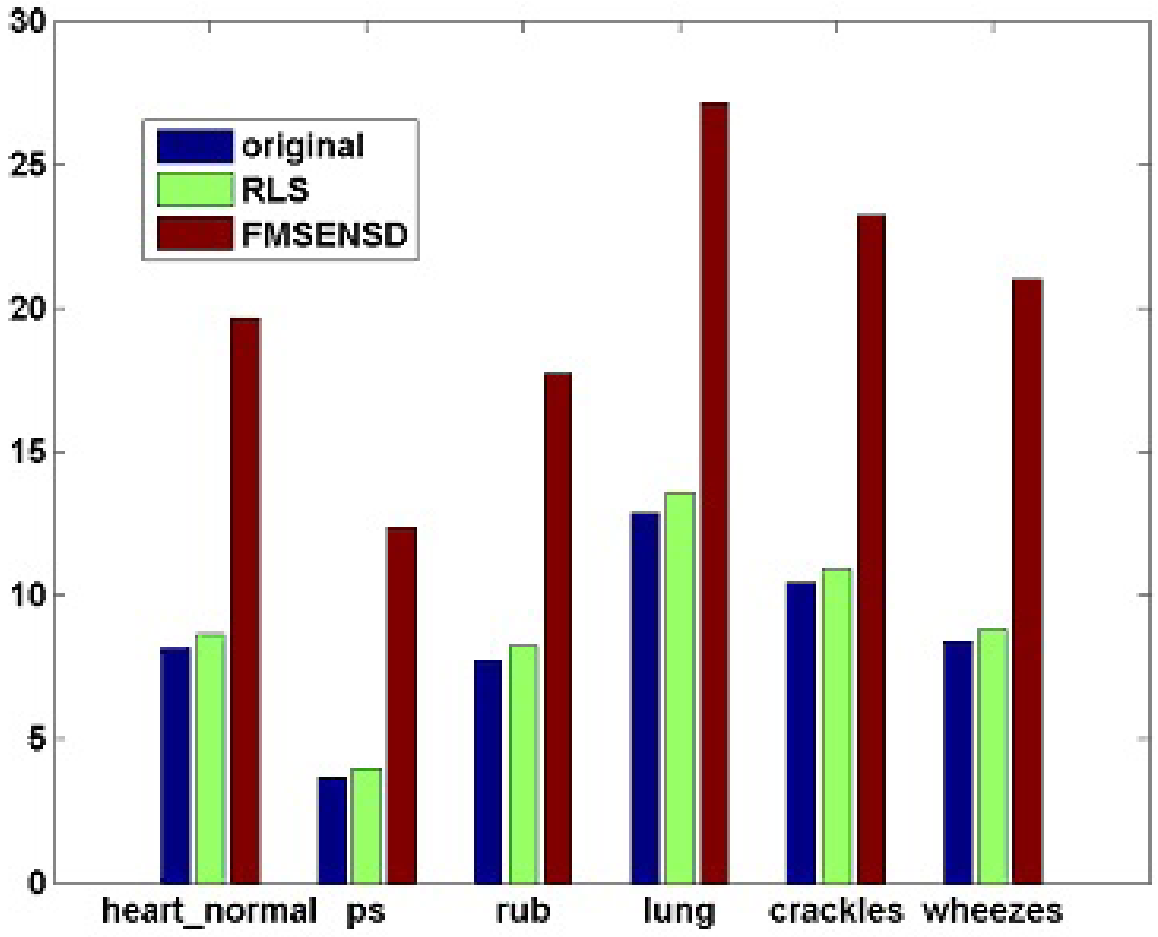
Remote Standoff Chemical Detection | We developed a user-friendly software tool for the Army. The tool analyzes the data from a remote standoff multispectral sensor. The chemical cloud can be detected more accurately than that of the state-of-the-art algorithm. The data are sensitive so we do not attach an image of our tool.

VSep™, Spatial-Sep™, Speaker-ID™, SpeechReg™ | VSep™, Spatial-Sep™, Speaker-ID™, SpeechReg™ are a set voice processing tools that allow users to integrate newly developed algorithms to separate, ID, and recognize voices under noisy environments. We target a niche market where speech separation is needed before speaker identification and speech recognition can start. Potential applications include personal identification in cocktail party environment, biometrics in multiple competing speaker environment, and hands free communications in cars.



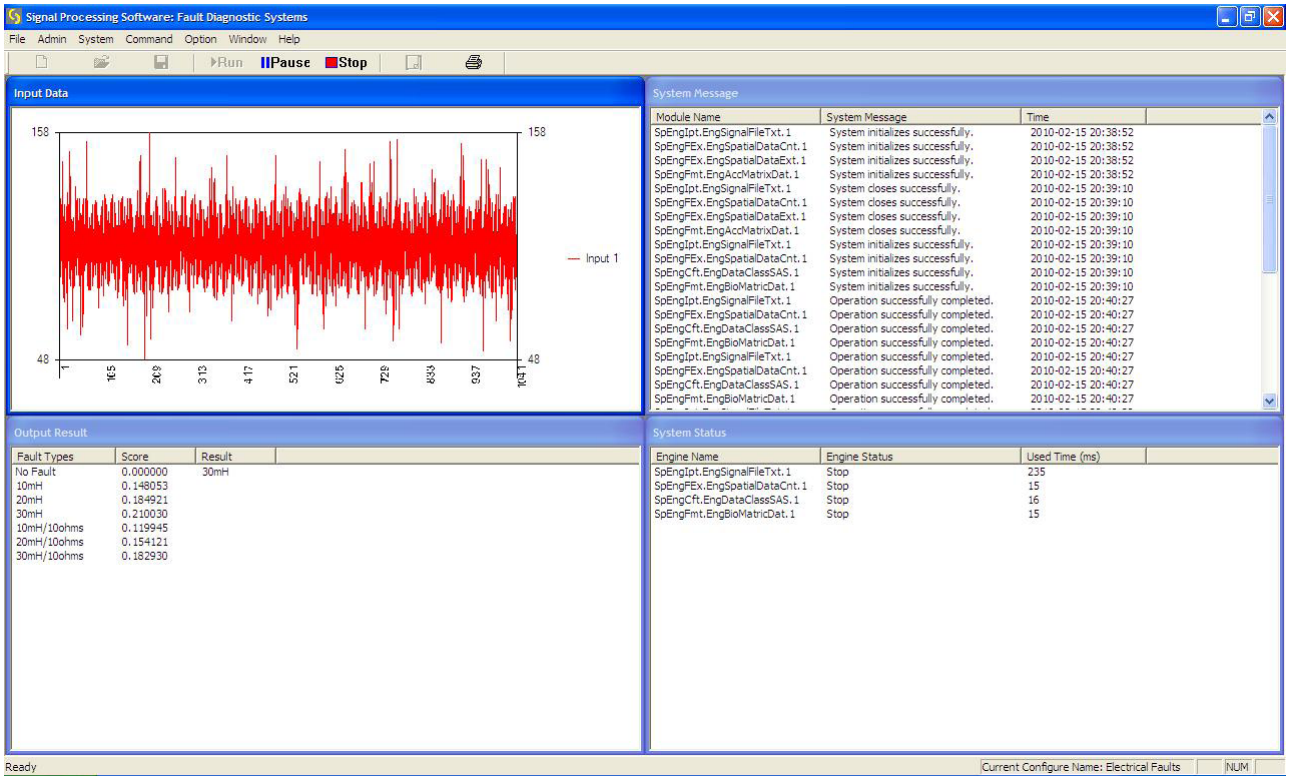
Products

High Performance Auscultation in Noisy Environments | In 2011, we developed a real-time and high performance system to enhance auscultation in noisy environments such as International Space Station (ISS) where the noisy level can be more than 66 dBA. Conventional stethoscopes are designed for quiet environments (45 dBA) and hence they are not suitable for noisy environments. Our approach incorporates a second stethoscope or microphone to pick up background noise and use this signal to enhance the auscultation performance. Real-time experiments were performed using a DSP board. The figure below demonstrates that our algorithm performed significantly better than a well-known adaptive filter called recursive least square (RLS). Moreover, the computational complexity of our algorithm is much simpler than RLS. An invention disclosure for our algorithm was filed and a patent will be filed soon.



Speech Enhancement In Battlefield | We cannot disclose the details, as this project was funded by the US Navy. We have collected some experimental data using 2 mics. The SNR in Mic-1 is -20.1837 dB and the SNR in Mic-2 is -22.3265 dB. Both are very low. The speech is not intelligible in such battlefield environment. However, after speech enhancement, we can recover the speech quite clearly (the SNR becomes 22.2848dB). Detailed sound files can be found in http://www.signalpro.net/se_dual2.htm.

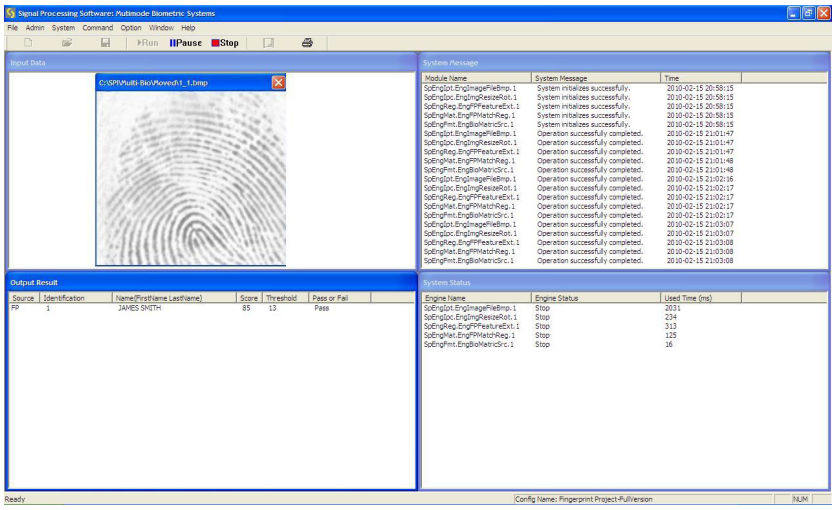
FDP™ | FDP™ is health monitoring software for rotating machinery using wireless sensors. The software tool consists of the following modules: 1) Input module for acquiring accelerometer, voltage, and current data; 2) Health monitoring (HM) tool; 3) Output module for displaying health index. If the system health deviates from the normal status, the health index will increase.



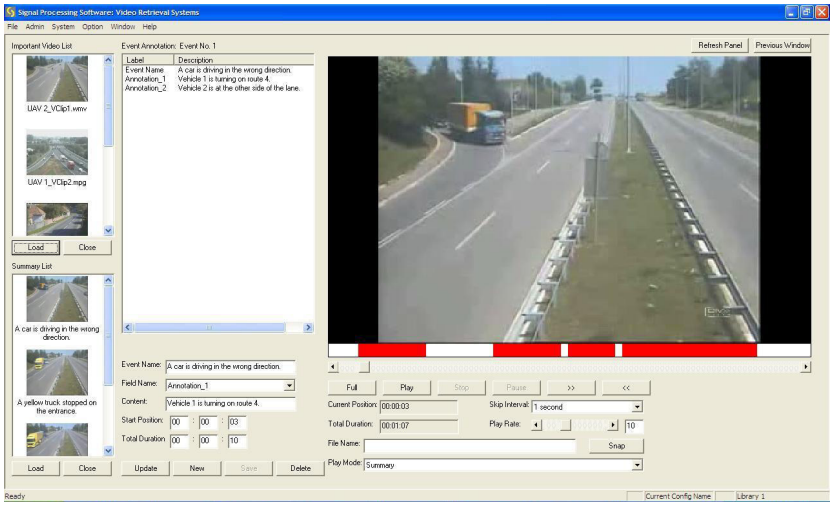
Products

By using Phase I and Phase II awards from federal government agencies, SPI has successfully created the following products:

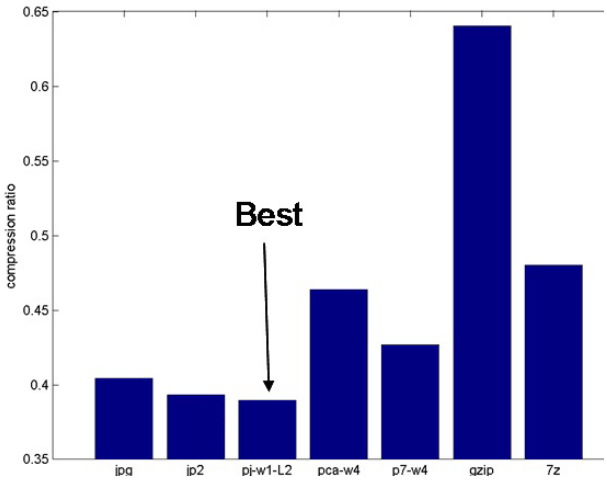
Multi-Bio™ | Multi-Bio™ is a personal identification system using finger and voice prints. This product uses low cost sensors that have complementary properties. We focus on a niche biometric market involving business executives, military personnel, and marketing people who need to protect valuable information in their desktops, PDAs, and laptops. Compared to passwords, fingerprint and voiceprint biometrics are hard to steal and more reliable.



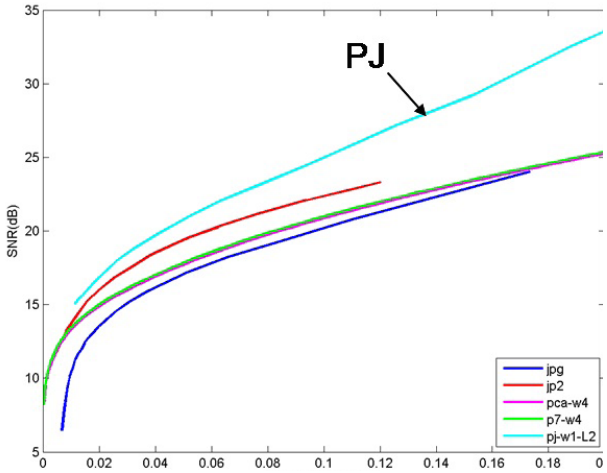
VST™ | VST™ is a new software tool that can generate highly compressed videos for reviewing and archiving. It is an event based approach. Novel algorithms are used to separate a long video into event segments and non-event segments. The determination of events and non-events can be done in real-time. The algorithms are robust to illumination changes, shadows, moving trees, the presence of multiple objects, changing traffic lights, etc. The tool is suitable for condensing long surveillance videos into much shorter videos and yet without losing any important information in the original videos. The conventional way of reviewing videos is to have an operator to manually view the videos, which is tedious and error prone. Having a much shorter video will reduce the operators' work load and also make the reviewing process interesting and fun. Moreover, the data storage can be much smaller. The video demo in our website shows the case where a raw video with a length of 14 minutes is compressed to a video with only 16 seconds, a compression ratio of 52 times.



High Performance Lossy and Lossless Data Compression | High Performance Lossy and Lossless Data Compression In 2012, we developed a novel and high performance algorithm for both lossy and lossless data compression. Actual wind tunnel data from NIST were used for performance evaluation. It was observed that our algorithm performed better than many commercial products in the markets. See figures below. An invention disclosure was filed and a patent will be filed soon.

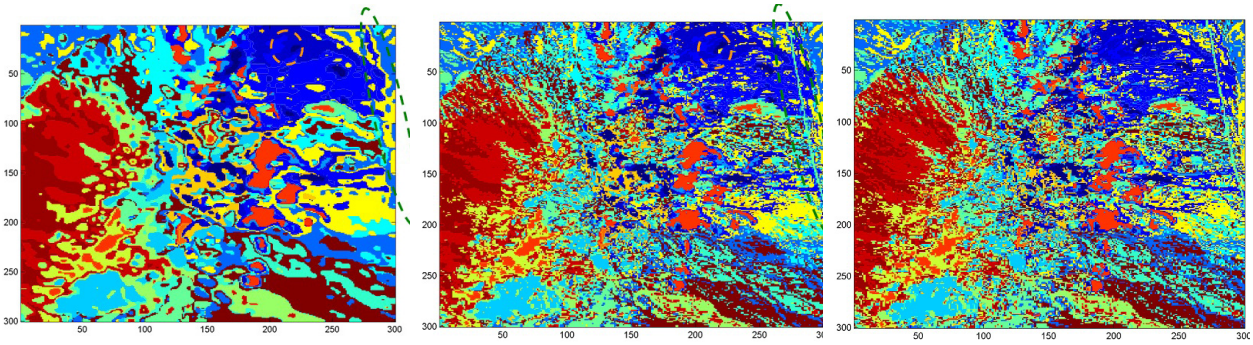


Lossless compression: Our method is called PJ and our performance in terms of compression ratio is better than JPEG, JPEG-2000 (lossless option), 7z, and Gzip.



Lossy compression: Our method is called PJ and our performance in terms of compression ratio is better than JPEG, JPEG-2000 (lossless option), 7z, and Gzip over a wide range of compression ratios.

A Novel Super-Resolution Algorithm for Hyperspectral Images | In 2012, we developed a novel algorithm, which fuses a high resolution color image with a low resolution hyperspectral image to yield a high resolution hyperspectral image. AVIRIS data (15 m resolution) was used in our experiments. The AVIRIS data has 213 bands with wavelengths range from 380 nm to 2500 nm. The image is downsampled to 60 m resolution. In the experiment, we pick only R, G, B bands from original high resolution hyperspectral image for fusion. The bicubic method in the following plots is implemented by upsampling the low resolution image using bicubic interpolation. The results of bicubic method are used as baseline for comparison study. To demonstrate our algorithm, we performed material classification studies using bicubic and our approach. From the figure below, it can be seen that the material classification using our super-resolution image gave results very close to the ground truth whereas bicubic missed a lot of the fine details in material distribution.



bicubic **Our results** **Ground truth material distribution**

Comparison of material classification results. The dotted circled area was missing in the bicubic results whereas our results can recover the line inside the dotted circle.

Products

Matrix Completion with Application to Missing Pixels Reconstruction | In 2011, we developed algorithms to fill in missing pixels in images. Some examples are shown below. We compared with an algorithm known as BPFA (beta process factor analysis) developed by Prof. Lawrence Carin at Duke. The left column shows the reconstructed images using BPFA. Two cases are shown: 90% and 95% of the image pixels are missing randomly. The right column shows our reconstructed images. It can be seen that our results are much better. Our algorithm can also deal with 99% and 99.9% missing data cases

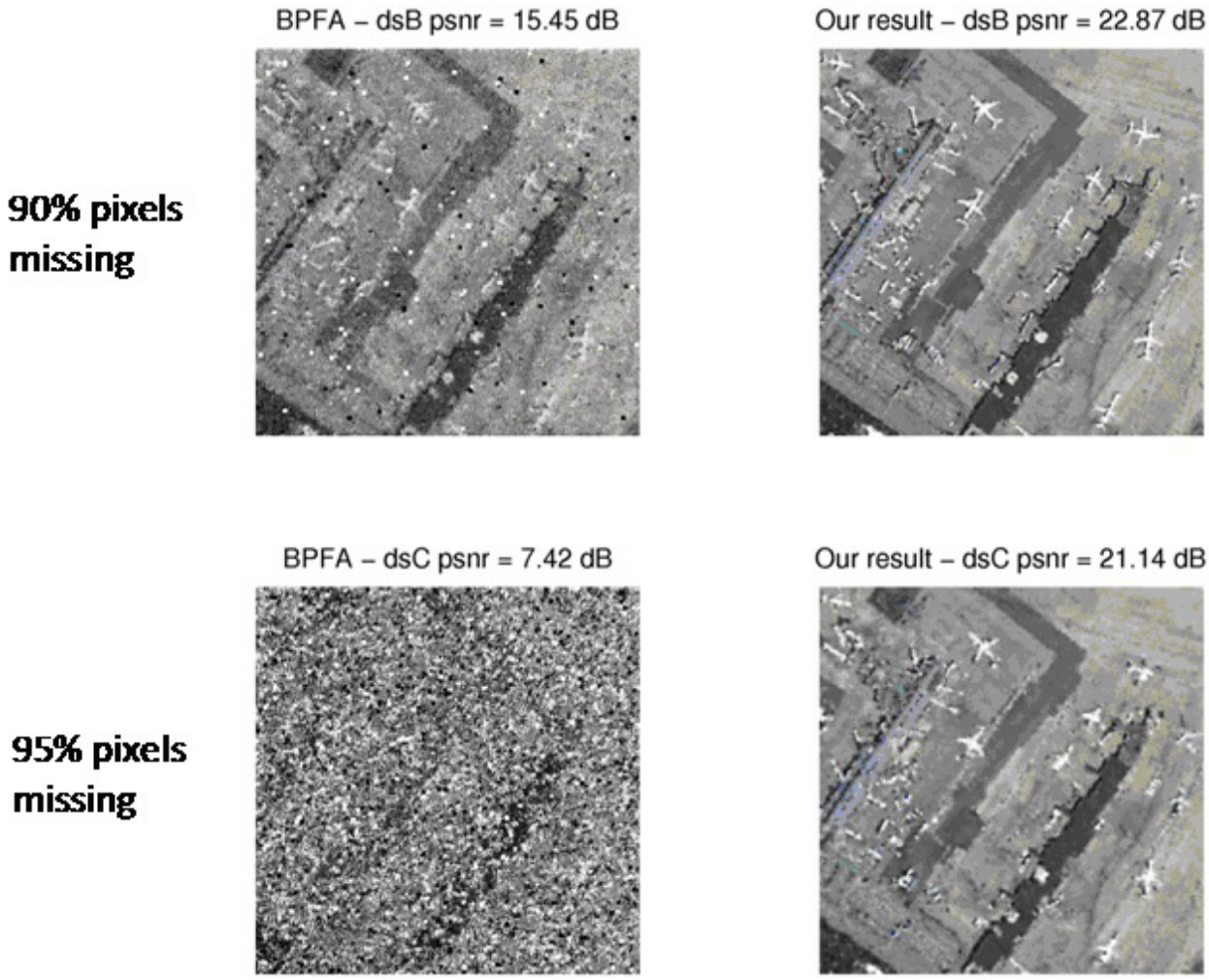


Image completion results using BPFA (left) and our method (right).

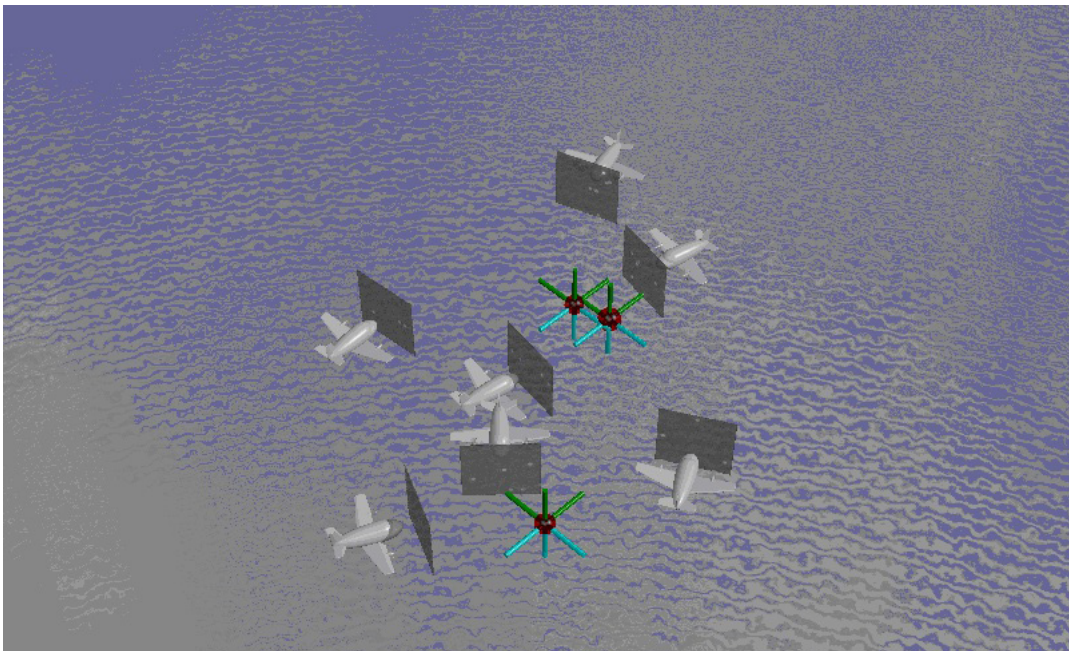
Multi-Thread Multi-Core Processing Architecture | Intel announced the design of a 48-core CPU last year. SPI has developed a multi-thread multi-core processing architecture that can take advantage of the massive processing power in multi-core PCs. We have successfully applied our architecture to speech recognition and genomic data processing. We applied this architecture to speech processing and genomic processing.

Pixel Target Tracking | In 2012, we developed a novel algorithm for tracking pixel size targets. To track multiple targets simultaneously, we maintain an extended Kalman filter (EKF) tracker for each target independently. To update each tracker with new observations, we use nearest neighbor strategy, i.e. for each image, the point which is closest to prediction position is assigned as new observation. To cope with missing pixels, we set a distance threshold. If the closest distance is larger than the threshold, we assume there is no new observation. If a tracker does not have any new observations for a long time, its covariance matrix will be large and we drop/stop it.

Our system has the following key features:

- It can handle pixel targets.
- It can detect and track multiple targets simultaneously.
- It can use partial observations to track targets.
- It can track multiple groups of targets based on automatic camera coordination.
- It can actively adjust cam era view angle to continuously track targets when the targets fall out of the field of view.
- It can handle missing observations, say targets (on image) may disappear randomly.
- It can handle false alarms, say there are some image points which look like targets and used as observations.
- It can handle non-linear target trajectory.
- It can automatically initialize new target's 3D state purely based on camera observations.
- It can automatically rescue the tracking failure based on automatic initialization.
- It can handle observation noise.
- Plug-in scheme for camera sensors, i.e. it's free to add or remove any camera without changing to the system. Sensor appending or removing can be even done on the fly.
- It can automatically kill false targets based on confidence and kill redundant target trackers.

In short, our tracking system is fully automatic, robust, flexible, scalable, efficient and practical for multiple pixel targets tracking. With all these capabilities, we believe that our multiple camera based tracking system is able to work in real world situations and provides a better solution than radar based tracking system in some complex scenarios. The figure below shows an example of pixel target tracking.



Frame 500 with realistic rendering. Three axes are the targets (single pixel) and red balls are EKF trackers. There are multiple cameras tracking the targets.

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