Signal Processing, Inc.

A pattern recognition company

Leadership Statement:
A leading provider to solving challenging problems in Signal Processing, Machine Learning and Pattern Recognition.

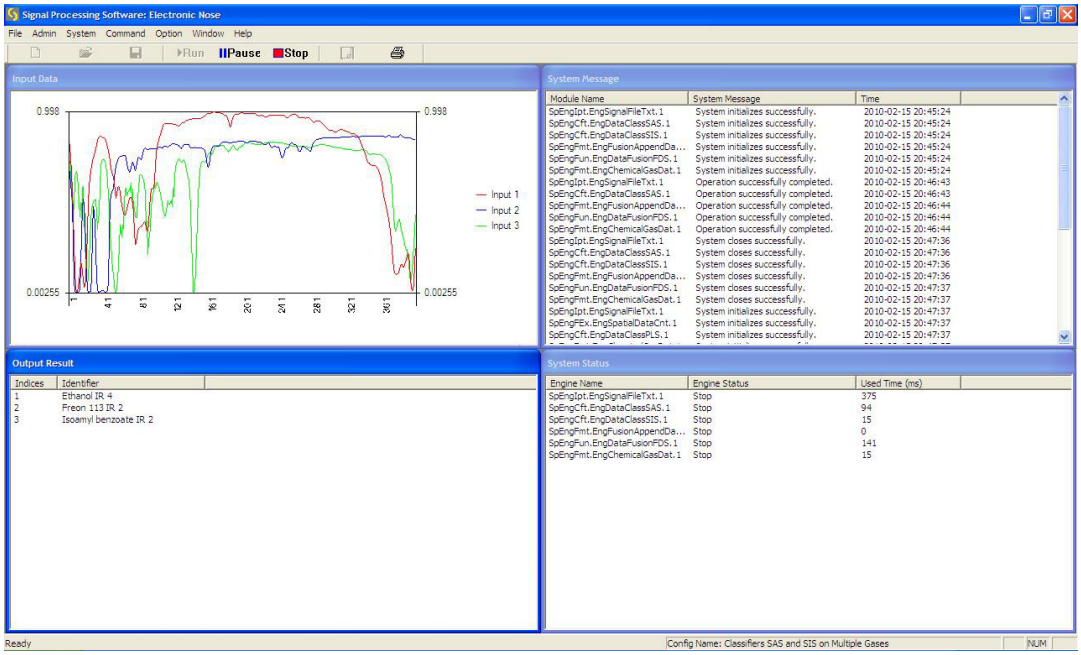
Mission:
Signal Processing, Inc. (SPI) researches, develops, licenses and supports proprietary signal processing, machine learning and pattern recognition software for government and commercial markets. We offer feasibility studies, consulting services, custom made solutions and software, development 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 SPI 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.

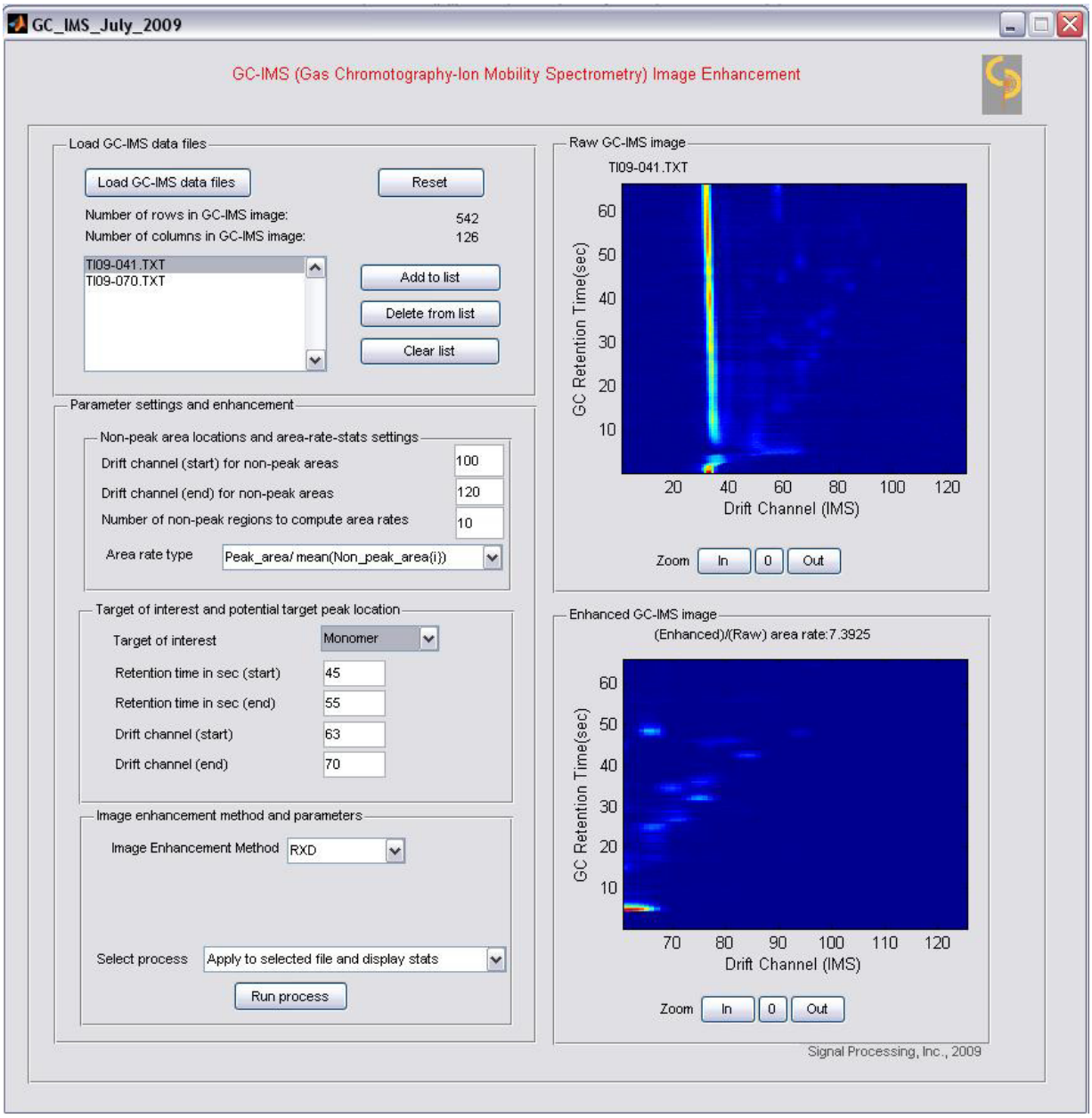
Products:
By using Phase I and Phase II SBIR awards from federal government agencies, SPI has successfully created the following products:

Chemical Agent Detection

CAC-CET^{TM} 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.



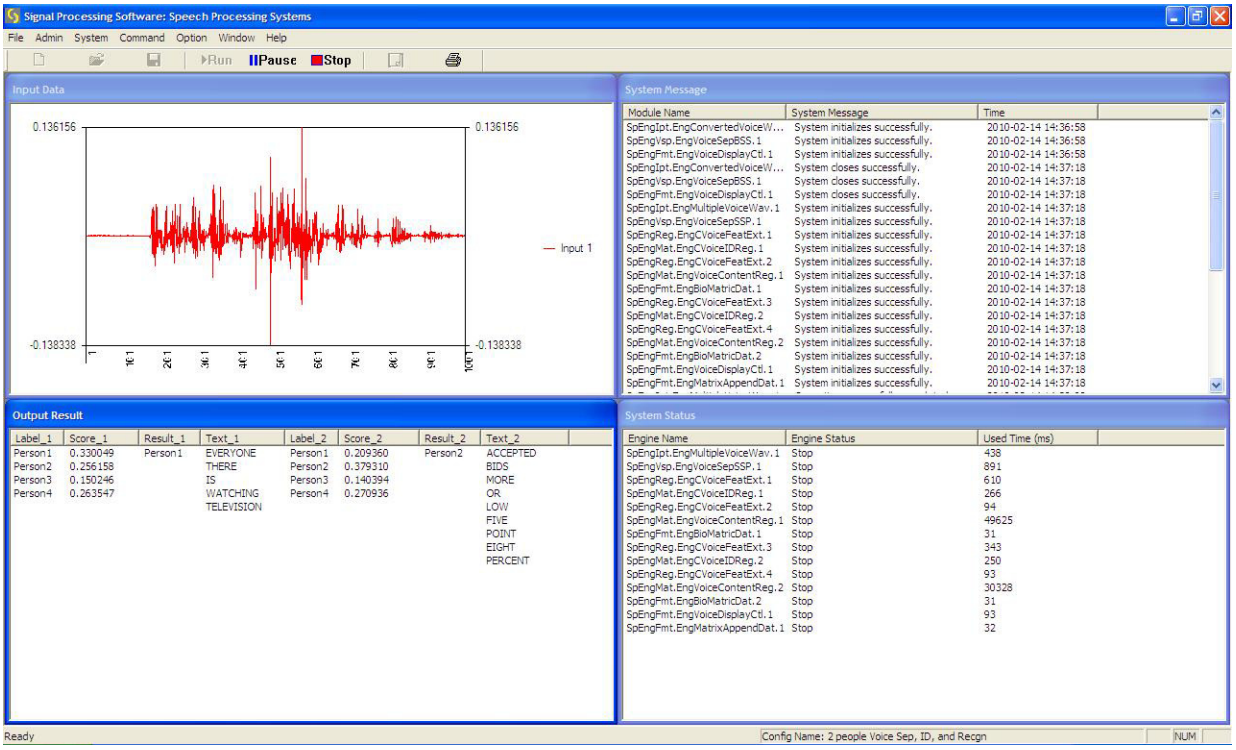
Chemical concentration estimation tool for GC-IMS is a software tool developed for the U.S. Army that enhances the detection performance in a portable Army GC-IMS (Gas Chromatography Ion Mobility Analyzer). The tool is user-friendly and enhances the state-of-the-art in chemical agent detection and concentration estimation in GC-IMS.



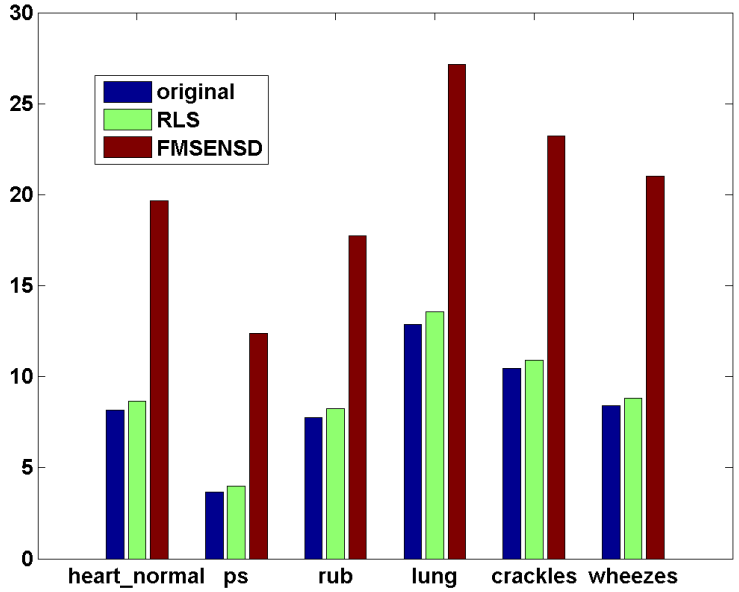
Remote standoff chemical detection is a user-friendly software tool developed for the U.S. Army that analyzes the data from a remote standoff multispectral sensor. The chemical cloud can be detected more accurately than that of the state-of-the-art algorithm.

Signal Enhancement

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. A niche market is targeted 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.



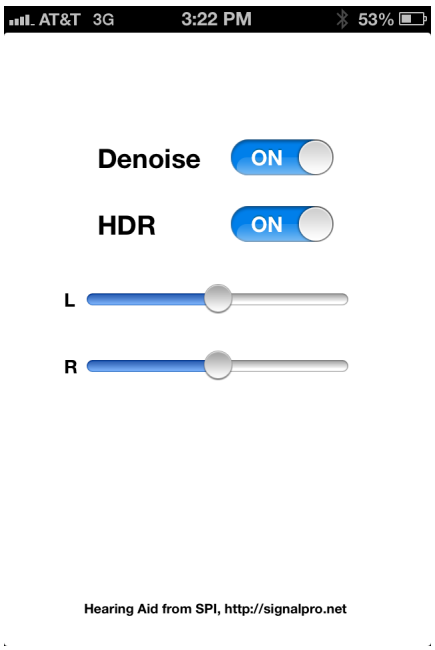
High Performance Auscultation in Noisy Environments was developed in 2011 as a real-time and high performance system to enhance auscultation in noisy environments such as International Space Station (ISS) where the noisy level can be more than 66 dBA. Conventional stethoscopes are designed for quiet environments (45 dBA) and hence they are not suitable for noisy environments. This 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 the algorithm performed significantly better than a well-known adaptive filter called recursive least square (RLS). Moreover, the computational complexity of this algorithm is much simpler than RLS.

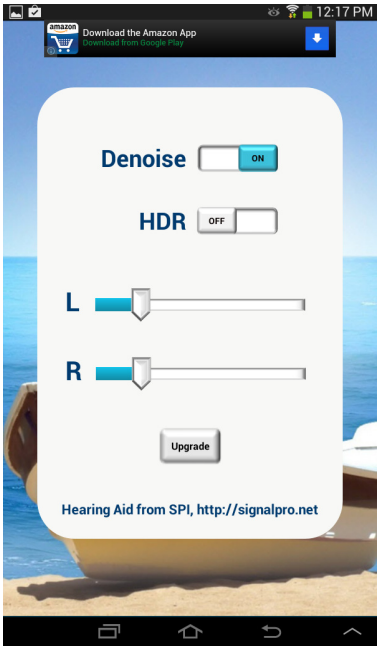


SNR levels before and after filtering. Our filter (FMSENSD) can improve the SNR by more than 10 dB. The background noise level is 66 dBA.

Speech enhancement in battlefield**,** funded by the US Navy, involves the collection of experimental data using two microphones (Mic). The resulting 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, the speech can be recovered quite clearly (the SNR becomes 22.2848dB). Detailed sound files can be found in http://www.signalpro.net/se_dual2.htm.

Good Hearing turns a smart phone into a high performance hearing aid. We offer free (with ads) and professional versions (no ads). Our app can run in iOS and Androids. Our apps have been uploaded to Apple app store and Google Play Store. Over 2,000 downloads were recorded since August, 2013.





iOS version Android version

Hearing aid app developed by our team.

Fault Diagnostics and Prognostics

FDP^{TM} 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.

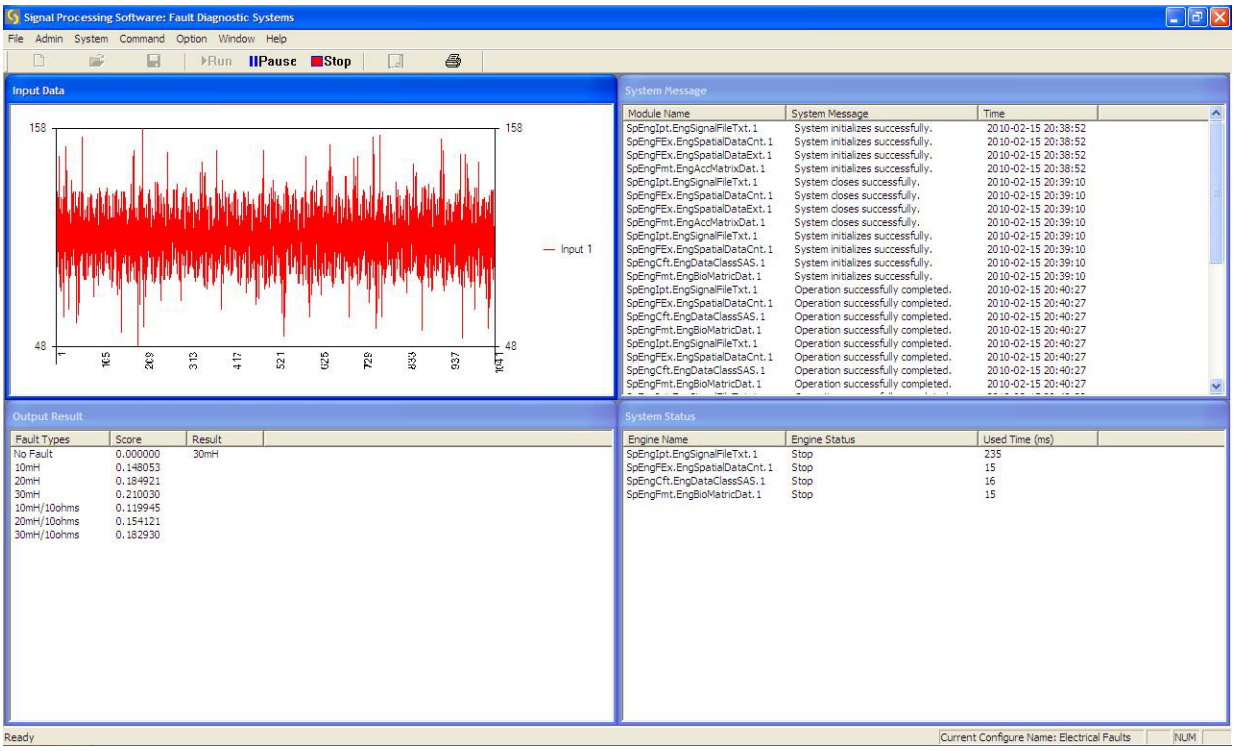
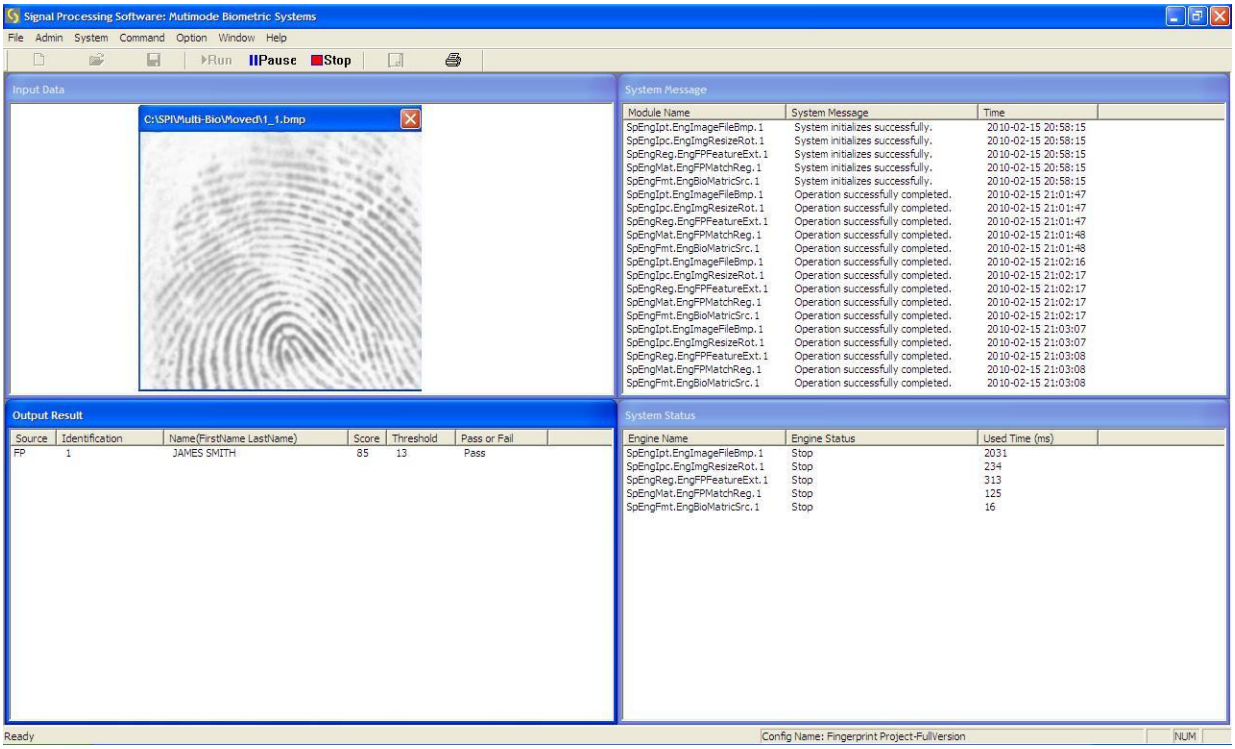
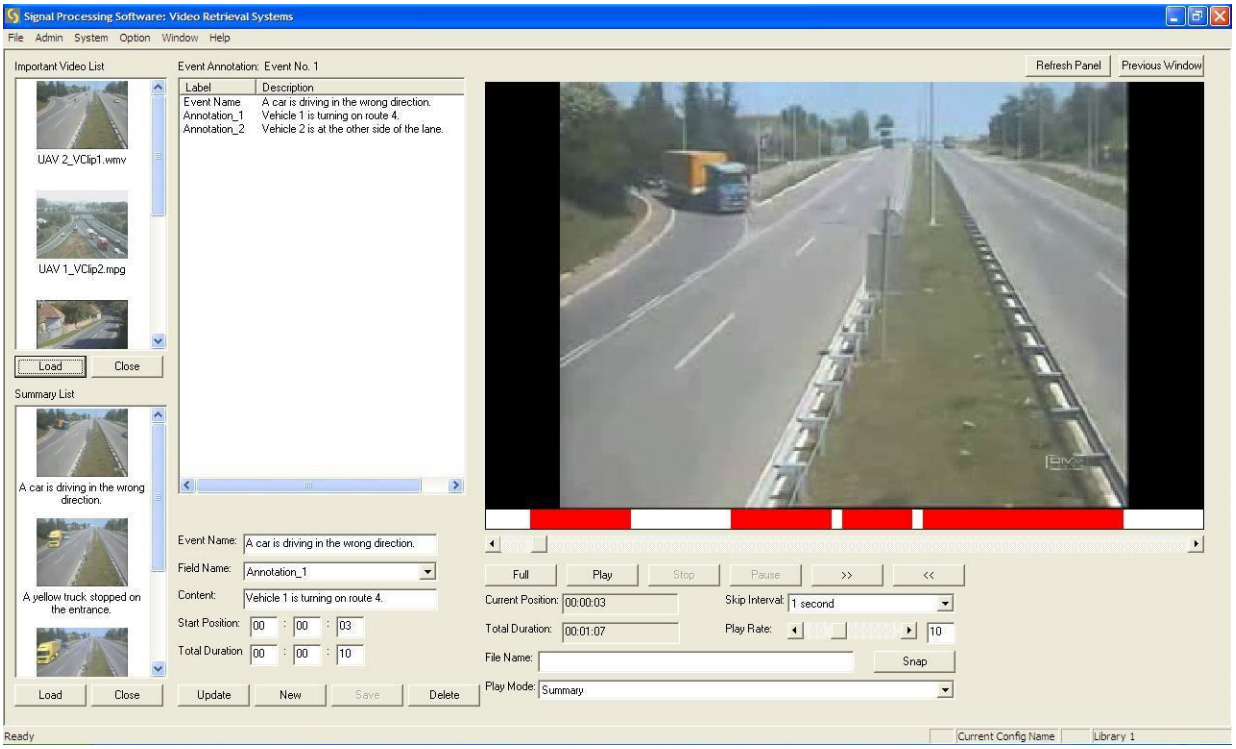


Image and Video Applications

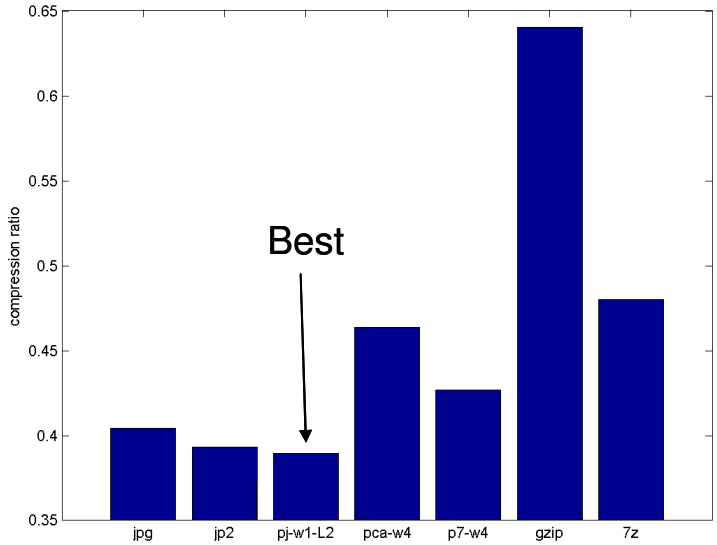
Multi-Bio^{TM} is a personal identification system using finger and voice prints. This product uses low cost sensors that have complementary properties. Targeted to niche biometric markets, it addresses needs of business executives, military personnel, and marketing people who need to protect valuable information in their desktops, PDAs, and laptops. Compared to passwords, fingerprint and voiceprint biometrics are hard to steal and more reliable.



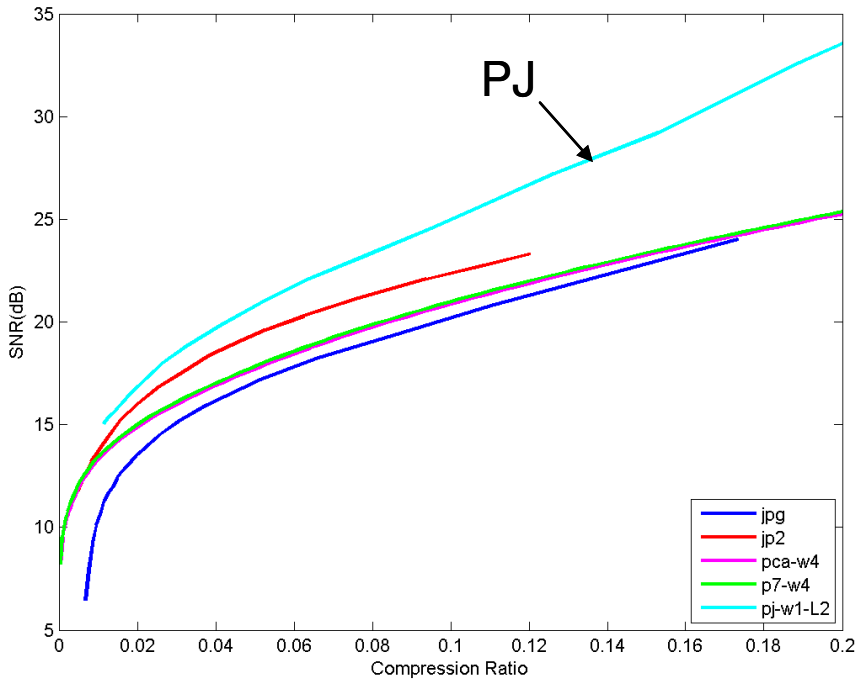
VST™ is a new software tool that can generate highly compressed videos for reviewing and archiving. It is an event based approach. Novel algorithms are used to separate a long video into event segments and non-event segments. The determination of events and non-events can be done in real-time. The algorithms 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 SPI's website (add URL) 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 was developed in 2012 as 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 this algorithm performed better than many commercial products in the markets. See figures below.

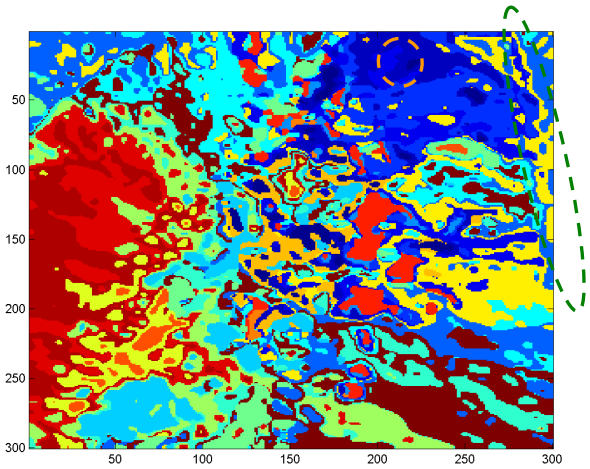


Lossless compression: Our method is called PJ and our performance in terms of compression ratio is better than JPEG, JPEG-2000 (lossless option), 7z, and Gzip.

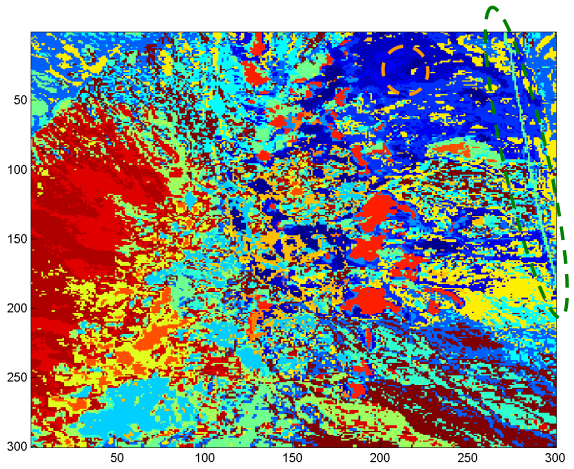


Lossy compression: Our method is called PJ and our performance in terms of compression ratio is better than JPEG, JPEG-2000 (lossless option), 7z, and Gzip over a wide range of compression ratios.

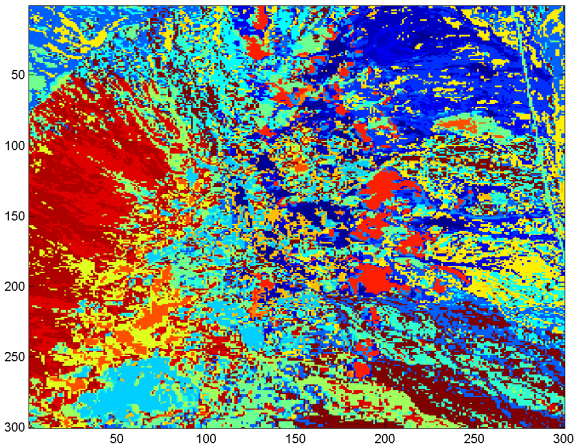
A Novel Super-Resolution Algorithm for Hyperspectral Images, developed in 2012, is a novel algorithm, which fuses a high resolution color image with a low resolution hyperspectral image to yield a high resolution hyperspectral image. AVIRIS data (15 m resolution) was used in SPI experiments. The AVIRIS data has 213 bands with wavelengths range from 380 nm to 2500 nm. The image is downsampled to 60 m resolution. In the experiment, SPI used 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 this approach. From the figure below, it can be seen that the material classification using this super-resolution image gave results very close to the ground truth whereas bicubic missed a lot of the fine details in material distribution.



bicubic



SPI 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.

Matrix Completion with Application to Missing Pixels Reconstruction was developed in 2011 and is an algorithms to fill in missing pixels in images. Some examples are shown below. SPI 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 the reconstructed and improved images. SPI's algorithm can also deal with 99% and 99.9% missing data cases (not shown here).

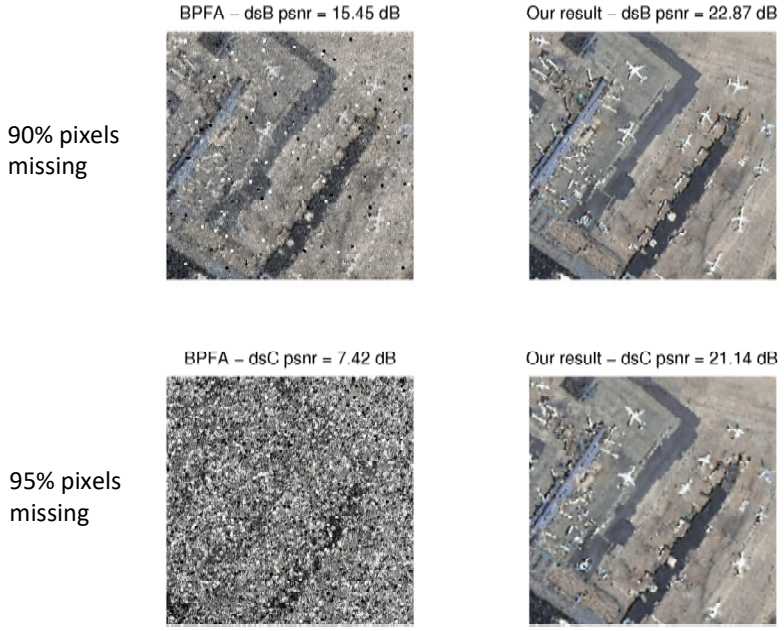
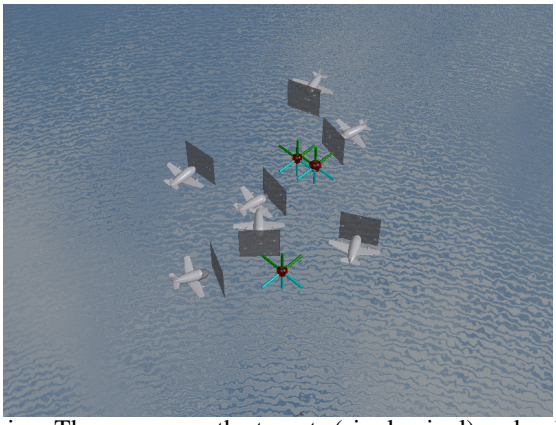


Image completion results using BPFA (left) and SPI's method (right).

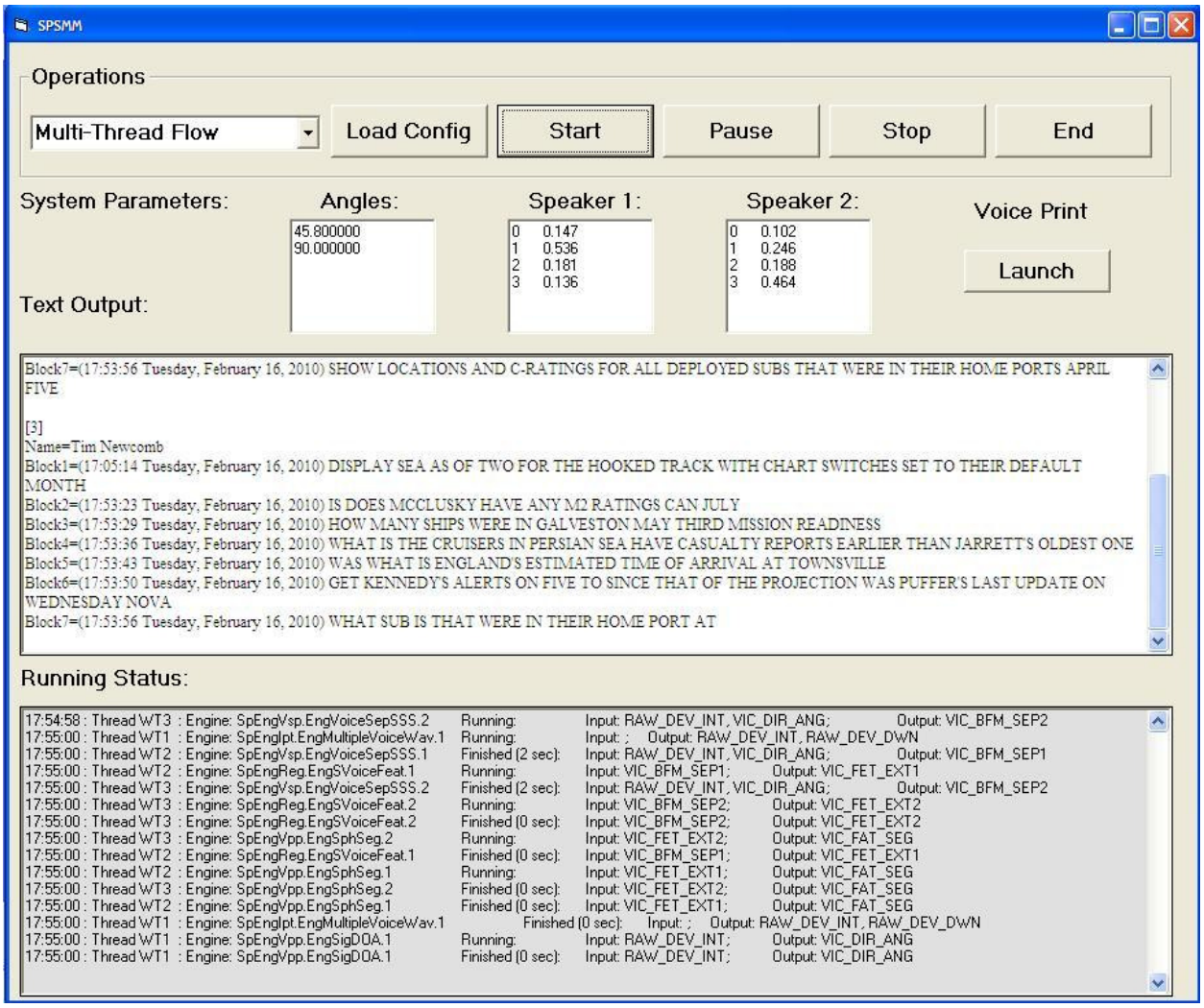
Pixel Target Tracking was developed in 2012, as a novel algorithm for tracking pixel size targets. To track multiple targets simultaneously, SPI maintains an extended Kalman filter (EKF) tracker for each target independently. To update each tracker with new observations, a nearest neighbor strategy is used, i.e. for each image, the point which is closest to prediction position is assigned as new observation. To cope with missing pixels, a distance threshold is set. If the closest distance is larger than the threshold, SPI assumes 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 it is dropped/stopped.

This tracking system is fully automatic, robust, flexible, scalable, efficient and practical for multiple pixel targets tracking. With all these capabilities, SPI's 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.

Multi-thread multi-core processing architecture was developed to provide a multi-thread multi-core processing architecture that can take advantage of the massive processing power in multi-core PCs. This architecture has been successfully been applied to speech recognition and genomic data processing.



Creamyphoto is a tool to enhance images. Million of digital images are collected using Smart phones, iPads, tablets, etc. on a daily basis. Quite many of these images are of low quality due to many reasons. For example, images taken in low light conditions look noisy. Conventional denoising software such as Adobe Lightroom and PhotoNinja cannot deal with such poor images in a satisfactory manner. In addition, these software packages and other algorithms require users to choose many parameters, including signal-to-noise ratio (SNR), contrast level, etc. Inexperienced users may have a hard time to choose the right parameters in order to get good denoising performance. In addition, SNR is hard to quantify for many users. A simple to use and effective denoising software simply does not exist in the market right now.

We developed a novel image denoising system called Creamyphoto that is general, of high performance, and low cost. A patent is pending. We summarize the key advantages of our methods:

- Applicable to gray, color, and hyperspectral images
- Excellent denoising performance in noisy and low lighting conditions
- One click solution: users do not need to choose parameters
- Automatic estimation of SNR
- Can also deal with missing pixels in images. Missing pixels could be due to pixel saturation or noise.

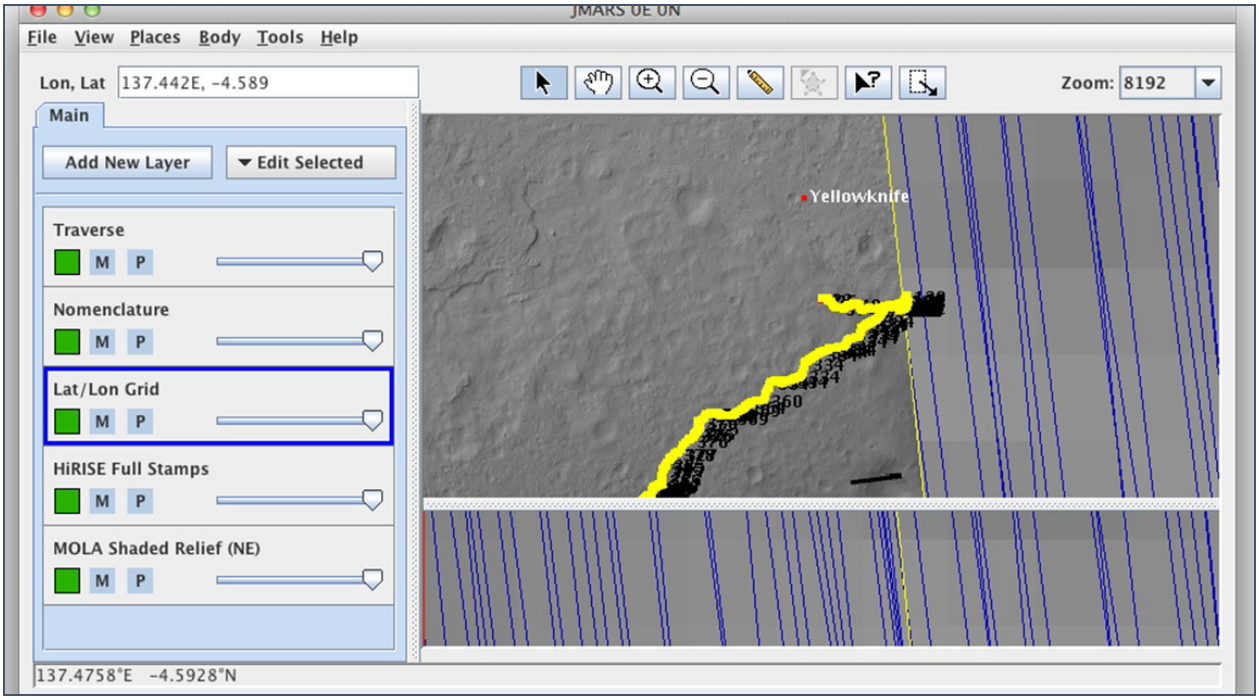
We compare the performance of our algorithm with two commercial products in the market. The image was taken in real low lighting environments. The filtered images are shown below. It can be seen that our software produces the best visual performance. We offer free on-line image denoising via Cloud, a free version with watermark, and a profession version ($29.90).

Filtered image using Lightroom.

Filtered image using our software.

Filtered image using PhotoNinja.

JMARS Enhancement is a new tool that we developed for NASA. JMARS (Java Mission-planning and Analysis for Remote Sensing) is a geospatial information system (GIS) developed by ASU's Mars Space Flight Facility to provide mission planning and data analysis tools for NASA planetary mission data to scientists, students of all ages, and to the general public. We developed a custom layer for JMARS to show the traverse maps of Mars rovers: Spirit, Opportunity and Curiosity (see figure below). The tool allows users to visualize spectral measurements (APXS and LIBS) collected by the rovers' instruments and their oxide composition estimations generated by scientists. When a particular sol day (Mars day) is selected, the graphics window of the JMARS software shows the site location of the rover at that sol day. The HiRISE data layer is also loaded to show the high resolution image of Mars.



Rover Traverse Layer developed for JMARS

Partnerships:
SPI has 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, Old Dominion U., Johns Hopkins U., Ohio State U., Digital Globe, Lockheed Martin, General Electric, BAE Systems, SAIC, and Raytheon. This enables our customers to use the best technology in combination with SPI's research.

Patents:
1. C. Kwan, "Knowledge Learning System and Process for Fingerprint Verifications," Patent # 8,295,561, 10/23/2012.
2. C. Kwan and J. Zhou, "Compact Plug-In Noise Cancellation Device," Patent # 9,117,457, 8/25/2015.
3. C. Kwan and J. Zhou, "Method for Image Denoising," Patent #9,159,121, 10/13/2015.
4. C. Kwan and B. Ayhan, "Automatic Target Recognition System with Online Machine Learning Capability," provisional patent #62/155748, May 1, 2015; non-provisional patent #15087235, filed on April 5, 2016.
5. C. Kwan, "A High Performance System with Explicit Incorporation of ATC Regulations to Generate Contingency Plans for UAVS with Lost Communication," provisional patent #62/192613, July 15, 2015; non-provisional patent #15193034, filed on June 25, 2016.
6. C. Kwan, "Active Noise Reduction System for Creating a Quiet Zone," provisional patent #62/207407, August 20, 2015; non-provisional patent #15206895, filed on July 11, 2016.
7. C. Kwan, "Method and System for Collaborative Multi-Satellite Remote Sensing," provisional patent #62/197864, July 29, 2015; non-provisional patent #15212662, filed on July 19, 2016.
8. C. Kwan and B. Ayhan, "Method and System for UGV Guidance and Targeting," provisional patent #62/204028, August 12, 2015; non-provisional patent # 15226406, filed on August 8, 2016.
9. C. Kwan, "Method and System for High Performance Video Signal Enhancement," non-provisional patent filing number 15/259447, September 8, 2016.
10. C. Kwan, "Method and System for Active Noise Reduction," non-provisional patent # 15361126, filed on November 26, 2016.
11. C. Kwan, "High Performance Sensor Data Compression," to be filed.
12. C. Kwan, "Generation of High Spatial and High Spectral Resolution Satellite Images," to be filed.

Company Background:
Signal Processing, Inc. (SPI) is located in Rockville, MD and was founded by Dr. Chiman Kwan in April 2006. SPI is an active award winner in SBIR/STTR and MIPS (a Maryland state funded grant) and partners with leading image processing research developers to bring you solutions for tough problems.

Management:
The President of Signal Processing, Inc. is Dr. Chiman Kwan. Prior to founding SPI, Dr. Chiman Kwan worked in the Beam Instrumentation Department of the SSC (Superconducting Super Collider National 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.

Company Contact:
Dr. Chiman Kwan, 240-505-2641, chiman.kwan@signalpro.net, http://www.signalpro.net