

SBIR Topic Number:
AF06-283

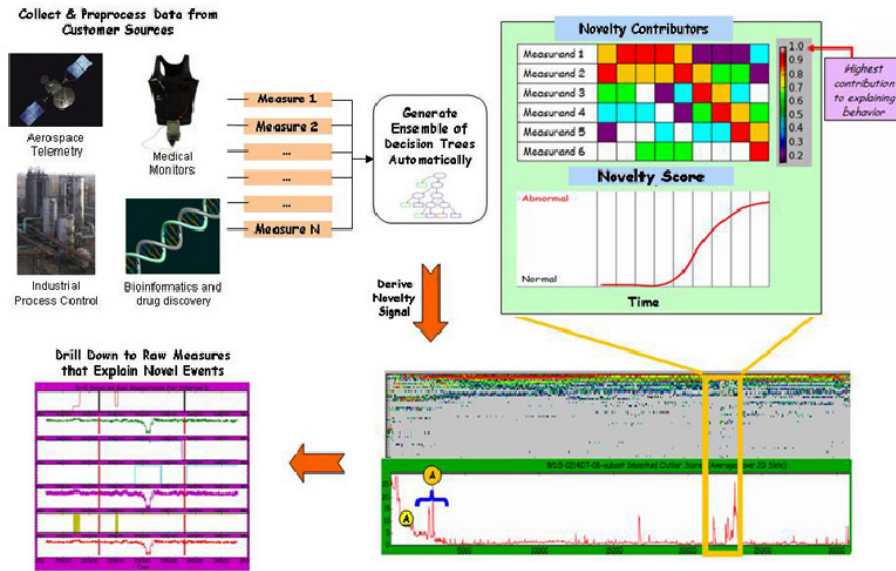
SBIR Title:
Threat Detection, Validation, and Mitigation Tool for Counterspace and SSA Operations

Contract Number:
FA9453-07-C-0056

SBIR Company Name:
Michigan Aerospace Corporation, Ann Arbor, MI

Technical Project Office:
AFRL Space Vehicles Directorate, Kirtland AFB, NM

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.



Approach to anomaly detection in telemetry from various monitoring devices

Threat Assessment and Validation Toolset

- The Air Force requires improved technologies for anomaly detection, as well as data fusion and threat assessment technologies for space situational awareness (SSA), to better protect their space-based assets
- The underlying machine learning technology is automatable and highly data-agnostic, making it cost effective for use across multiple application domains that produce telemetry
- VigiLens, Michigan Aerospace Corporation's pattern recognition software toolset, is based on ensembles of decision trees; it performs anomaly detection in telemetry collected from satellites and many other monitoring devices
- Potential additional applications include NASA telemetry, chemical plant monitoring, bioinformatics novelty detection, biomedical monitoring, water quality monitoring, industrial process control, and crew fatigue detection

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Air Force Requirement

The Air Force required improved technologies for anomaly detection, as well as data fusion and threat assessment for space situational awareness (SSA), in order to better protect their space-based assets. This SBIR program was funded to develop a machine learning technology for anomaly detection. It was originally conceived as a candidate component of AFRL's Joint Situational Awareness and Response System (JSARS) program, and required to operate within the larger framework of the Joint Directors of Laboratories (JDL) model for data fusion.

SBIR Technology

Michigan Aerospace Corporation (MAC) has developed powerful pattern recognition technology (shown schematically on the previous page), based on ensembles of decision trees (EDTs), which drives tools for anomaly detection in telemetry collected from various monitoring devices. EDT-based technology has many advantages over existing techniques, including scalability to handle very high dimensional data, automatic drill-down to display a ranked list of input measurands that explain why that interval appeared anomalous to the machine learning models, and extremely rapid evaluation. This approach is also amenable to deployment on field programmable gate array (FPGA) devices, graphical processing units, parallel processors, and other accelerated platforms.

The technology developed on this Phase II SBIR is a software tool, called *VigiLens*, with graphical user interface (GUI) and command-line interface (CLI) for anomaly detection on satellite telemetry.

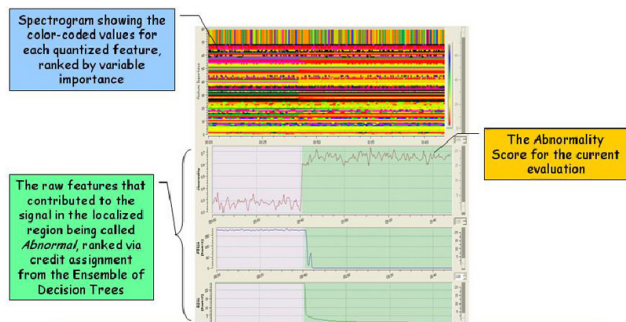


Figure 1

Screen shot of *VigiLens* pattern recognition software tool (bottom) and changing spectrogram pattern (top)

VigiLens supports automated training of anomaly detection models, and evaluation of those models on independent telemetry. The operator can use the *VigiLens* GUI to intuitively drill-down on any region of an anomaly signal, to determine the particular measurands that contributed to the system's anomaly assessment and their values. The lower portion of Figure 1 shows the *VigiLens* anomaly signal and drill-down on two telemetry variables used to discern the anomaly. In the upper portion of this figure, this anomaly also manifests itself as a change in the spectrogram pattern.

Potential Air Force Application

The *VigiLens* anomaly detection software has potential applications, not only in satellite telemetry, but also in other aerospace defense systems that collect telemetry for system monitoring. The underlying machine learning technology is automatable and highly data-agnostic, making it cost effective for use across multiple application domains that produce telemetry.

Products for discovering novel events and detecting anomalous behavior are quickly becoming indispensable for the proper operation and maintenance of the complex systems employed by the Air Force and other defense agencies. Aircraft, space-based assets, and warfighter health monitors regularly produce mega channels of real-time telemetry which must be monitored for possible indications of failure. These present an enormous opportunity for software tools, such as *VigiLens*, that can detect events of interest. These tools can be used to discover valuable new insights into operations, diagnose faults during post-mortem investigations, and predict failures before they cause costly damage or injury.

Company Impact

The anomaly detection technologies developed on this SBIR program have led directly to follow-on work with NASA for adaptation and further development applied to their telemetry. Since this *VigiLens* technology utilizes an anomaly detection engine that is substantially domain independent, Michigan Aerospace Corporation is also pursuing commercial partnerships for multiple anomaly detection applications. These include domains as diverse as chemical plant monitoring, renewable energy, crew fatigue monitoring, biomedical monitoring, novelty detection for bioinformatics, industrial process control, and water quality monitoring.



SBIR/STTR

Air Force SBIR Program
AFRL/XP
1864 4th Street
Wright-Patterson AFB OH 45433

AF SBIR/STTR Program Manager: Augustine Vu
Website: www.sbirsttrmail.com
Comm: (800) 222-0336
Fax: (937) 255-2219
e-mail: afrl.xppn.dl.sbir.hq@wpafb.af.mil

