SYSTEMS ENGINEERING
Research Center

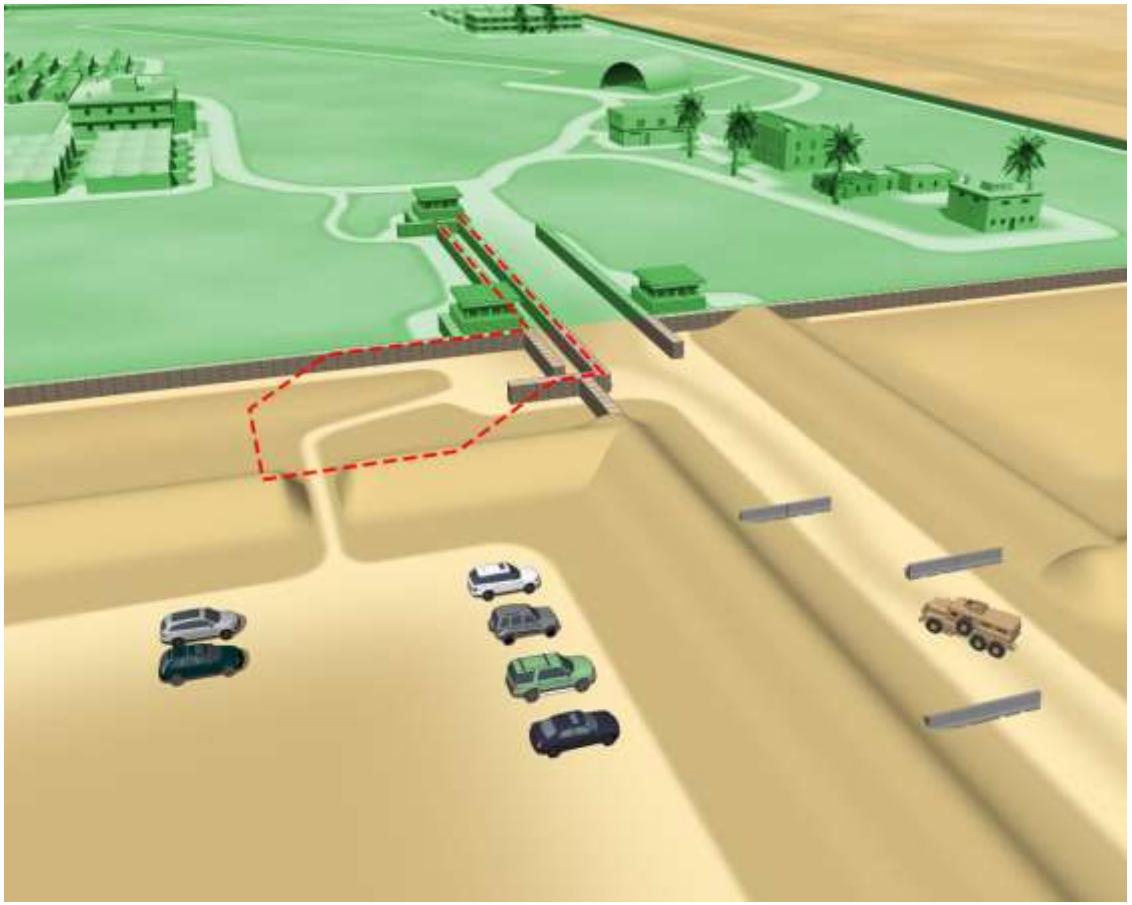
Self-adapting Sensor Networks for Semi-automated Threat Detection in a Controlled Area

By Jorge Buenfil
US ARMY RDECOM ARDEC
1st Annual SERC Doctoral Fellows Forum
February 24, 2014
Georgetown University
Hotel and Conference Center
Washington, DC

www.sercuarc.org

Problem Statement

Military systems today rely heavily on trained specialists to monitor and provide security to military installations. The threat presented by asymmetric warfare imposes constant vigilance against terrorist attacks using chemical, biological or nuclear weapons.



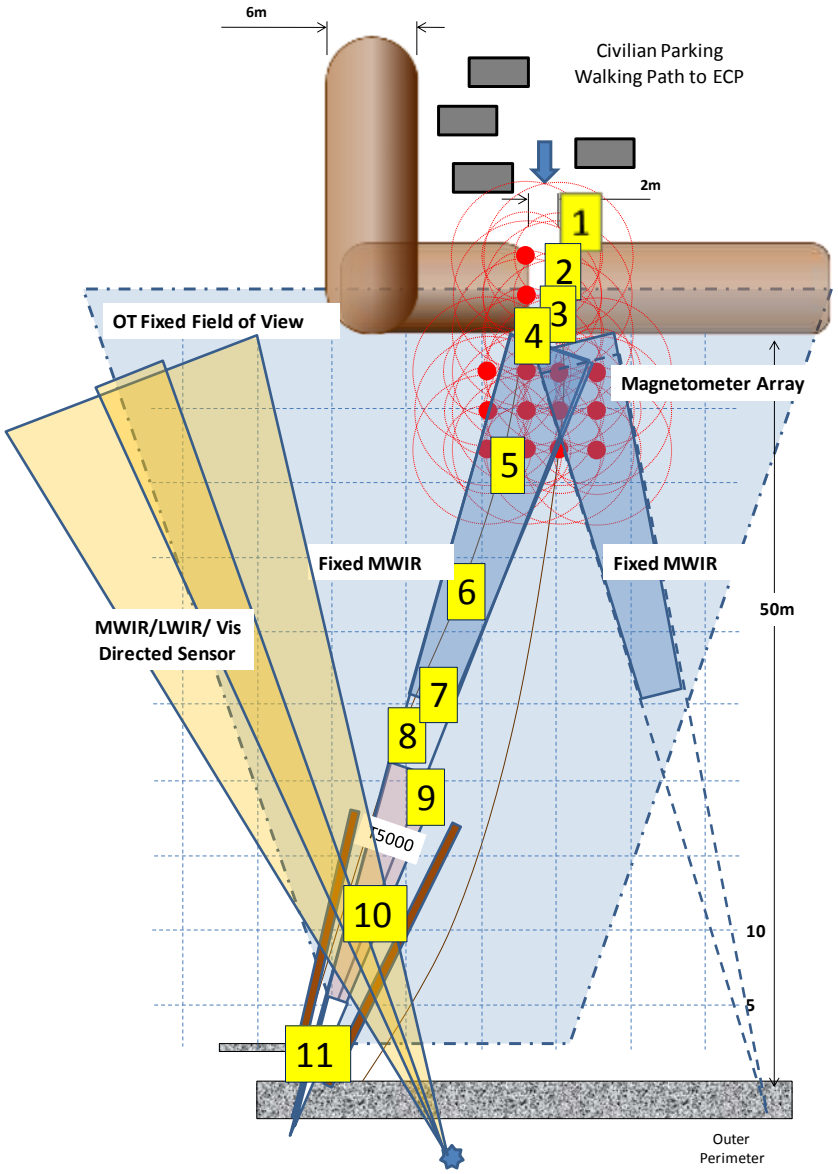
Problem Statement

Terrorist attacks have so far consisted mainly of improvised explosive devices carried by personnel or vehicles and detonated in areas where many people congregate (such as the Boston Marathon) or where high value targets exist (like the Oklahoma City bombing).

Problem Statement

Technology exists today to detect, identify and counteract asymmetric weapons before they are used but the burden on human operators is heavy.

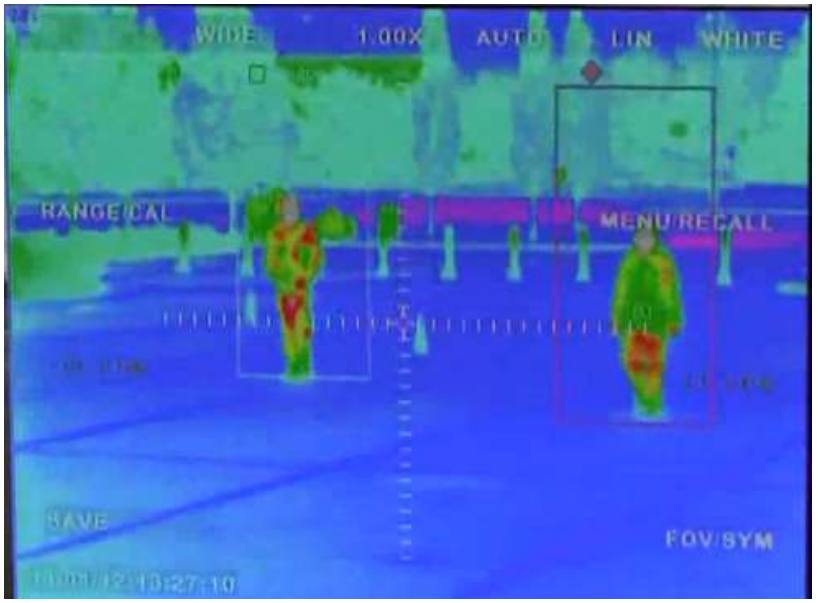
Typically, specially trained personnel are responsible for the interpretation of sensor data to positively identify valid threats.



Problem Statement

Sensor data usually involves signals on the visible, infrared and microwave segments of the radio spectrum. Their correct interpretation is complex and requires extensive experience to avoid excessive false alarms.

If too many false alarms are issued by a security system, personnel tend to ignore them and as a result compromise the efficacy of such system and thus the protection of a controlled area.

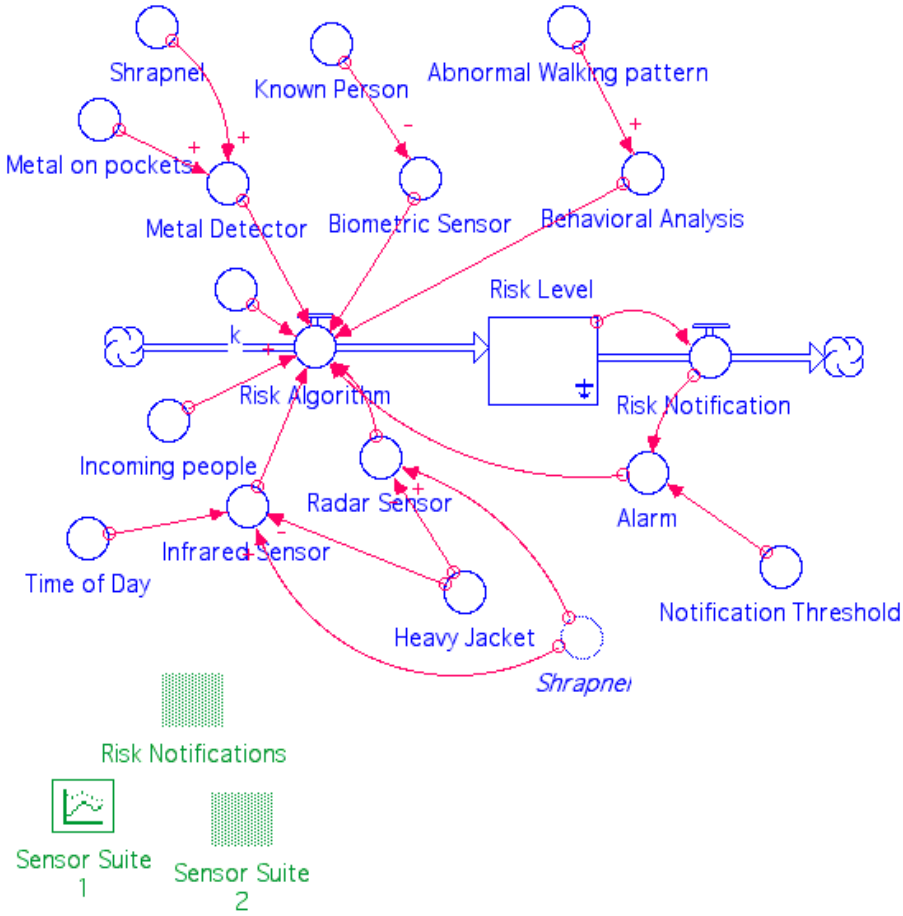


Problem Statement

A solution is needed to lessen the burden on human operators by using computing power to process complex signals and identify anomalous situations that require human intervention while recognizing acceptable margins of operation that can be handled by the system itself. This will free specialized personnel to do other tasks while also allowing for a massive expansion on the number and types of sensors and actuator that can be deployed to monitor and control a particular area.

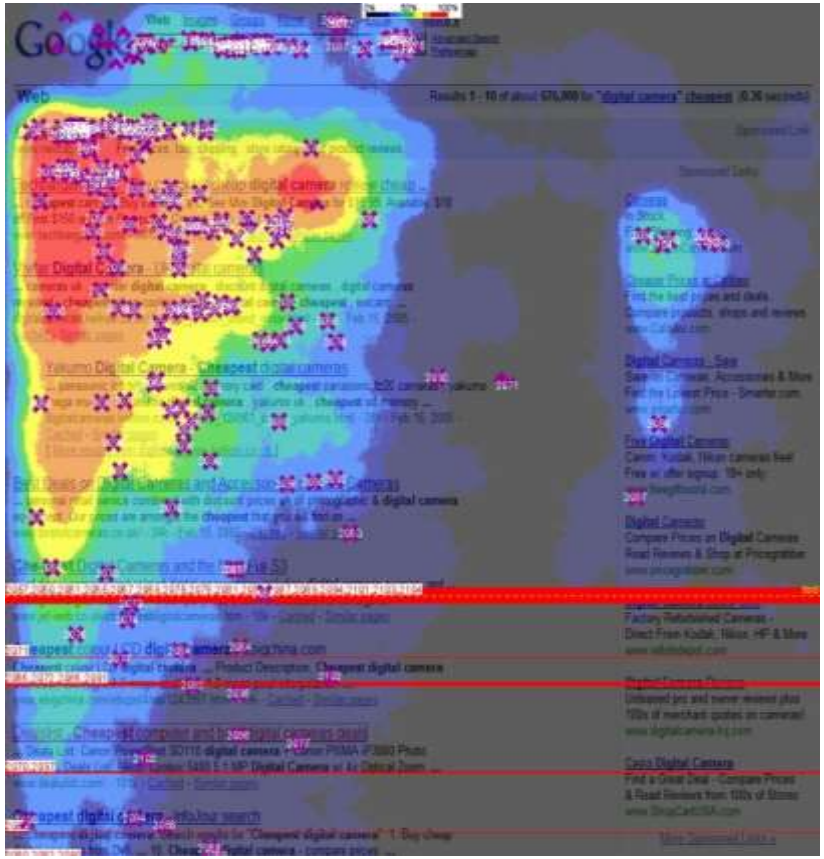
Proposed Solution

- Proposed solution
  - Modeling and Simulation of a self-adapting data fusion algorithm
  - Automated Multivariate Analysis to find "exceptional conditions" present on the controlled area
  - Data Visualization techniques to transform raw data into actionable information to aid human operators take countermeasures and also provide select inputs to other sensors and actuators to improve their performance.
  - Machine-learning via analysis of historical data to self-calibrate the data fusion algorithm



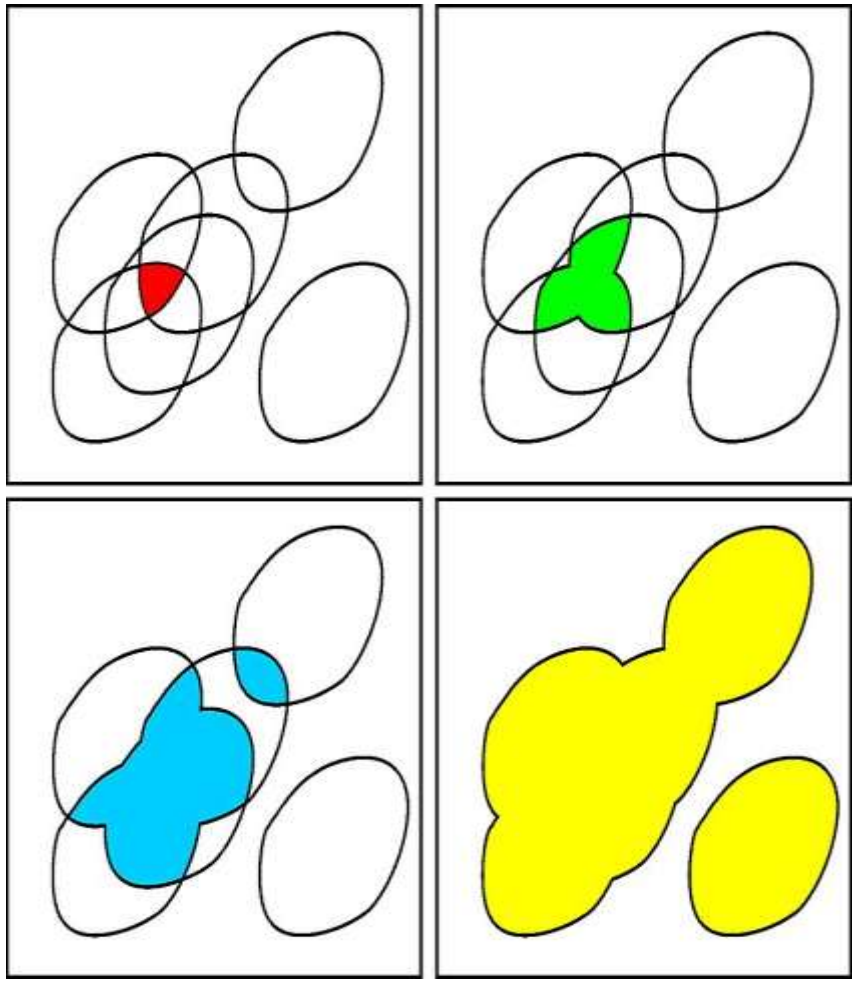
Progress to Date

- Started Ph. Program in the Fall of 2013
- Developed a strawman model of the proposed solution for the class of “Sys 611 Modeling and Simulation.”
- Currently taking “BIA-652 Automated Multivariate Analysis” to learn better ways to find “exceptional conditions” present on the controlled area
- Enrolled in “EM-622A Decision Making via Data Analysis” to transform massive amounts of raw data into actionable information to aid human operators take countermeasures.
- Dissertation research just starting but real interest in the topic from DoD organizations has been identified.



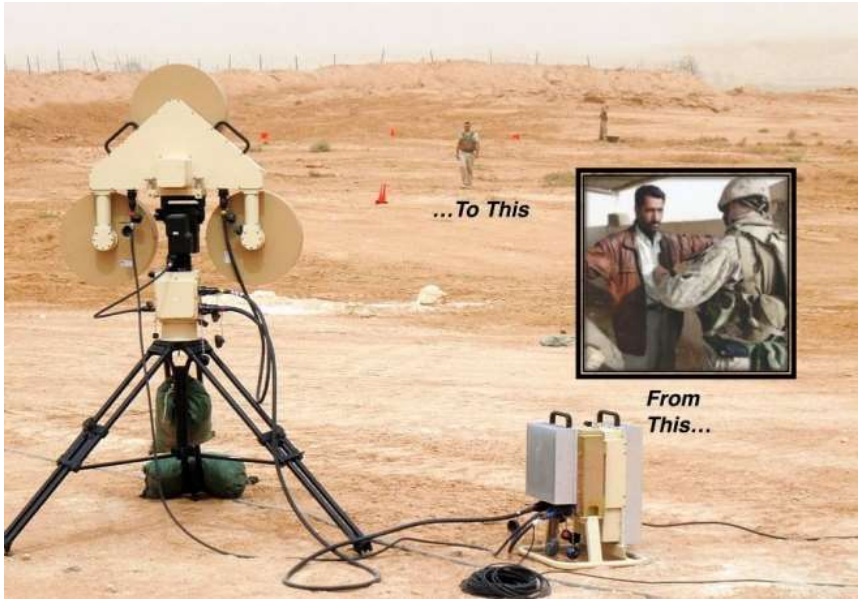
Future Steps

- Conduct extensive literature search of approaches to similar problems
- Refine my knowledge of data analysis methods and tools
- Take a class in Statistical Learning and Analytics
- Continue refining the dynamic system model started in the class of Modeling and Simulation to find ways to improve it to learn from past events and recalibrate itself.



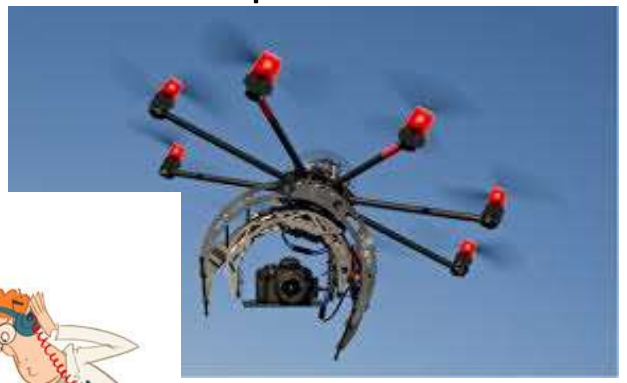
Current Limitations

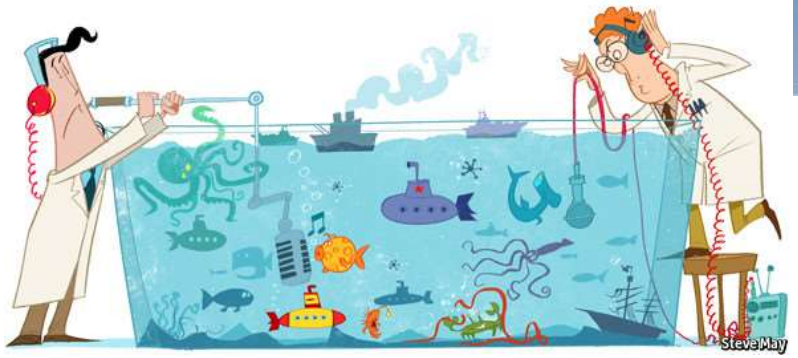
- Current limitations to solving the problem
  - Integration of sensors and actuators from diverse manufacturers is needed for a SoS solution, but lack of standardization makes it difficult to quickly reconfigure the SoS to interact with new equipment, adjust for equipment failures and grow the sensor/actuator network as needed during times of elevated threat conditions or vice versa.



Other Applications

- Other applications to this research work
  - Semi-autonomous robots operating in a self-coordinated, self-adapting ways to carry out a mission as a team with minimal human operator needs.
  - Monitoring of activities in networks (computer or social) to identify anomalous behavior that require human operator intervention.
  - Monitoring of critical systems such as vehicle health management systems where preventive maintenance is required to prevent catastrophic failures (fighting vehicles, aircraft, submarines, etc.)





SYSTEMS ENGINEERING
Research Center

Questions?