

Netted Sensors R&D

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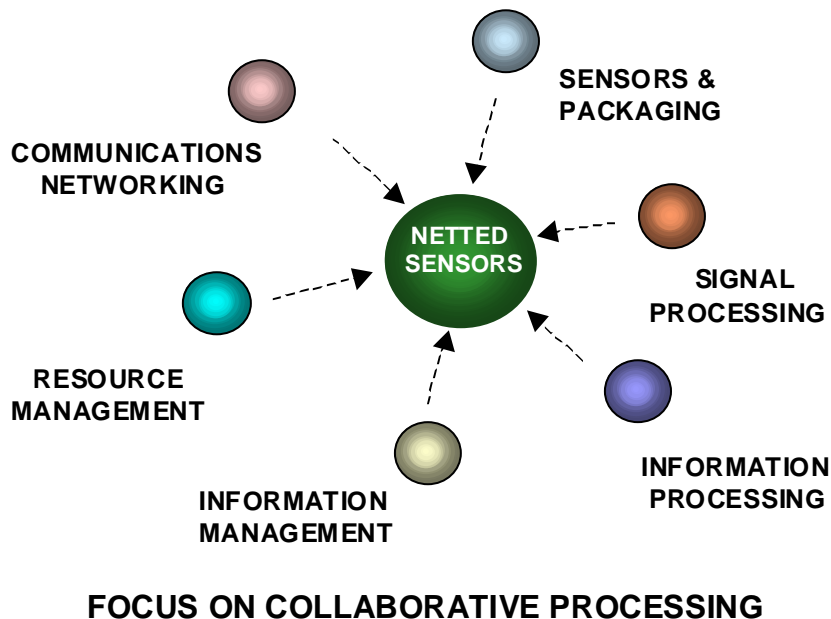
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MITRE Sponsored Research



**MITRE
Technology
Program**

Overview



OBJECTIVES

- Near-term efforts will focus on the development of sensor, channel, kinematic, and waveform models in support of the testbed infrastructure effort
- Majority of first-year effort will address several technical problems germane to Combat ID and Urban Warfare in the areas of:
 - Sensors and Packaging
 - Signal/Information Processing
 - Information Management
 - Resource Management
 - Communications & Networking

PROBLEM

- The technology program supports the spiral development of new collaborative netted sensor algorithms for the Combat ID and Urban Warfare challenge problems
- Intend to leverage existing MSR work to address the Border Monitoring problem demonstration by the end of FY04

PRIMARY RESEARCH AREAS

- System optimization methods for resource constrained environments
- Distributed particle-based multi-target algorithms for cluttered environments
- Multi-sensor fusion and target ID
- Information services and data exfiltration
- Multipath and reverberation mitigation in non-free space environments
- Sensor calibration/localization for mobile networks

R&D Perspective (1)

- The netted sensors community is focused on a few “big ticket” items: low-power processors, self-configuring networks, and wireless communication protocols.
- Few people have addressed the important role of signal processing beyond simple applications.
- A fact of life is that bandwidths do not support centralized processing approaches; distributed processing is the key.
- This argues for more functionality at the sensor (mote) level with increased distributed collaboration between local sensors.

R&D Perspective (2)

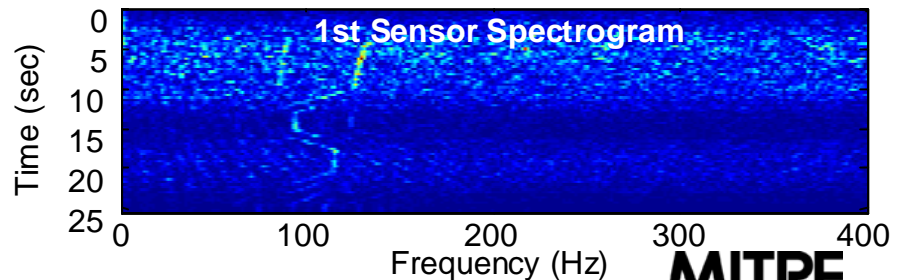
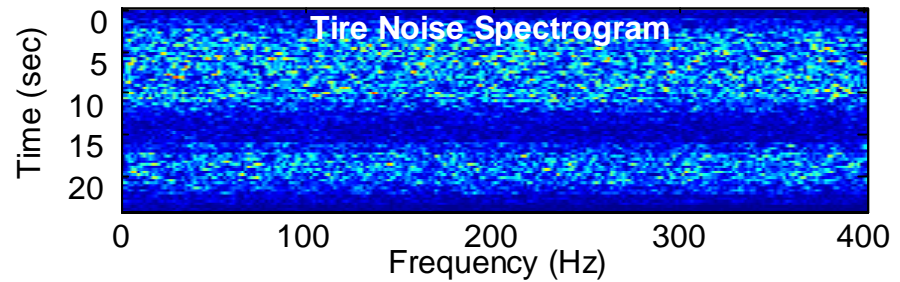
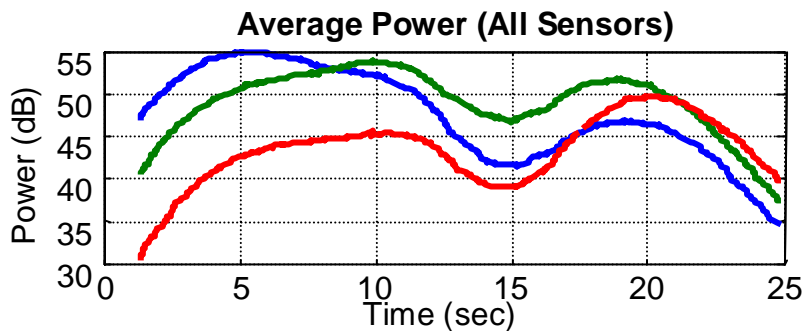
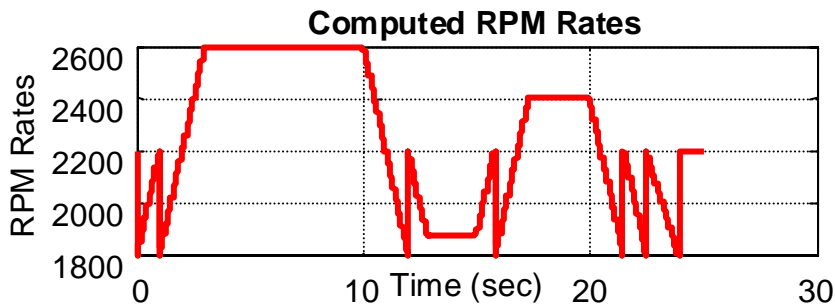
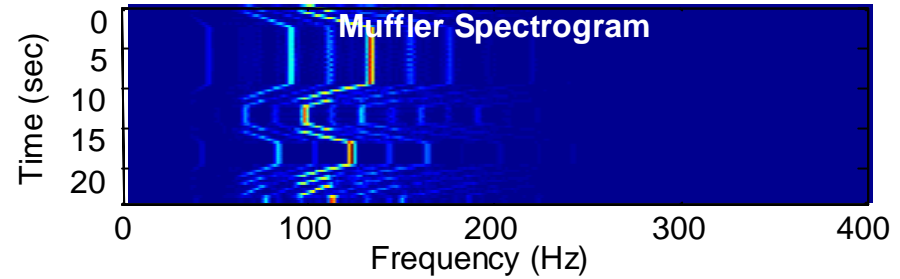
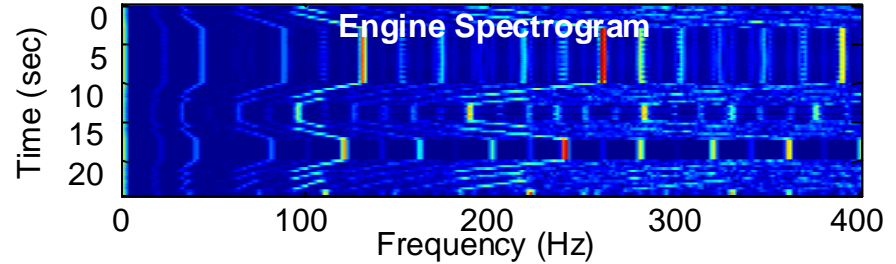
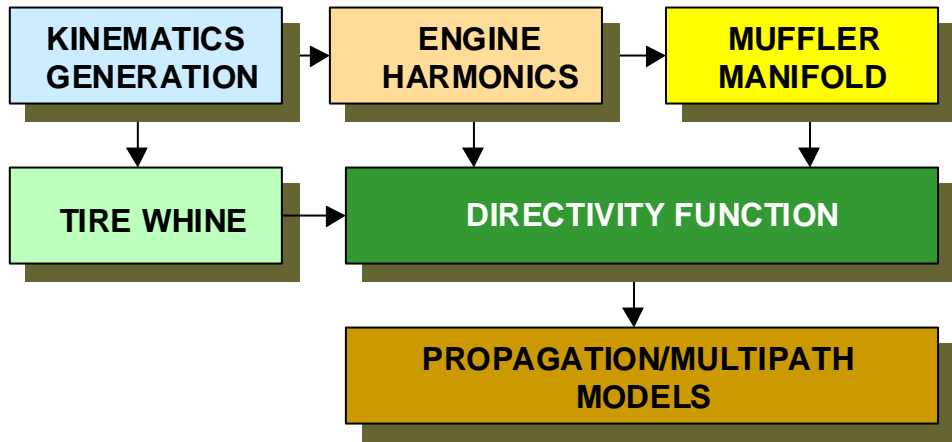
- **Most collaborative signal processing problems are technically difficult. They include:**
 - **Autonomous passive/active sensor localization and calibration**
 - **Energy-efficient system optimization methods for sensor tasking and cueing**
 - **Multipath and reverberation mitigation in urban environments**
 - **Resource-constrained distributed multi-target tracking**
- **MITRE is conducting research in each of these areas.**

Activities

- **Waveform/sensor channel modeling in support of first-year concept demonstration effort**
- **Distributed detection and classification of acoustic and electromagnetic signatures in multipath/reverberation-limited environments**
- **Distributed multi-target tracking using particle-based filter methods**
- **Netted sensor optimization (algorithm and sensor tasking) using Markov decision theory**
- **Exfiltration and sensor calibration methods**
- **Information management concepts including Bayesian inference networks**

Highlight: Waveform Modeling

HIGH-FIDELTY WAVEFORM SIMULATOR



Highlight: Mote Development

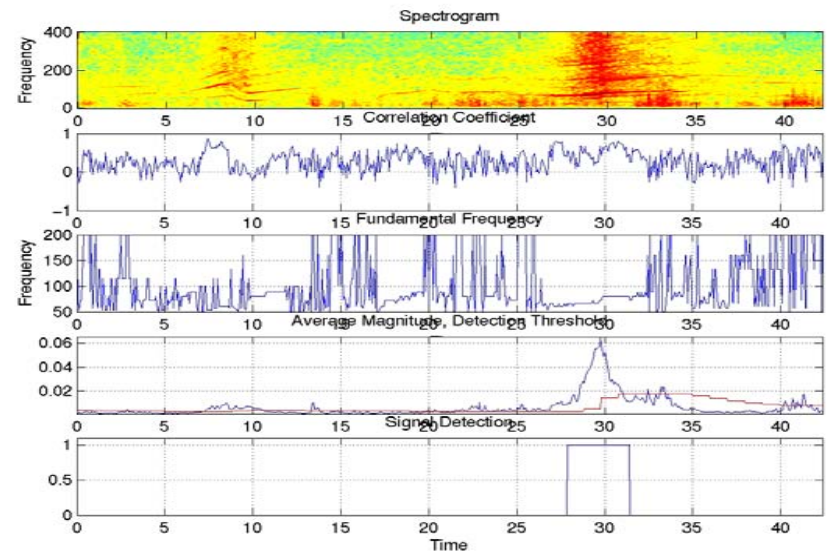


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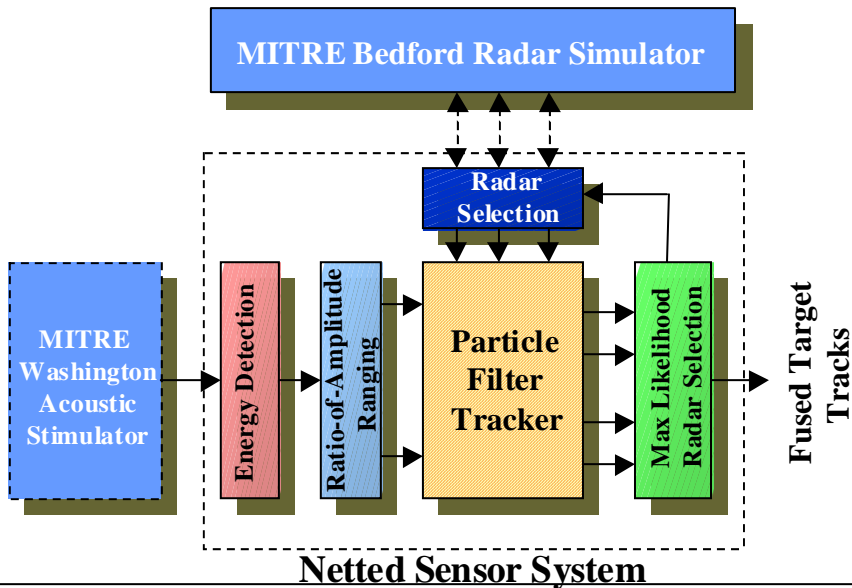
- Dynamic threshold energy-based detection
- Classification uses time-domain pitch analysis
- Crossbow TinyOS tool chain support
- Host/mote algorithm development environment
- In situ data collection
- Distributed synchronization
- Supernode fusion, exfiltration
- Algorithms tested in host/mote configuration, porting to mote

PROBLEM

- Great deal of interest in netted sensing using impoverished “mote” sensor nodes
- Primary focus to date on simple on-board detection, collaborative tracking across network
- Signal processing capabilities of motes largely unexplored
- Develop Crossbow mote-based system for vehicle detection/classification via (relatively) sophisticated acoustic analysis



Highlight: Distributed Tracking

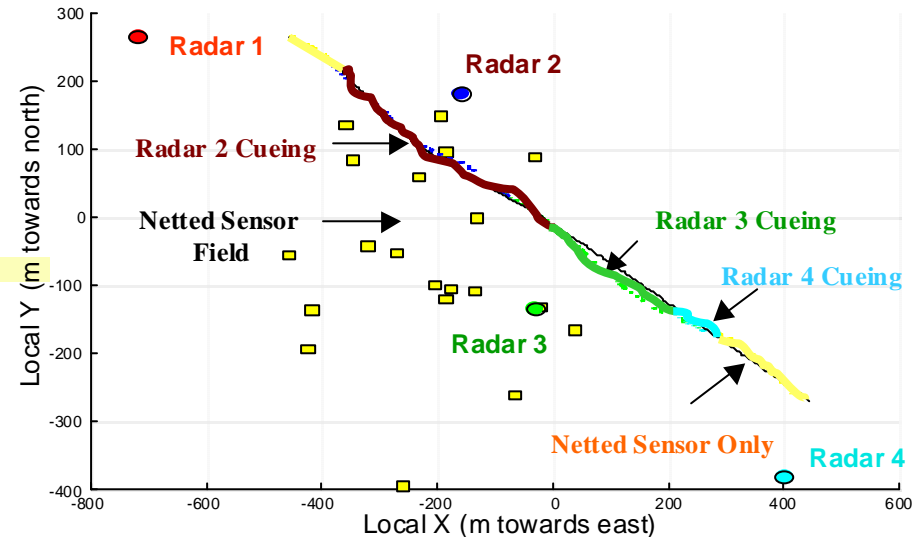


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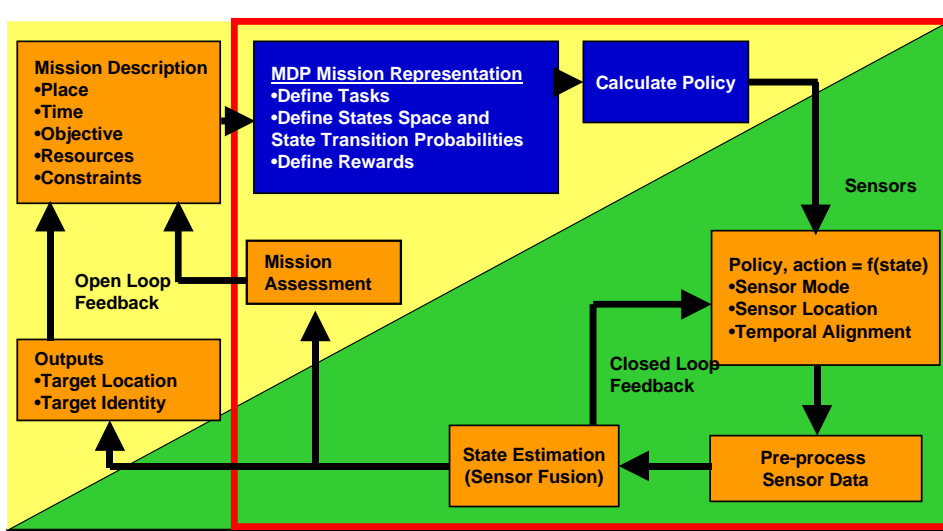
- High fidelity acoustic/radar models
- Robust least-squares amplitude ranging algorithms
- Particle-based nonlinear tracking algorithms
- Maximum likelihood radar sensor selection (cueing) algorithm
- Distributed particle-based track fusion algorithms
- **Maturity: Algorithms designed and tested in software**

PROBLEM

- Addressing two important problems:
 - The timely cueing of stand-off sensors by a field of netted proximate sensors
 - The distributed fusion of multi-target track information across heterogeneous sensor networks
- These are challenging signal processing and communications/networking problems
- We are leveraging expertise across a number of related MITRE research projects



Highlight: System Optimization



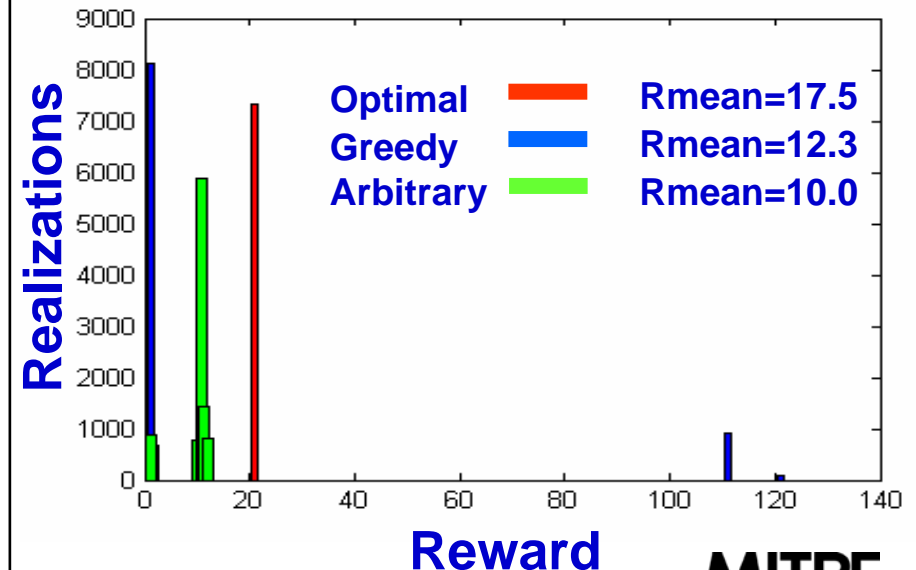
APPROACH

- Develop and implement adaptive sensor tasking and sensor fusion methods for Combat Identification (CID) applications within a unified analytical framework.
- Evaluate these approaches using “Engineering Quality” simulated data

PROBLEM

- The overwhelming majority of operational automated or assisted military target ID data fusion systems function at the first two levels of fusion (0 and 1).
- Automated fusion at the more cognitive levels (2 and 3) has only appeared sparsely in systems to date.
- State information from Level 1 can be used to control future actions such as modifying sensor operation modes, sensor locations, etc., to better satisfy overall mission requirements.
- This approach is particularly appropriate for netted sensor systems.

MDP OPTIMAL RADAR EXAMPLE



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Schedule and Deliverables

