Synergistic Signal Processing Methods for Sensor Fields

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MITRE Sponsored Research

MITRE Technology Program

Problem

- There has been a lot of DoD and commercial interest in the use of distributed low-cost unattended sensors for remote sensing.
- The primary focus of these efforts has been in areas such as:
  - Network protocols
  - Adaptive network topologies.
- However, very little thought has been given to the signal processing issues associated with netted sensors.

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Background

- Netted sensors will play an increasingly important role in commercial and military operations as evidenced by:
  - Military shift from platform centric to network centric operations
  - Added emphasis on early warning capabilities for homeland security
  - Utility of distributed netted sensors in the Afghanistan campaign
  - Increased interest in proximal in-situ environmental monitoring

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Objective

- Develop robust signal processing algorithms for distributed sensor detection, classification, localization, and tracking applicable for Navy littoral and Army battlefield environments as well as homeland defense/security
- Particular emphasis on unique localization and tracking techniques constrained by sensor power and bandwidth limitations:
  - Leverage existing work in blind beam- forming and numerically efficient classification techniques
  - Develop robust sensor-selective multi-target tracking algorithms

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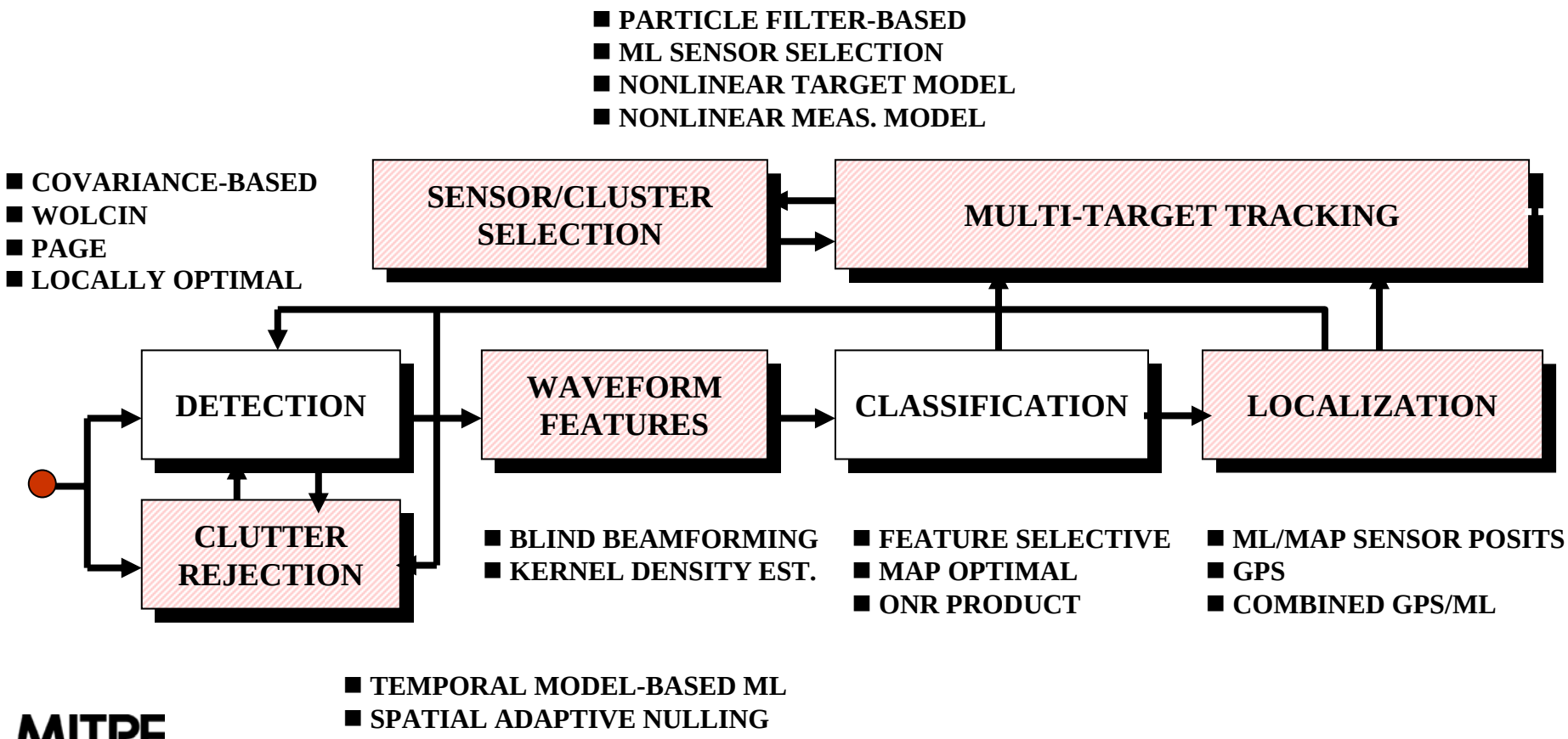
Activities

- **Cluster-Level Signal Processing (FY03)**

Develop a logical approach for addressing key signal processing components in a locally optimal manner given numerous resource constraints



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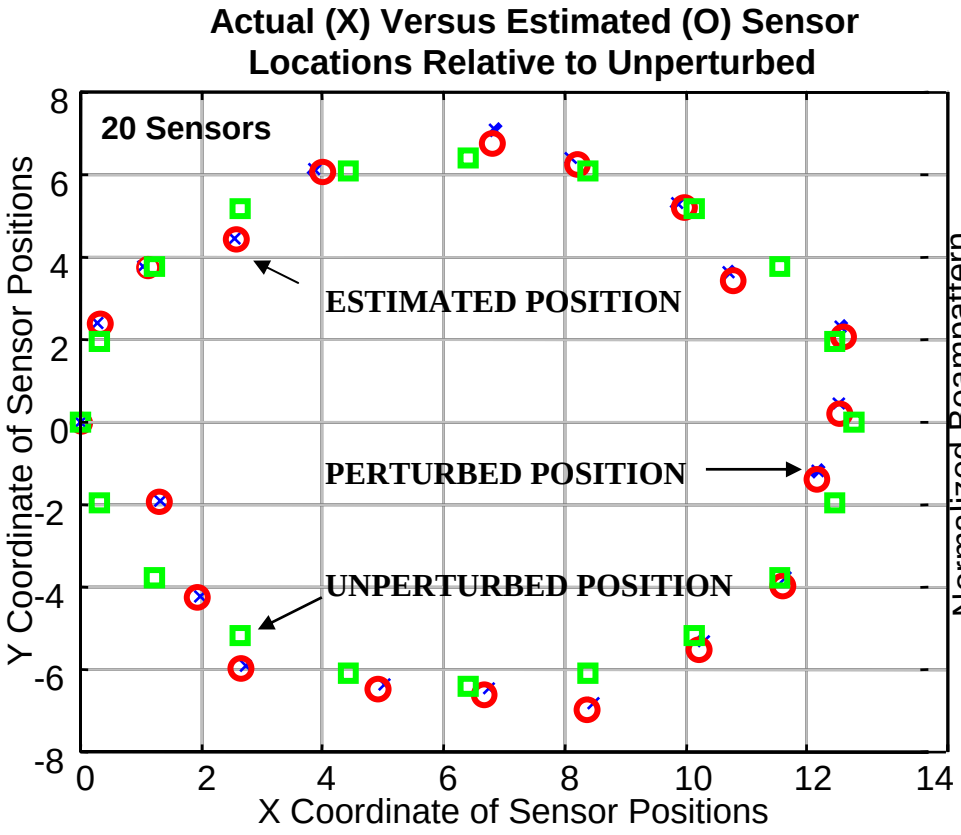
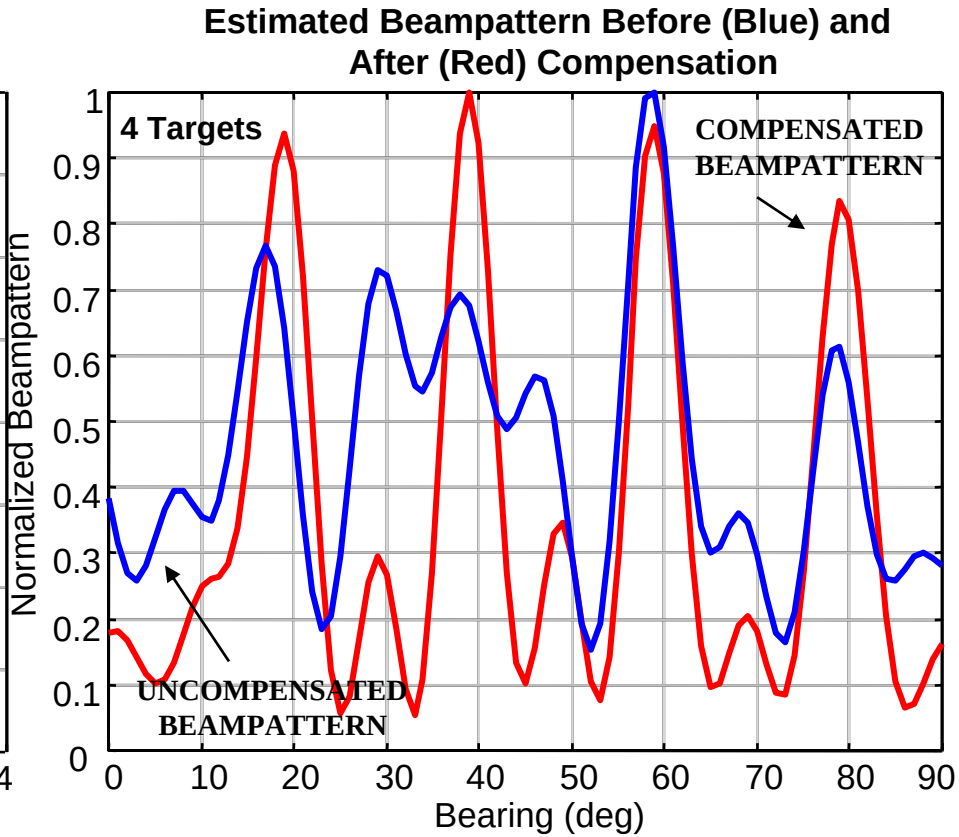
Highlight

I. We developed a robust nonlinear estimation algorithm to correct for sensor position uncertainties that does not require a separate GPS receiver for each sensor.



SENSOR POSITION ESTIMATION



COMPENSATED BEAMPATTERNS

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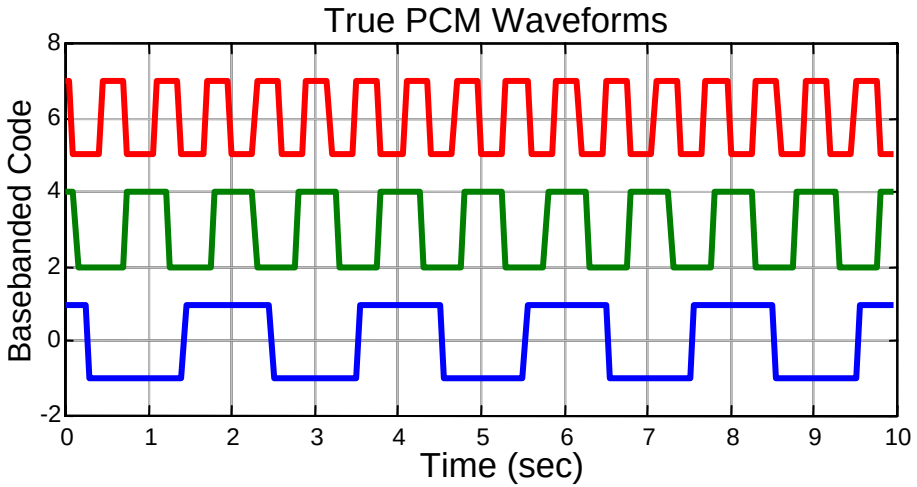
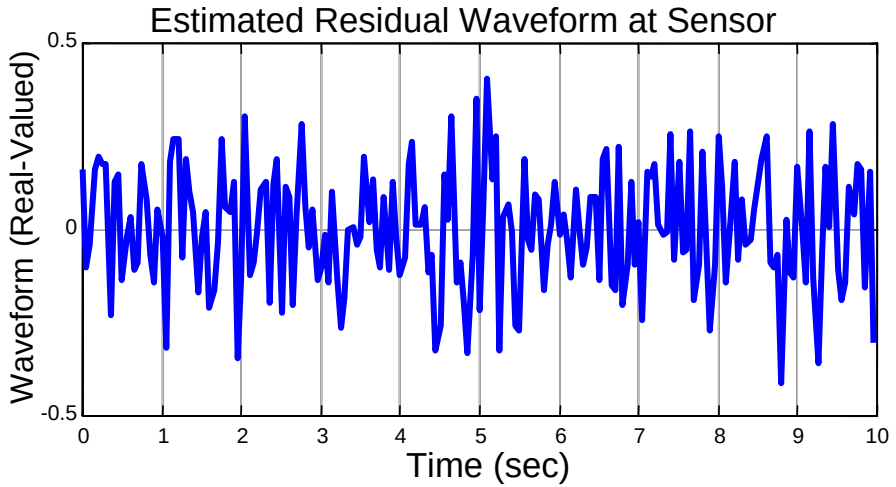
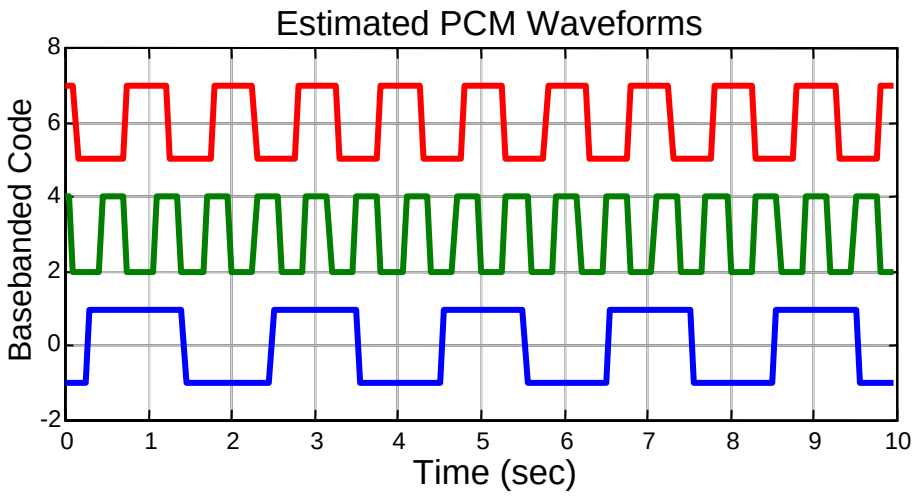
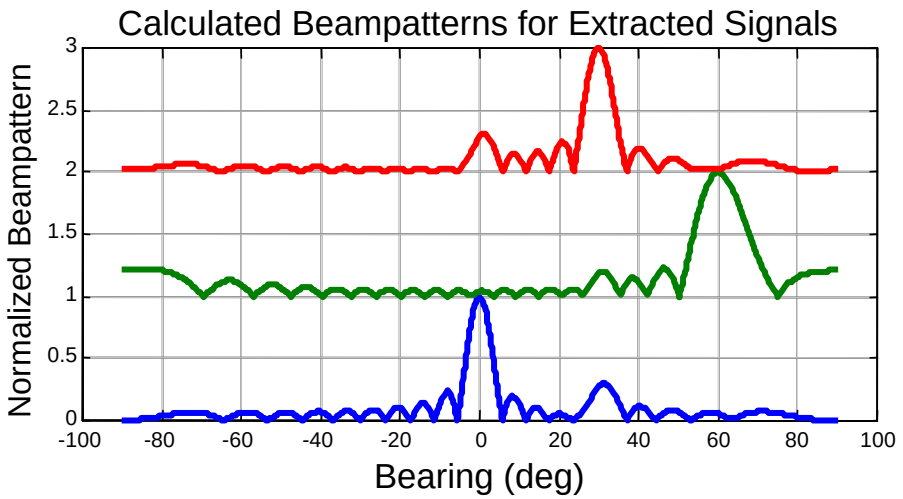
Highlight

II. We developed four ICA-based methods for extracting signal information from a linear mixture of signals in noise









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Impacts

- Developed proof-of-concept algorithms for:
  - Clutter mitigation
  - Beamforming with non-stationary arbitrarily-arranged sensor elements
  - Blind beamforming for signal feature extraction
  - Distributed sensor-selective tracking
- Ideas applicable across the spectrum of netted sensors problems within MITRE and the community at large

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Future Plans

- **Sensor Field Signal Processing (FY04)**

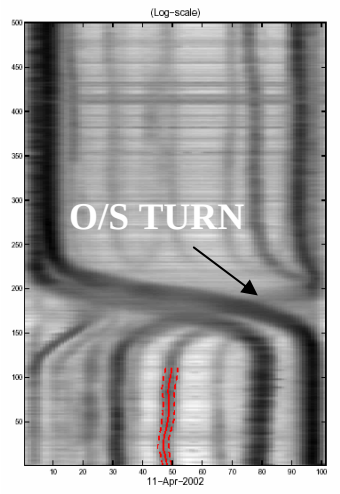
Develop methods for combining track fragments from disparate sensor clusters given limited cluster detection ranges/resources

ENCODED FEATURES
TIME/SPATIAL TAGS

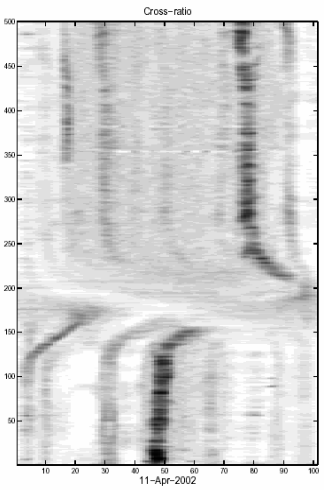
ML SENSOR SELECTION ALGORITHM
CHOOSES CLUSTER K+1 FOR HANDOFF

CLUSTER K → CLUSTER K+1

BTR



CROSS RATIO



DETERMINE IF CLUSTER IS ACTIVE

- USE CROSS RATIO TEST
- RATIO OF ECKART FILTERS
- USES SPECTRAL/KINEMATIC FEATURES
- OPTIMAL IN GLR SENSE

YES

TRACK ASSOCIATION

NO → KEEP SEPARATE TRACKS

YES

KEEP ONE TRACK

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