

# Integrated Fusion, Performance Prediction, and Sensor Management for Automatic Target Exploitation



## Summary

MURI Annual Review Meeting

Randy Moses

September 14, 2007



*MURI: Integrated Fusion, Performance Prediction, and Sensor Management for Automatic Target Exploitation*



# Today's Presentations

*ATE Objectives  
Sensor Resources*

*ATR/ATE Inferences  
and Confidences*

*Optimal, Robust Information  
Fusion (A. Willsky, lead)*

***Optimal, Robust Information Fusion in  
Uncertain Environments (Willsky)***

- Information State Propagation
- Contextual Models
- Learning and Adaptation

***Information-Driven Inference in  
Resource-Constrained Environments  
(Fisher)***

Features and  
Uncertainties

Priors and

Value of

***Adaptive Radar Sensing Strategies (Hero)***

*Adaptive Front-End Signal  
Processing (R. Moses, lead)*

*Dynamic Sensor Resource  
Management (D. Castanon, lead)*

***Sparse Reconstruction and Feature  
Extraction (Potter Cetin, Ertin, Karl,  
and Moses)***

***Tools for Analyzing Shapes of Curves  
and Surfaces (Srivastava)***

***Algorithms and Bounds for  
Networked Sensor Resource  
Management (Castanon)***

- D
- E
- a
- Multi-level planning
- Performance uncertainty



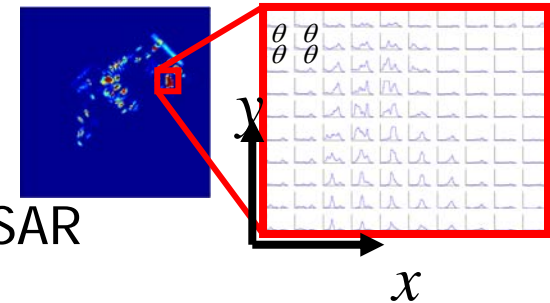
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# Year 1 Advances I

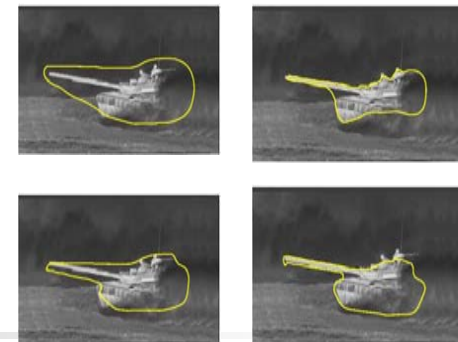
## ■ Regularized Tomography for Sparse reconstruction

- Sparse apertures
- Sparse 'objects' (targets or scenes)
- Anisotropy characterization
- Reconstruction for wide angle and circular SAR
- Decision-directed reconstruction



## ■ Shape Statistics for Curves and Surfaces

- Shape Analysis
- Bayesian Classification from Shapes

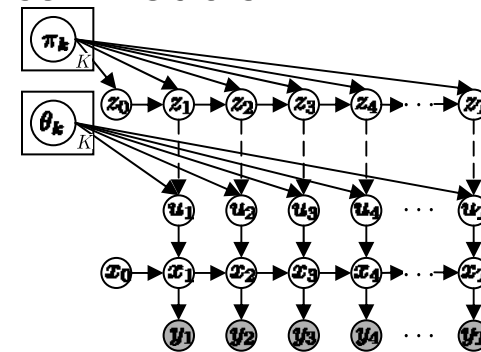


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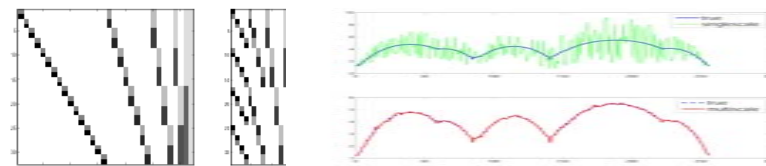


# Year 1 Advances II

- Scalable, flexible inference
  - Low-rank uncertainty estimation in graphical models
  - GM-based Tracking
  - Learning Model structure



- Distributed Estimation and Management
  - MIMO radar fusion with calibration errors
  - Distributed estimation with unreliable communications



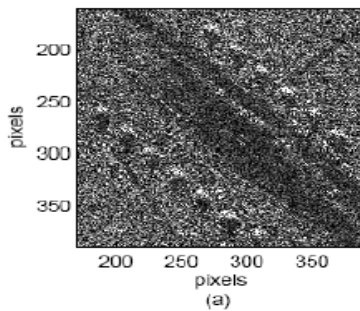
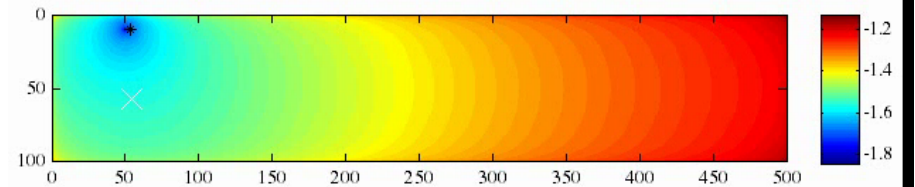
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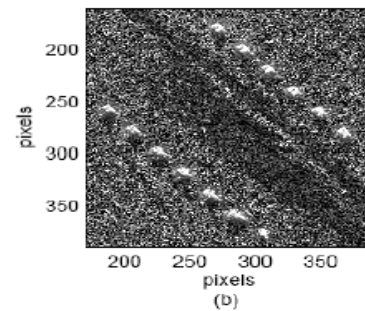
# Year 1 Advances III

## ■ Sensor Management:

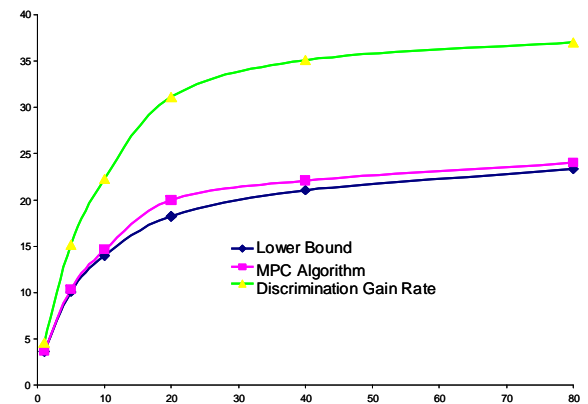
- Adaptive data fusion
- Adaptive waveform scheduling
- Real-time SM algorithms and performance bounds



Wide area SAR acquisition



Optimal two step SAR acquisition



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# What's next – Signal Processing

- Regularized linear inversion
  - Automatic hyperparameter choice
  - Errors in sensing model parameters
  - Learn scattering functions from data
  - Design dictionary from target hypotheses
  - Anisotropic penalties in 3D
- Radar sensor degrees of freedom for unambiguous signal representation
- Regularized linear inversion for nonlinear regression problems
  - Unifying parametric and nonparametric processing techniques
- Shape estimation features for ATE
  - One-Shot Learning of Shapes
  - Graphical Models for Studying Configurations of Shapes



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## What's next – Information Fusion

- More on learning behavioral models and multi-target tracking
- More on learning tractable models for fusion and discrimination
  - E.g., introducing hidden variables to capture hidden causes
- More on informing resource management
  - Which data should be gathered and fused
  - How to do this efficiently
- Integrated learning of embedded graphical models
  - Joint clustering/classification and manifold learning
  - Distributed topological inference



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## What's next – Sensor Management

- More on scalable algorithms
- More on performance bounds
- Integration of graphical fusion models and performance estimates into algorithms
- Algorithms for unknown target classes
- Integrated SM and front end processing for imaging
  - SM driven by info theoretic imaging criteria
  - Incorporating inverse scattering models
  - Image priors e.g., sparsity, smoothness, shape



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Questions or Comments?



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