



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

MURI Kickoff Meeting

Randolph L. Moses

July 21, 2006



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



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

Agenda

8:30am (30 min)	Continental Breakfast	
9:00am (10 min)	Welcome	Randy Moses
9:10am (20 min)	MURI Overview	Randy Moses
9:30am (30 min)	Information Fusion Research	Alan Willsky
10:00am (30 min)	Signal Processing Research	Randy Moses
10:30am (15 min)	Break	
10:45am (30 min)	Sensor Management Research	David Castanon
11:15am (30 min)	AFRL Perspective	Lori Westerkamp
11:45am (30 min)	Summary	Randy Moses
12:15pm (15 min)	Questions and Comments	
12:30pm (45 min)	Lunch	
1:15pm (90 min +)	Discussions/Collaborative Breakouts	



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



MURI Team

UNIVERSITY TEAM:

- Ohio State University (lead)
 - Randy Moses (PI)
 - Lee Potter
 - Emre Ertin
- Massachusetts Institute of Technology
 - Alan Willsky
 - John Fisher
 - Mujdat Çetin
- Boston University
 - David Castañón
 - Clem Karl
- University of Michigan
 - Al Hero
- Florida State University
 - Anuj Srivastava

AFOSR: John Tangney; Jon Sjogren; Sharon Heise

AFRL POC: Greg Arnold



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



Research Goal

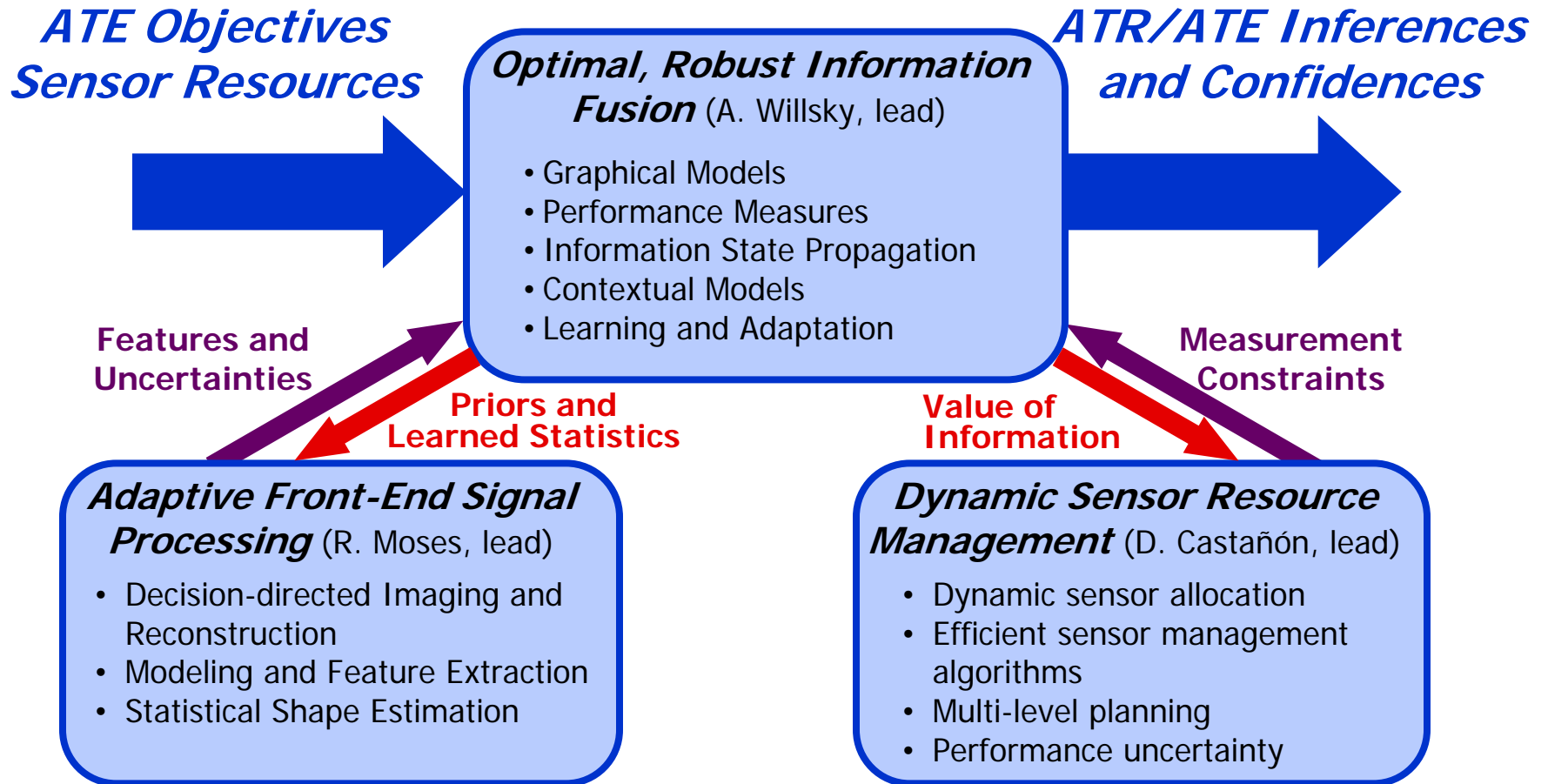
- *Develop an integrated systems theory that jointly treats information fusion, control, and adaptation for automatic target exploitation (ATE).*
 - Multiple, dynamic sensors
 - Multiple sensing modes
 - Resource-constrained environments



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



Research Framework



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



Information Fusion: Key Research Questions

*ATE Objectives
Sensor Resources*

*ATR/ATE Inferences
and Confidences*

Optimal, Robust Information Fusion (A. Willsky)

- Graphical Models
- Performance Measure
- Information State Pro
- Contextual Models
- Learning and Adaptat

Inference on Graphical Models:

- **Structures and algorithms for fusion, tracking, identification**
- **Scalable algorithms**
- **Learning and adaptation**
- **Contextual Information**

How to effectively direct front-end signal processing?

Features and Uncertainties

Priors and Learned Statistics

Value of Information

Constraints

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

- Decision-directed Imaging and Reconstruction
- Modeling and Feature Extraction
- Statistical Shape Estimation

Dynamic Sensor Resource Management (D. Castanon, lead)

- Dynamic
 - Efficient
- level planning
performance uncertainty

What are the 'right' performance measures and bounds for FE and Sensor Mgmt?

State propagation in graphical models.



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



Signal Processing: Key Research Questions

*ATE Objectives
Sensor Resources*

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

*ATR/ATE Inferences
and Confidences*

*Problem formulations that admit
context, priors and directed
queries*

*Features and
Uncertainties*

*Priors and
Learned Statistics*

*Measurement
Constraints*

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

- Decision-directed Imaging and Reconstruction
- Modeling and Feature Extraction
- Statistical Shape Estimation

- *Flexible imaging and reconstruction*
- *Unified Parametric/Nonparametric processing*
- *Feature uncertainty characterization*
- *Statistical shape estimation*
- *Adaptation and Learning*

- algorithms
- Multi-level planning
- Performance uncertainty

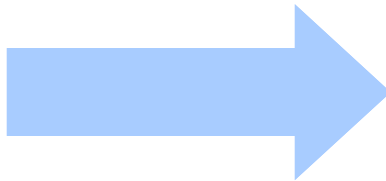


*MURI: Integrated Fusion, Performance Prediction,
and Sensor Management for Automatic Target
Exploitation*



Sensor Management: Key Research Questions

ATE Objectives
Sensor Resources



Optimal, Robust Information Fusion (A. Willsky)

- Graphical Models
- Performance Measure
- Information State Propagation
- Contextual Models
- Learning and Adaptation

- *Integrate ATE performance based on graphical models*
- *Manage evolution of "information state" in support of ATE missions*

- *Active control of trajectories, sensor modes, activities*
- *Multi-modal, heterogeneous platforms*
- *Adaptive Sensor Management*
- *Scalable real-time algorithms for theater-level missions*

- Modeling and Feature Extraction
- Statistical Shape Estimation

Dynamic Sensor Resource Management (D. Castañón, lead)

- Dynamic sensor allocation
- Efficient sensor management algorithms
- Multi-level planning
- Performance uncertainty

Value of Information

Measurement Constraints



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



MURI Payoff

Goal: Develop an integrated theory for ATE systems that combines information fusion, platform control, signal processing, and adaptation.

Research Outcomes:

- *An integrated theoretical framework for dynamic information exploitation systems.*
- *Theoretical foundations for adaptivity and learning in complex inference systems.*
- *New algorithms and performance metrics for coupled signal processing, fusion, and platform control.*

Payoff:

- *Systematic design tools for end-to-end design of multi-modal, multi-platform ATE systems.*
- *Active platform control to meet ATE objectives.*
- *System-level ATE performance assessment methods.*
- *Adaptive, dynamic ATE systems.*



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



MURI Students/PostDocs

- Ohio State

- Subhojit Som
- Naveen Ramakrishnan
- Julie Jackson
- Christian Austin
- Kerry Dungan

- MIT

- Emily Fox
- Jason Johnson
- Venkat Chandrasekaran
- Kush Varhney
- Jason Williams
- Mike Siracusa

13 Students + 1 Postdoc
Several leveraged students

- Boston U

- Karen Jenkins
- Birant Borten
- +2 Autumn 06

- Florida State

- Shantanu Joshi
- Wei Liu

- U Michigan

- Kuang Hung Liu
- Mark Kliger (postdoc)



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



Management and Team Collaboration

- Management Team:
 - Moses^{FE}; CastañónSM; Hero, Srivastava, Willsky^{IF}
- Website for sharing and disseminating
 - algorithms; code; data; research ideas
- Regular Team Meetings:
 - November 2006 in Boston
 - April 2007 in Orlando (SPIE)
- Personnel Exchanges:
 - Al Hero to MIT Au06 (sabbatical)
 - Student visits
 - Joint student advising
 - e.g. D. Castañón (BU) on Jason Williams' committee (MIT)



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



Government and Industry Transitions

■ Industry:

- BAE/AIT (Alphatech); General Dynamics; SET Associates; SAIC; ATK; Raytheon Missile Systems; Information Sciences Laboratory
- Student internships
 - e.g. Christian Austin, Ahmed Fasih at SET Summer '06

■ Government:

- Student internships at AFRL
- Transition and context from other AF programs
 - AFRL SAB; Gotcha; SAVig



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