
# 3rd VoI MURI Review 2014


# Value-centered Information Theory for Adaptive Learning, Inference, Tracking, and Exploitation

[http://wiki.eecs.umich.edu/voimuri]

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# 3nd Year VoI MURI Review: Agenda

| Time | Activity |
|---|---|
| 8:00 -8:30 | Get settled with coffee |
| 8:30 -8:35 | Welcome (Liyi Dai) |
| 8:35 -8:50 | Project overview (Al Hero) |
| 8:50 -9:30 | Mathematical foundations of VoI (Al Hero and Doug Cochran) |
| 9:30 -10:10 | Learning with information constraints (Michael Jordan) |
| 10:10 -10:30 | Break |
| 10:30 -11:30 | Poster highlight talks |
| 11:30 -1:30 | Poster session and lunch |
| 1:30 -2:10 | Information fusion and exploration (Stefano Soatto) |
| 2:10 -2:50 | Information planning (John Fisher and Jon How) |
| 2:50 -3:10 | Break |
| 3:10 -3:30 | Radar testbed (Emre Ertin) |
| 3:30 -3:45 | Wrapup (Al Hero) |
| 3:45 -4:30 | Government discussion and de-briefing |
| 4:30 | Adjourn |

# MURI coPIs

Al Hero
Michigan

Raj Nadakuditi
Michigan

Randy Moses
Ohio State

Emre Ertin
Ohio State

Jon How
MIT

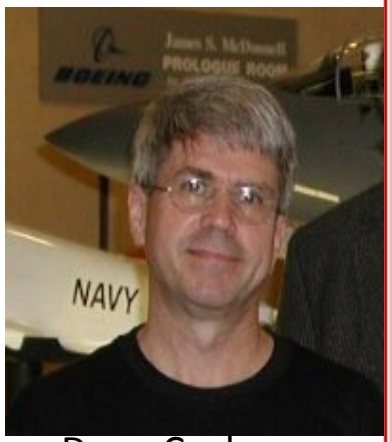
John Fisher
MIT

Alan Willsky
MIT

Angela Yu
UCSD

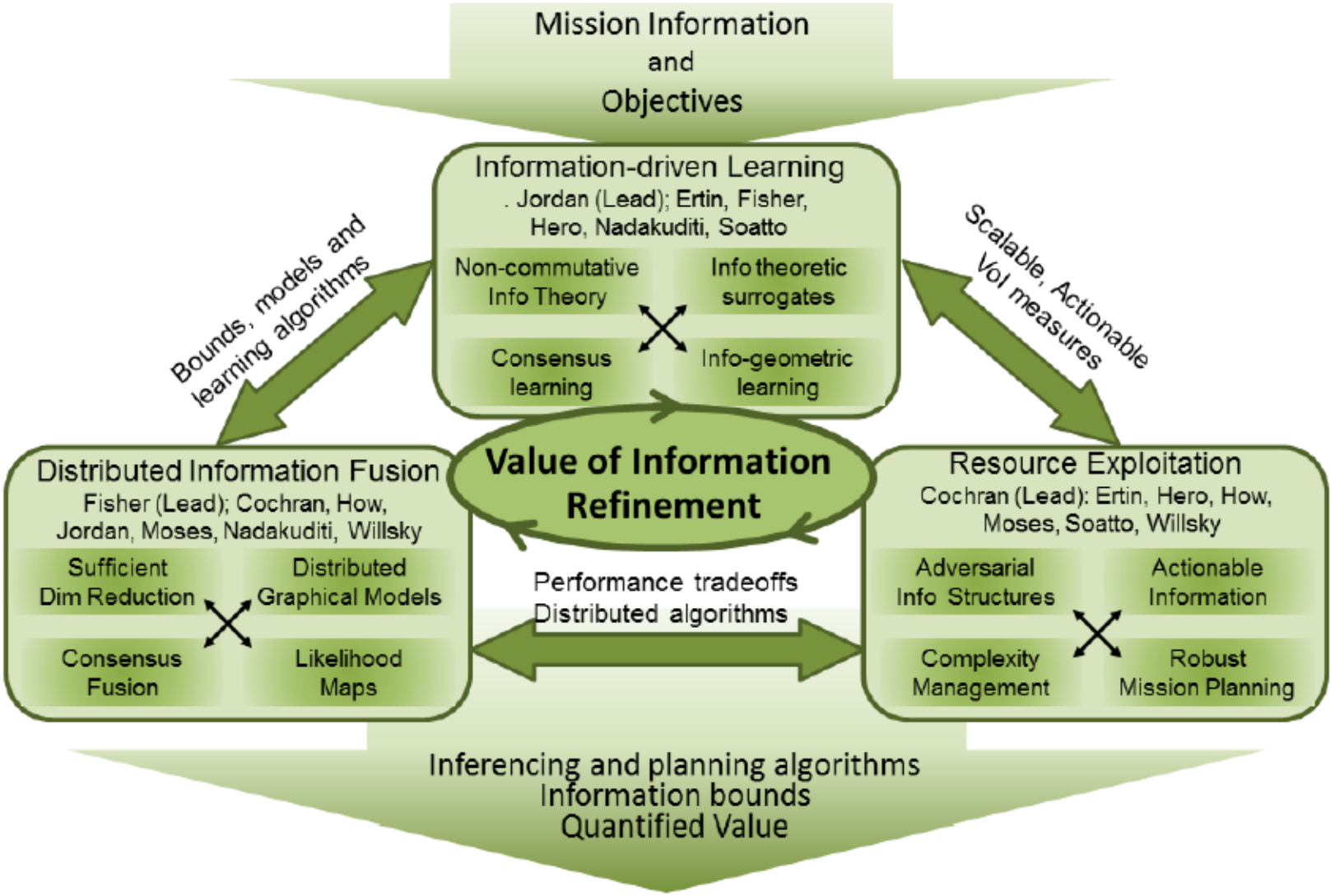
Stefano Soatto
UCLA

Mike Jordan
UC Berkeley




Doug Cochran
Arizona State

# Research program: High level view



# Our MURI's principal aim

- To derive a comprehensive set of principles for task-specific information extraction, distributed information fusion, and information exploitation that can be used to design the next generation of autonomous and adaptive sensing systems.

- **Specific objectives:**

  - Develop analytical frameworks for quantifying value of information.
  - Study fundamental tradeoffs for information collection and fusion
  - Develop info processing algorithms with performance guarantees
  - Validate theory and algorithms on sensing testbeds at MIT, OSU, UCSD and UCLA

- **Technical approach:** value-centered information theory, machine learning and control.

# Design space is high dimensional

**Information sources**

Collected sensor data
Target/clutter signatures
Contextual information
Soft data

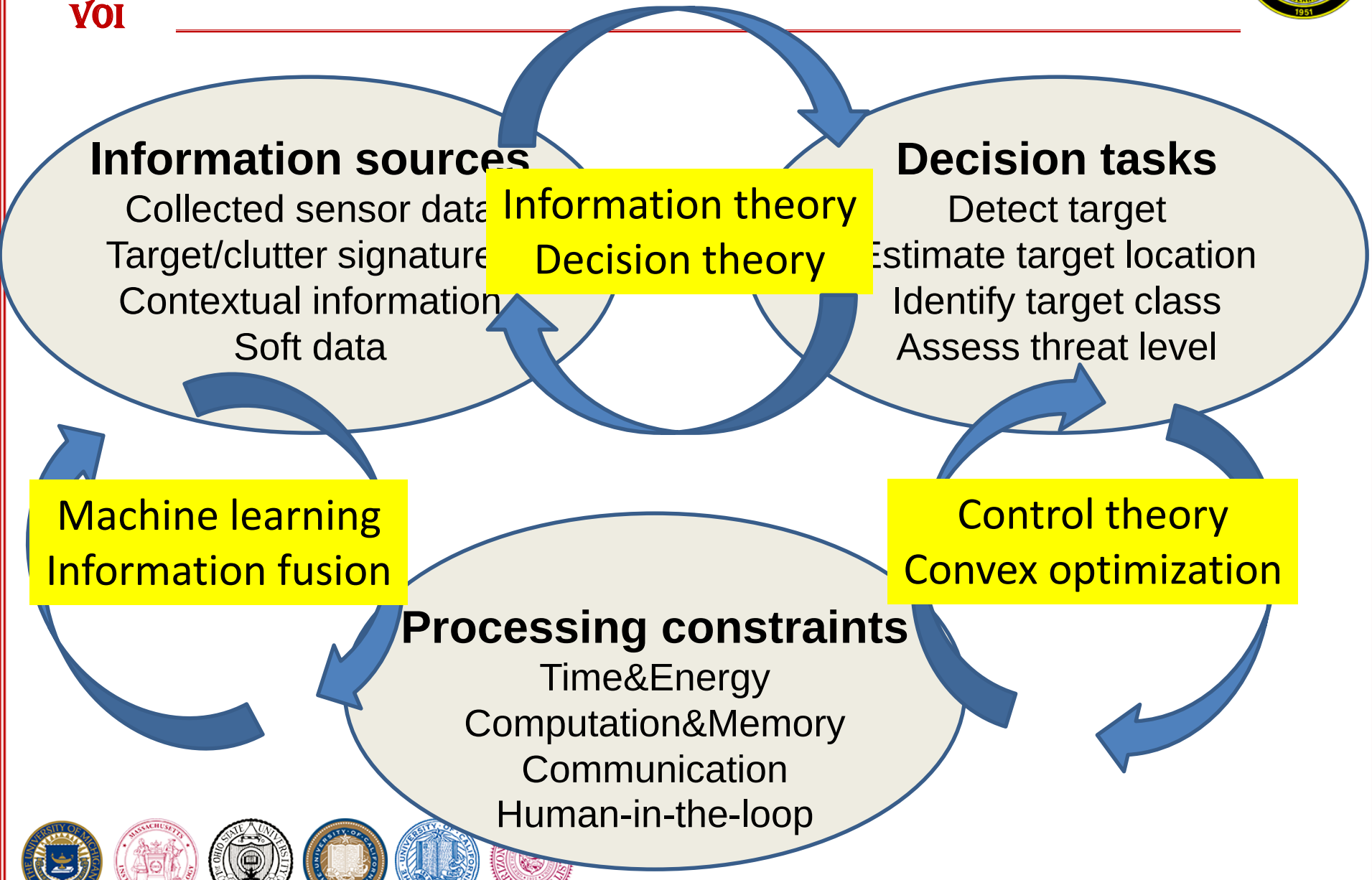
**Decision tasks**

Detect target
Estimate target location
Identify target class
Assess threat level

**Processing constraints**

Time&Energy
Computation&Memory
Communication
Human-in-the-loop

# Theory applicable to design space



# Theory applicable to design space

**Central questions addressed by our MURI**

What is intrinsic value of information for a task?
How do constraints affect value?
What algorithms ensure max value?
How to overcome computational bottlenecks?

**Our technical approach to address questions**

Value-centered information theory
Information-driven data fusion
Information-aware controlled sensing/processing

Communication

# Research highlights

- Information-driven structure learning and representation
  - Learning in graphical models latent variable structures [Hero, How, Fisher]
  - Trade-offs between complexity and performance [Ertin, Fisher, Hero, Jordan]
  - Representations of information for video analysis [Hero, Soatto]

- Distributed information fusion
  - Decentralized learning and local information aggregation [Ertin, Hero, Jordan, Moses]
  - Subspace processing and fusion of information [Ertin, Jordan, Nadakuditi]
  - Robust information-driven fusion [Ertin, Fisher, Hero]
  - Multimodality fusion with missing or unreliable information [Hero]

- Active information exploitation for resource management
  - VoI proxies for  resource management [Ertin, Hero, Cochran]
  - Information geometric foundations [Cochran, Hero]
  - Models of human and human-machine interaction [Hero, Yu]
  - Mission adaptive planning with convex proxies [Hero, How]

# Research highlights (ctd)

- Application domains being considered
  - Space-time adaptive processing (STAP) (Ertin, Cochran, Hero, Zelnio)
  - Moving target estimation in SAR (Hero, Zelnio)
  - Robust video motion segmentation (Nadakuditi, Hero)
  - Object and feature recognition in video (Soatto)
  - Fusion of WAMI and LIDAR imagery (Fisher)
  - Intruder detection with multi-modality sensors (Hero, Nasrabadi)
  - Human collaboration and HMI modeling (Yu, Hero, Sadler)
  - Wide area search and mission adaptive planning (How, Hero)
  - Social media, crowdsourcing and text streams (Hero and Jordan, Kaplan)
- Experimental model building and validation
  - Factors influencing human performance in collaborative tasks (Yu)
  - Radar test-bed to validate VoI proxies and associated algorithms (Ertin)

# 2013 review government comment 3

- **The committee noted current efforts addressing relevant subproblems of Value of Information (VoI). Team needs to coordinate research activities toward establishing a rigorous, foundational framework of value of information for distributed fusion. A unifying theme is needed...**
  Research coordination has occurred on several levels and several subgroups have been working together on foundational themes. This will be reported today in the talks and posters

# Previous government comments 5

- **…the highest priority of research be to establish a framework first using whatever type of data the team is familiar with.** This has been and continues to be the team's approach to model validation in building our framework for VoI**.**

- **Generalization of the framework to include soft data could be done later with possible modifications. The team is certainly encouraged to include soft data in research.** We are developing general theory capable of handing hard and soft data. Several coPIs will report on soft data in the talks and posters.

# Previous government comment 6

- **UCSD is new to the team and offers complementary research agenda. The focus of research should be on human aspects of value of information, going beyond attention detection and eye tracking.**
  We report results on modeling human behavior in problem solving experiments. As shown in Angela Yu's ARL presentation last June, UCSD's results generate models for the team's efforts on human-in-the-loop and collaborative learning.

# Previous government comment 7

- **While the government committee understands the tradeoff between complexity and elegance of a theory, it is desirable for research efforts to focus on theory and methods that are applicable to problems of practical complexity as opposed to results that are valid only under overly simplified assumptions.**
  Our team recognizes the importance of model validation and applying our results to real world data. The team has achieved this through designing experiments, disciplinary collaborations, and technology transitions.

# Previous government comment 8

- **Future research is encouraged to place more emphasis on multimodality sensors, particularly visual modality.**
- This year we report on several multimodality sensing problems, including those involving visual data.

# Previous government comment 10

- **The government committee discussed the use of real data for research validation and motivation….**
  Real data from various sources, including ARL, AFRL, and co-PI labs, is being used to validate models and results. We expect to coordinate with ARDEC to explore other multimodal data sources.

- **The team will set up a testbed, under the support of a DURIP grant, to address the need of creating realistic scenarios for research validation, verification, and problem motivation.**
  We anticipate collection of radar data from the DURIP testbed to begin by the end of the calendar year.

# Today's posters

1. Gene T. Whipps, Emre Ertin, Randolph L. Moses, "A consensus based decentralized EM for a mixture of factor analyzers“
2. Diyan Teng and Emre Ertin, “Learning to Aggregate Information for Sequential Inferences”
3. Nithin Sugavanam, Emre Ertin, “Optimal measurement matrix design for structured signals in clutter and noise”
4. K. Greenewald, A.O. Hero, "Regularized Block Toeplitz Covariance Matrix Estimation via Kronecker Product Expansions“
5. H.W. Chung, T. Tsiligkaridis, B. Sadler, A. Hero, “Collaborative 20 questions”
6. Z. Meng, B. Erikson, A.O. Hero, "Learning Latent Variable Gaussian Graphical Models"
7. Zhang, Chen, Zhou and Jordan: Spectral methods meet EM: A provably optimal algorithm for crowdsourcing
8. Zhang, Wainwright and Jordan: Lower bounds on the performance of polynomial-time algorithms
9. Nishihara, Jegelka and Jordan: On the convergence rate of decomposable submodular function minimization
10. J. Duchi, M. Jordan, M. Wainwright and Wibisono: Optimal rates for zero-order optimization: the power of two function evaluations
11. Brian E. Moore, Raj Rao Nadakuditi, and Jeffrey A. Fessler, “Improved robust PCA using low-rank denoising with optimal singular value shrinkage”
12. L. Crider and D. Cochran, “Value of Information Sharing in Network Signal Detection”
13. S. Zhang, A. Tran and A. Yu, “Personality and Behavioral Predictors of Human Exploration/Exploitation Behavior in a Bandit Task”
14. B. Mu and J. How, “ Focused information gathering with an application in SLAM”
15. Josh Hernandez, Konstantine Tsotsos, Gottfried Graber, and Stefano Soatto, “"Scene Segmentation with Dense Reconstruction from Monocular Video“
16. Konstantine Tsotsos and Stefano Soatto, “"Robust Visual-Inertial Navigation and Mapping"