Test and Evaluation of Cognitive and Social Capabilities of Unmanned Autonomous Systems

First International Workshop on Cognitive Dynamic Systems and Their Applications

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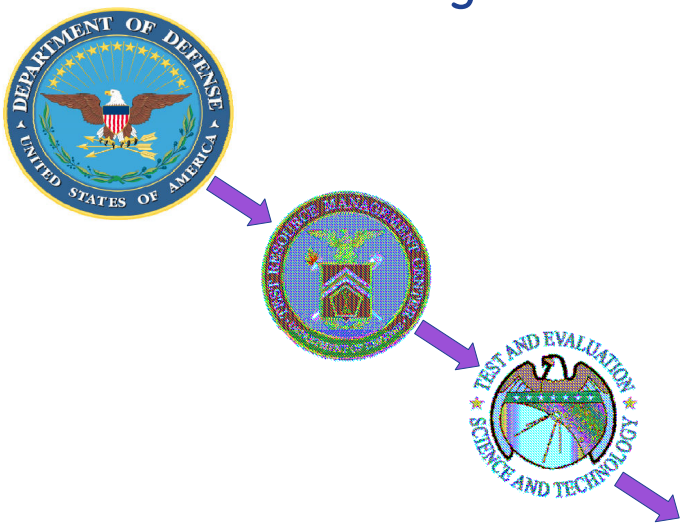
Signal Electronics and Embedded Systems Lab
May 27, 2008

Overview

- Our customer – origins and needs
- Project goals
- Autonomous systems concepts
- Cognitive systems concepts
- Social system concepts
- A few details on our approach

Customer needs and challenges

Our customer - origins



Unmanned and Autonomous System Test (UAST) Focus Area

Our customer – challenges and needs

Challenges: UAVs are becoming more sophisticated, autonomous, and ubiquitous. How does DoD test infrastructure evolve to accommodate for that?

Topic areas covered by the proposal:

1. Information / Knowledge processing / management
2. UAS collaboration in System of Systems (SoS) / Family of Systems (FoS) setting
3. Emergent behavior / complex systems

Stated project goals

- Develop deep understanding of UAV testing
- Develop solid expertise in cognitive systems
- Apply this expertise to meet UAV testing needs through development of a prototype
- Demonstrate results to customers
- Develop technology transition strategy
- Have a lot of fun doing it

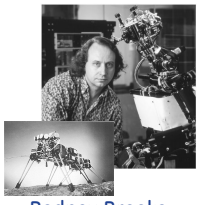
Autonomous System Concepts

Rough Timeline of Mobile Robotics

"Shakey"
SRI's AI Center
First Mobile Robot
Controlled by AI

1966

Deliberative School
of Robotics



Rodney Brooks

1986

Reactive -
Behavioral School
of Robotics

Ronald Arkin

1990

Hybrid Control
Architecture

S. Thrun

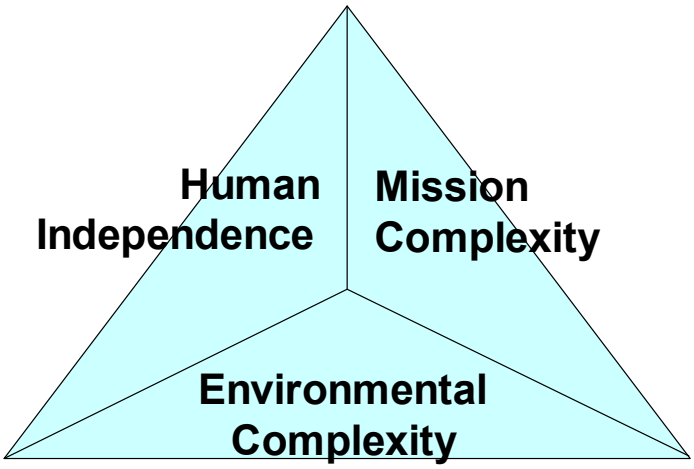
"Stanley" (2005)

"Minerva"
(1998)

1995

Probabilistic
Robotics

Technical background:
UAVs and autonomy – ALFUS metric (NIST)



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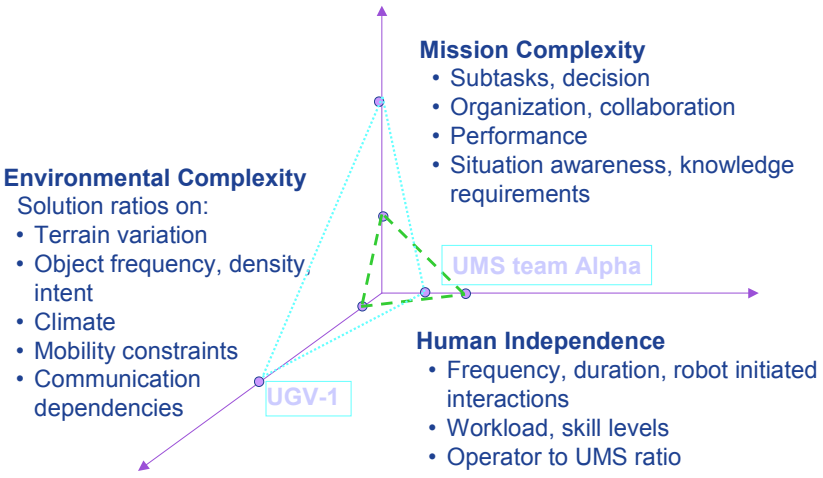
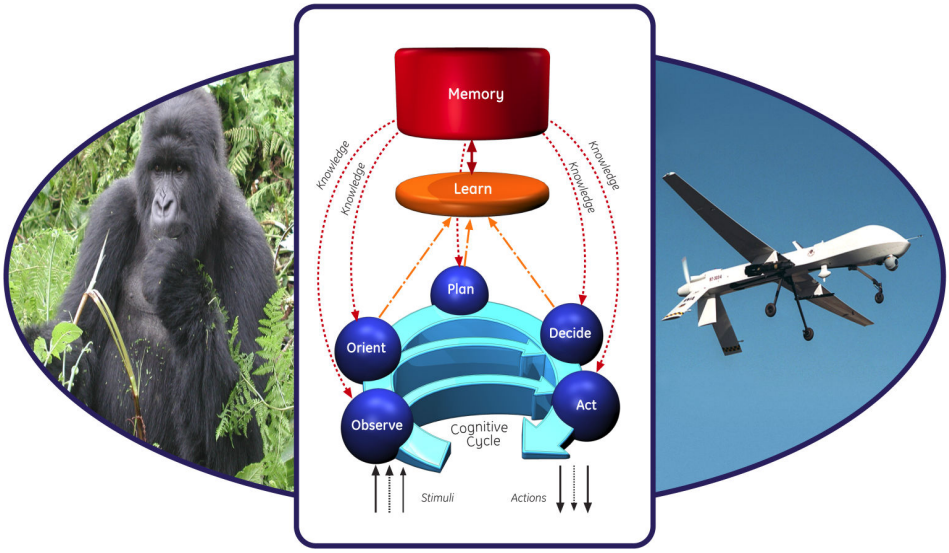


Cognitive Systems Concepts

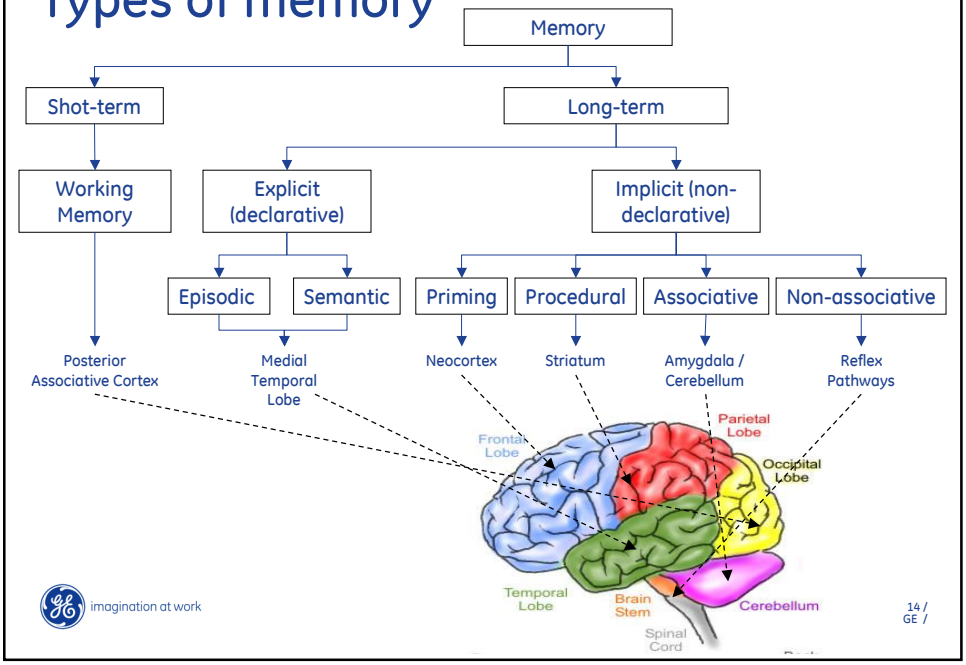
Cognition in autonomous systems

- Higher-level cognition developed evolutionary (unless you keep your mind open to "Intelligent design" principle)
- It developed so for a reason – to accommodate for rapid changes in the environment that genetic encoding could not respond to fast enough

Cognitive cycle Technical Reference Model



Types of memory



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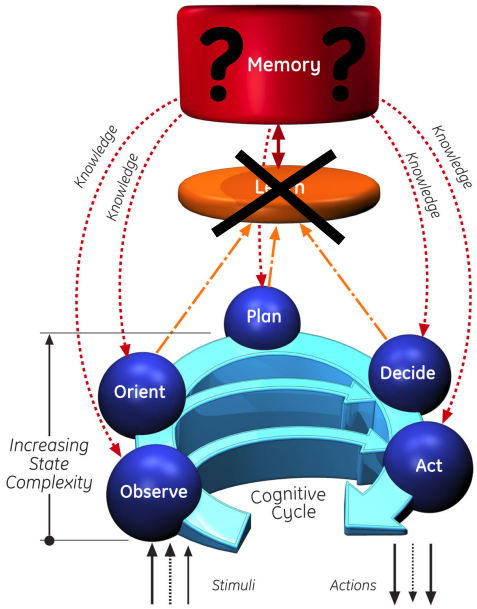
Deliberative school

"Shakey"
SRI's AI Center
First Mobile Robot
Controlled by AI



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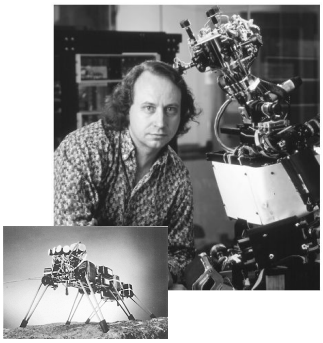
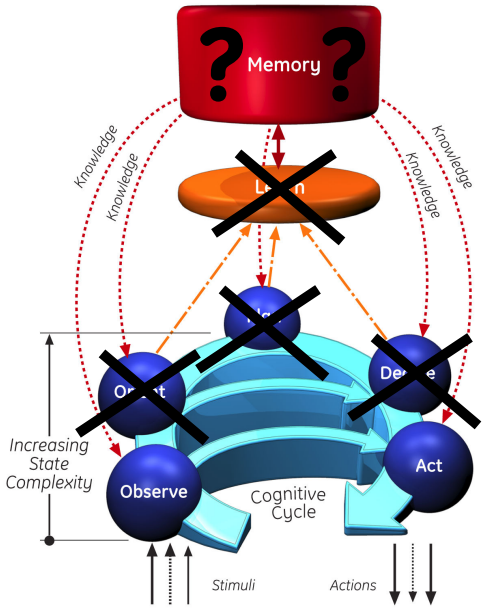
Reactive school



Rodney Brooks

Reactive - Behavioral School of Robotics



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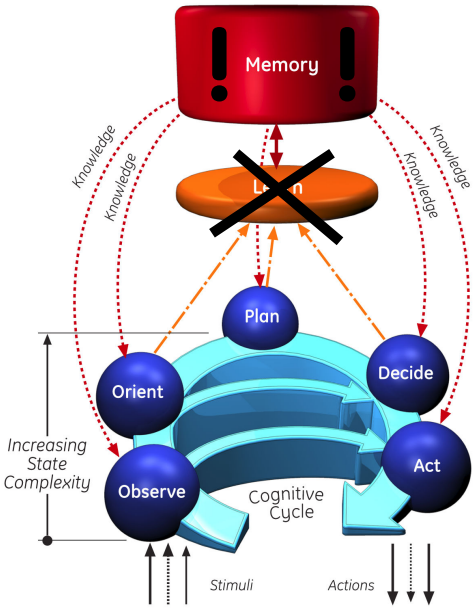
Hybrid/probabilistic school

S. Thrun

"Stanley" (2005)

Ronald Arkin

Hybrid Control Architecture



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VIDEO

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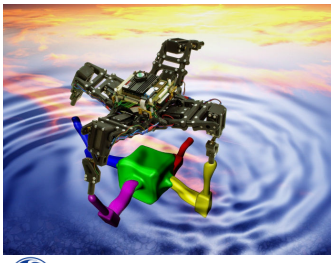
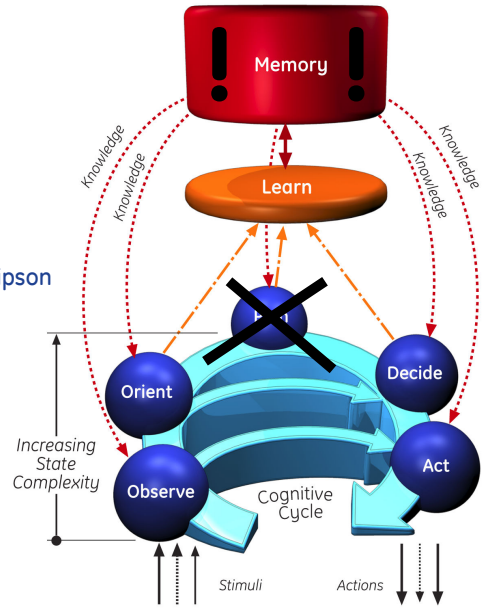
Learning robots

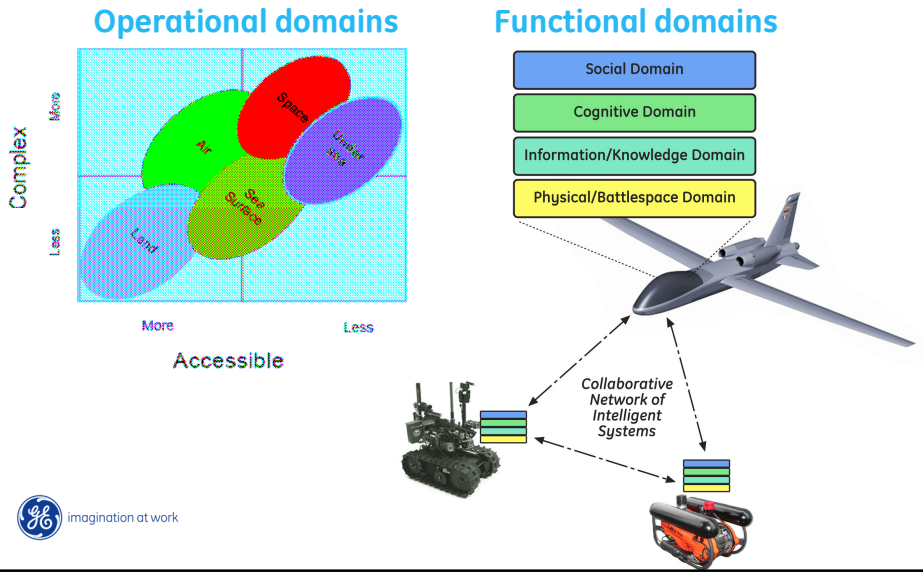
Victor Zykov, Josh Bongard, Hod Lipson





Social Systems Concepts

Technical background: Domains of UAVs



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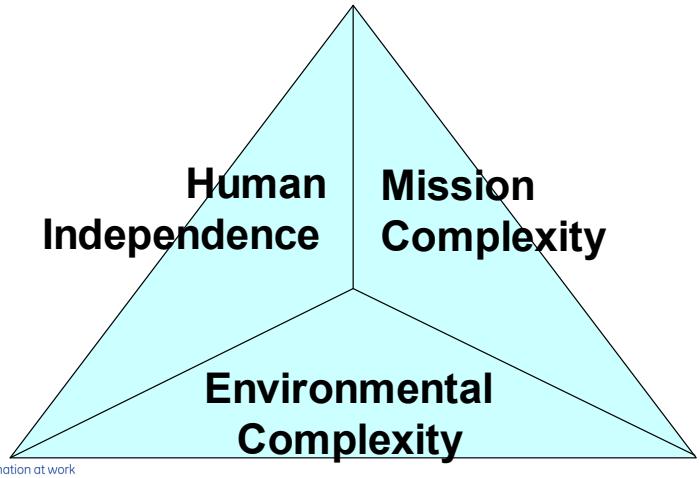
Technical background: ALFUS revisited – Social Interaction capacity

Fourth facet of the pyramid is needed



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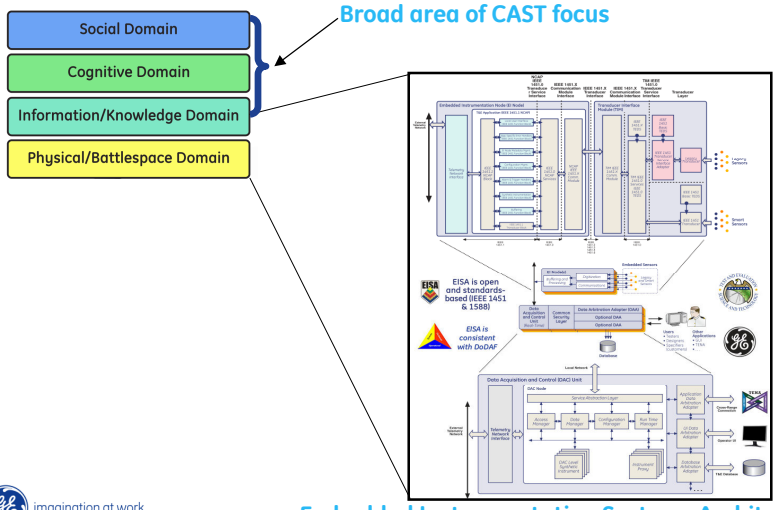
Emergent behavior in social UAVs

- Emergent/unpredictable behavior is a consequence of decentralized massively parallel system with reactive properties
- Higher-level cognitive systems will be gravitating towards centralized forms of social organization, and therefore, emergent behavior is less likely

A few words about our approach to the cognitive T&E problem

Technical background: Functional domain coverage – EISA



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Embedded Instrumentation Systems Architecture (EISA)

Technical background: Demonstration platform

VIDEO