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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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

- **1966**: Deliberative School of Robotics
- **1986**: Reactive - Behavioral School of Robotics
- **1990**: Hybrid Control Architecture
- **1995**: Probabilistic Robotics

- "Shakey" SRI's AI Center First Mobile Robot Controlled by AI
- Rodney Brooks
- Ronald Arkin
- S. Thrun
- "Minerva" (1998)
- "Stanley" (2005)
Technical background:
UAVs and autonomy – ALFUS metric (NIST)

Human Independence
Mission Complexity
Environmental Complexity

Environmental Complexity
Solution ratios on:
- Terrain variation
- Object frequency, density, intent
- Climate
- Mobility constraints
- Communication dependencies

Mission Complexity
- Subtasks, decision
- Organization, collaboration
- Performance
- Situation awareness, knowledge requirements

Human Independence
- Frequency, duration, robot initiated interactions
- Workload, skill levels
- Operator to UMS ratio

UMS team Alpha
JGV-1
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

Memory
- Shot-term
- Long-term
  - Explicit (declarative)
    - Episodic
      - Posterior Associative Cortex
    - Semantic
      - Medial Temporal Lobe
    - Priming
      - Neocortex
    - Procedural
      - Striatum
    - Associative
      - Amygdala / Cerebellum
    - Non-associative
      - Reflex Pathways
**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
Hybrid/probabilistic school

S. Thrun
“Stanley” (2005)

Ronald Arkin
Hybrid Control Architecture

VIDEO
Learning robots

Victor Zykov, Josh Bongard, Hod Lipson

Social Systems Concepts
Technical background: Domains of UAVs

Operational domains

- Complex
- More

- Accessible

Functional domains

- Social Domain
- Cognitive Domain
- Information/Knowledge Domain
- Physical/Battlespace Domain

Fourth facet of the pyramid is needed

- Human Independence
- Mission Complexity
- Environmental Complexity
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

Technical background:
Demonstration platform
VIDEO