Human Centered Research Involving UAVs in Military-Focused Domains

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The WSU Research Approach

Humans in Complex Systems

- Interactive decision aids
- Optimization techniques
- Human-in-the-loop
- Planning under uncertainty
The Design Approach

Domain Analysis
Computing
Cognitive Systems Engineering

Domain Tasks Human Operator Models

Computational Infrastructure

Represent problem scenario and human operator models

Design multi-modal interfaces, and customize ROV autonomy

Answers to Questions in Problem Scenarios

Learn
Apply

Evaluate
Human Operator Issues

- How to build reusable and modular software components for representing complex human behavior exhibited in ROV problem scenarios.
- What is the right number of human operators and system autonomy for certain realistic mission scenarios?
- How can modeling results be used to specify the content and form of multi-modal interfaces?
- For what situations are immersive technologies useful?
- What should the visualizations be to provide situational awareness to the operators?
Interface Capabilities

- Multiple UCAVs
- A realistic environment
  - Built using simulations to drive information
- Predictive feedback
- Protection from wrong decisions
- Provide direction for action
- Provide multiple perspectives
- Provide ability to override automation
Study by Ruff (1997)

**Experimental Design**

**Mixed Design (2x3x3)**

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<th>Level of Automation</th>
<th># of Vehicles Supervised</th>
<th>0% Error</th>
<th>5% Error</th>
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<td>Management by Exception</td>
<td>G</td>
<td>H</td>
<td>I</td>
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<tr>
<td>Management by Consent</td>
<td>D</td>
<td>E</td>
<td>F</td>
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<tr>
<td>No Decision Aid</td>
<td>A</td>
<td>B</td>
<td>C</td>
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UCAV HIL Interface
Recent Ground UAV
Optimization and Analysis Efforts
- Up to 500 targets daily
- Multiple assets with multiple depots
- Intelligence cell must allocate the targets to assets
- Operators must find route subject to
  - √ Time windows
  - √ Threats
  - √ Target priorities
  - √ Vehicle endurance
Defined an Architecture

- Problem classes
- Defined components for each level and built each component

- Technique
- Algorithms
- Heuristics
- Interfaces
- Applications
- Simulations

- Defined components
  - for each level and built each component

- Meses
- Prototypes
- Mapping
- Software
- Simulations

- Universal Vehicle Router
- Core AFIT Router
- Solvers
- Genetic Algorithm
- Linear Program
- General TS
- WRP Tabu Search

- Java Virtual Machine
- Windows
- MacOS
- Solaris
- Linux
- WWW
Built an Application Level

The application is the only portion of the AFIT router presented to the user. All other portions are hidden.

Users liked this feature
## Details within Application Level

### Shooting/Trucking

**General TS**

**Core AFIT Router**

**Mapping Software**

**Simulations**

**Prototype Application**

**Mapping Framework**

**Tracking**

**AFIT/VIP**

**Solaris**

**Linux**

**Java Virtual Machine**

**WWW**

### Other VRPs/TSPs

**Linear Program**

**Genetic Algorithm**

**Etc.**

### Solvers

**VRP Tabu Search**

### Details within Application Level

#### Summary

- **Total:** 100
- **Enabled:** 96
- **Earliest time window:**
- **Latest time window:** 06:39 h + 2 days

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<th>Longitude</th>
<th>Service Time</th>
<th>Priority</th>
<th>Requirement</th>
<th>Earliest Allowed</th>
<th>Latest Allowed</th>
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<td>10:00 h</td>
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Coordination and Control of Cooperative Swarms of Unmanned Aerial Combat Vehicles via a Virtual Testbed Environment
Themes of Effort

- Agent models and heterogeneous agents within the swarm
- Swarm limitations in terms of size, capability, cooperation, or loss of cohesiveness
- AOC control issues to include number of controllable agents, information presentation and influence on the swarm
Research Questions

- What degree of cooperation is attainable?
- Can heterogeneous agent cooperation be accommodated?
- Can the swarm enlarge or constrict gracefully?
- Can emergent behavior be recognized and then beneficially controlled?
The “Control Cube”
Architecture Requirements

- Interactivity
- Multi-user connectivity
- Reconfigurable user interfaces
- Representation of information flow
- Analytical-based and controller-based information presentation
- Modularity and reusability of software architecture components
Activities Thus Far

- Project initiated in March 2004
- Establishing link with AFRL/MN for potential collaboration and technology transition
- Conducting the domain analysis and task analysis from which to define, design, and realize the software abstractions required to realize our virtual test environment
Research Challenges

- Models of agent cooperation
- Interfaces for human control of swarms of UCAVs
  - √ Protocol for human-computer interaction
  - √ Control cues for effective coordination
- Examine network-centric models involving swarms of UAVs
  - √ How to use emergent networks
  - √ How to guard against their attack
Questions?