Creating a Tactical Pilot's Assistant for Combat Operations in Contested Denied Environments:

An Overview of Three Different Approaches and Results

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Integrity ★ Service ★ Excellence

Overview

- Our Motivation
- Operational and Technical Challenges
- Converging Approaches
- Implications from the Work

Our Motivation

- How to improve human operator decision making for future combat environments
- Leverage agent development advances to explore assistant technology in fast jet ops
- Assess capacity to develop agents in more complex environments
- Demonstrate agent applications having utility in these environments
- Better define the seam between agents and humans in decision making contexts

The Ops Problem

- Tactical environments are complex
- Variety of spectrum challenges impact quality of services
- Dependence on off-board capabilities increasing – lots of data on many things
- Adversaries expected to creatively contest data, services and spectrum (in real time)
- Aircraft systems may not directly provide indicators of credibility (reliability and validity)

The Agent Development Problem

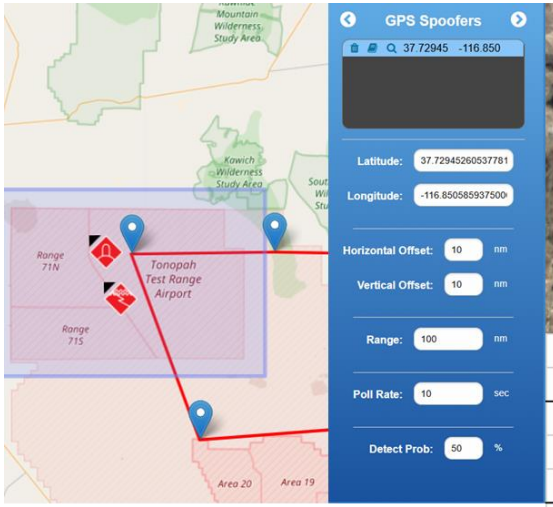
- Hand crafted models are the current SOA
- Dependence on software programmers and SMEs limits practical applications
- Variety of modeling architectures and unique data requirements
- Models are brittle
- Potential operational application spaces are very complex
- Ill-defined locus of human and machine interaction

The Data Availability Problem

- Fine-grained data representing environment and behaviors is not routinely available
- Data rarely contextualized for understanding
- Typical data, if available, are classified
- It's expensive to integrate software products into existing aircraft systems
- Limited examinations to quantify the seams between human and machine interoperability and mutual support

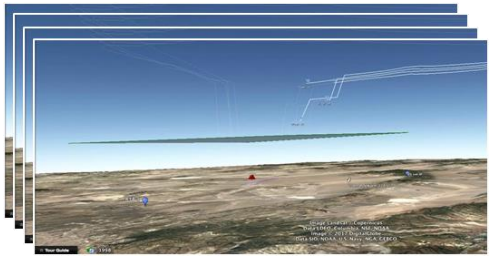
Converging Approaches to a Solution (1a)

- **Incorporating Socio-Technical Factors in Simulations**
  - **Develop simulations of activity, namely situated and interactive behavior incl. spatial/geographical model, cultural features and objects, and -information systems**
  - **Create tools for activity capture & socio-technical context**
  - **Apply approach for predictive analysis & constructive agent control in simulations w/uncertain, complex threats**

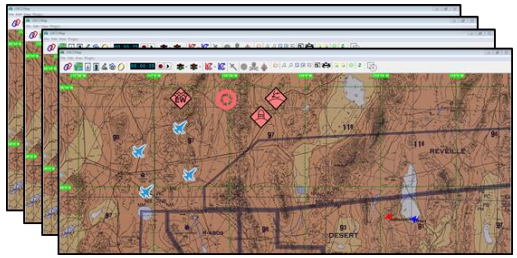


		DID NOT Observe TGT	Released Bomb	Action
Wx Late +	DataLink Jam	17	39	CLIMB
	GPS Jam	1	39	DESCEND
	GPS Spoof	1	39	DESCEND

Where Are We Today (Solution 1b)?



- **Socio-technical model that informs:**
  - **Detection of denial attacks**
  - **Evaluation of counter-measures**
  - **Course-of-action analyses**
- **Constructive agent integration w/USAF sims (NICE, NGTS)**
- **Stand-alone Analyst Toolbench capabilities**
- **Interoperable, integration-ready**
- **Analyses, CONOPS, Planning, Training, Rehearsal**
- **Future Application: Support for Tactical Pilot Assistant**



U.S. Air Force photo by Staff Sgt. Jonathan Snyder

Added dimension to helping pilots in denied environments

Converging Approaches to a Solution (2a)

- **Configurable Adversary Response Prediction (CARP)**
  - **Extends and exploits the state of the art in modeling human decision making**
  - **Supports simulation of scenario and mission outcomes that provide the analytical forecasts necessary to perform situation assessment**
  - **Represents analytic results in an efficient knowledge base that can create assessments in real time**
  - **Addresses the difficulty of running large-scale analyses during mission execution**

Converging Approaches to a Solution (2b)

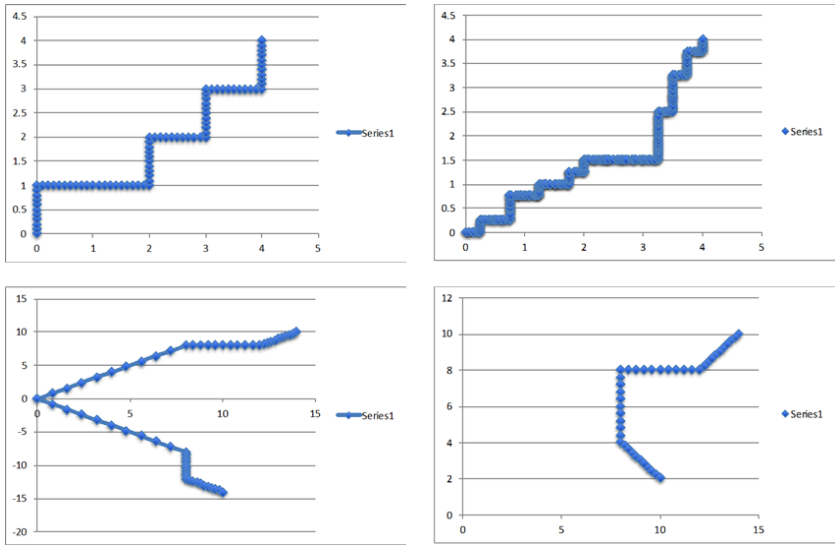
- **Prototype scenario-exploration engine**
  - **Abstraction layer for configuring simulation-based scenarios using integrated, parameterized models**
  - **Functions for specifying configuration ranges for "parameters of interest"**
  - **Data collection using Monte Carlo sampling over selected configuration ranges**
- **Prototype data-analysis engine (PA)**
  - **Bayesian and search-based exploration tools to identify complex correlations and causal patterns**
  - **Ability to enrich knowledge representation based on discovered patterns**
  - **Generation of formal expectation models for consumption by the PA**

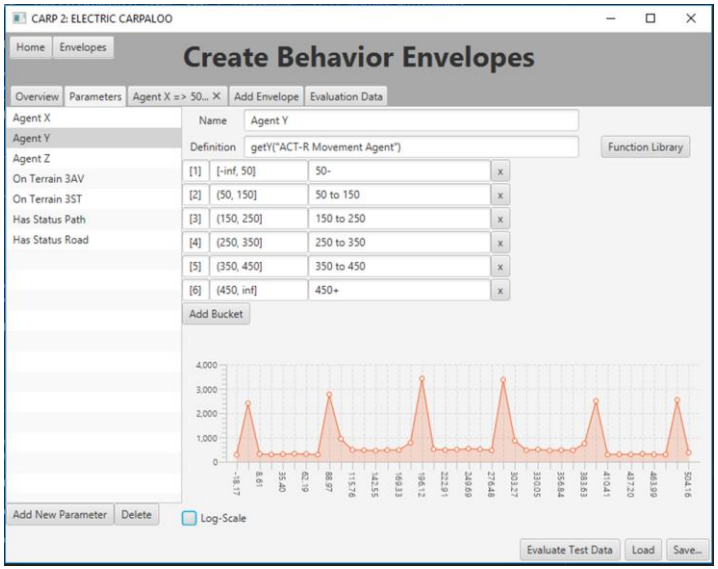
Converging Approaches to a Solution (3a)

- **DREAMIT: A Framework for Integrating Agent Models**
  - **Create a framework that can be used to:**
  - **Examine how otherwise distinct agent technologies might be combined as assistants**
  - **Explore if a model of agent perceptions can be combined with a diagnostic reasoning module to assist a pilot in generating and verifying expectations about a tactical situation**
  - **Determine a useful division of labor among agent models and the human pilot they are designed to support**

Converging Approaches to a Solution (3b)

- Implemented a generic planning agent to simulate movement under different initial conditions
- Integrated agent model and diagnostic inference engine to support off-line training





What We Were Able to Do: Our Outcomes

- Created prototypic agent exemplars
- Evaluated exemplars in tactically relevant use cases
- Examined appropriate interoperability for agents and human operators
- Demonstrated a level of practical utility in developing agent-based assistant models
- Identified gaps in the state of the art for future research

Implications for Future Work

- **Definition of minimum data requirements for future applications**
- **Potentially viable assistant technology and models**
- **Practical use case analyses**
- **Better definition of locus of human and agent interoperability**
- **Gaps in existing research for future development**

Contacts and References

CARP: rjones@soartech.com

Read about it: Primary publication on CARP:
Jones, R. M., Bechtel, R., & DeGrendel, B. G. (2018). Configurable adversary R\response prediction: Building efficient expectation models from high-fidelity behavior simulations.
In *Proceedings of the 2018 Winter Simulation Innovation Workshop (SIW).* Orlando, FL.

Publication on the "Behavior Envelope" knowledge representation that is the target output of the CARP system:
Jones, R. M., Bachelor, B., Stacy, W., Colonna-Romano, J., & Wray, R. E. (2015). Automated monitoring and validation of synthetic intelligent behavior. In *Proceedings of the 17th International Conference on Artificial Intelligence*. Las Vegas.

DREAMIT: w.warwick@tier1performance.com

Read about it:
Warwick, W., Buchler, N., & Marusich, L. (2018). An Integrated Model of Human Cyber Behavior. In D. N. Cassenti (Ed.), Proceedings of the International Conference on Applied Human Factors and Ergonomics (pp. 290-302).
Orlando, FL: Springer International Publishing AG.
Warwick, W., Lebiere, C., & Rodgers, S. (2018). No Representation Without Integration! Better Cognitive Modeling Through Interoperability. Paper presented at the International Conference on Applied Human Factors and Ergonomics.
Warwick, W., Walsh, M., Rodgers, S., & Lebiere, C. (2016). Integrating heterogeneous modeling frameworks using the DREAMIT workspace. Paper presented at the AHFE 2016, Orlando, FL.

QUESTIONS?

THANK YOU!

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