Research Projects

Active Research Projects

- NPS-ROS: NPS Robot Operating Systems (ROS) development
- Swarm Vs. Swarm Concept Generation and Field Experimentation
  - Swarm vs. Swarm Grand Challenge Competition
  - Agent-Based Modeling and Simulation
- Concepts for Cooperative UUVs using Covert Coordination
- Situational Awareness for Surveillance and Interdiction Operations (SASIO)
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- MultiScale Search using Probabilistic Quadtrees
- Optimal Surveillance Patrol
- Models and Algorithms for Probabilistic Search Decisions
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  - Analysis of Exhaustive Probabilistic Search

NPS-ROS: NPS Robot Operating Systems (ROS) development

Swarm Vs. Swarm Concept Generation and Field Experimentation

Swarm vs. Swarm Grand Challenge Competition

A Red Vs. Blue competition with teams of low-cost, effective, autonomous UAVs. Live fly experimentation efforts incorporate advances in platform design, embedded sensing and information processing, dynamic communication and network topologies, and algorithms for increased autonomy in decision making, distributed task assignment, and optimization.

Agent-Based Modeling and Simulation
Algorithmic modeling of individual UAV agent behaviors as well as their networked interactions as a swarm is well-suited to agent-based simulation (ABS) studies. In this project, modeling and simulation of Red vs. Blue UAV swarms in three-dimensional virtual environments is used to develop and inform future concepts of operations. Additionally, these simulation studies translate directly to physical design specifications and requirements for implementation in iterative validation, test, and evaluation field experiments.

**Concepts for Cooperative UUVs using Covert Coordination**

Increasingly, more complex operations are entrusted to autonomous systems, which can leverage teams of robots to accomplish their tasked missions. The subsurface environment offers numerous unrealized opportunities to leverage unmanned underwater vehicles (UUVs). The goal of this project is to generate future concepts of operations employing a team of coordinated UUVs, specifically highlighting methods for covert coordination in support of persistent ISR missions.

Collaborative research with Vlad Dobrokhodov

**Situational Awareness for Surveillance and Interdiction Operations (SASIO)**
Complex operations require extensive coordination between multiple heterogeneous agents, such as unmanned aerial vehicles (UAVs) and ground units. We investigate the role of augmenting a team comprising a surveillance asset ("Surveyor") and interdiction ground Quick Reaction Force ("Interdictor") with an additional UAV (the "Tracker") which can perform tracking tasks and is organic to the interdiction unit. Measures of performance from SASIO simulation studies include the change in expected number of hostile targets interdicted and the expected increase in the time spent conducting surveillance.

Experimental validation using SASIO decision support at Camp Roberts includes operations using the NPS Rascal autonomous UAV (Surveyor), a mounted interdiction unit ("Interdictor") serving as a mobile ground control station for a Raven UAV (Tracker). Automated embedded visual detection using computer vision algorithms is integrated in the Rascal payload and is used to report cues of possible targets to SASIO. This project reflects a collaborative effort with multiple NPS faculty: Vlad Dobrokhodov, Kevin Jones, Michael Clement, Mathias Kölsch.

Tactical Installation Protection
This California Homeland Security Consortium project proposes a prototype surveillance infrastructure including hardware and software components that would vastly increase the actionable information available to law enforcement and emergency responders in municipal contexts.

Overall the architecture combines four well-developed techniques including (i) SA environment, (ii) Video/Image geo-registration with TIVO-like capability, (iii) airborne UAVs with network enabled sensory and control capability, and (iv) the robust and wireless and wired network. Each of the developed capabilities complements the proposed system, thus making it suitable for the task at hand. This project reflects a collaborative effort with multiple NPS faculty: Vlad Dobrokhodov, Kevin Jones, Michael Clement, Mathias Kölsch.

Joint Expeditionary Force Experiment (JEFX)

Naval Warfare Development Command, Command Second Fleet
Developed and deployed the Situational Awareness for Surveillance and Interdiction Operations (SASIO) modeling framework in support of the Navy Maritime Operations Center (MOC) during the JEFX10-3 Live Fly Experiment. SASIO leverages probability, stochastic, and optimization models to determine efficient and effective allocation of Intelligence, Surveillance, and Reconnaissance (ISR) assets. The decision support software, called SASIO: Command, was deployed in the MOC at the Mitscher Center to provide recommendations for unmanned aerial vehicle (UAV) search routes to the Intel Cell in support of numerous Navy operational threads. This project received support from CDR John Looney, Ph.D. and CAPT(ret) Carol O'Neal.

Reference to SASIO in NTTP 3-32.1 (Maritime Operations Center) Appendix
SASIO software binaries

MultiScale Search using Probabilistic Quadtrees
Collaborative research with Stefano Carpin at UC Merced.

Optimal Surveillance Patrol

Office of Naval Research
We investigate a class of problems in which a defender dynamically allocates its surveillance assets in anticipation of an attack. The surveillance asset can be an unmanned aerial vehicle (UAV), a radar mounted on a small nonrigid airship, or a patrol officer.

We study a patrol problem where the defender chooses a patrol sequence among possible attack locations to maximize the probability of detecting an attack. The adversary chooses the attack location to minimize this detection probability. We examine patrol policies that utilize Gittins indices to determine the next location to visit during a patrol. This research leverages rigorous analytical tools from game theory, optimization, stochastic modeling, and simulation, to ultimately generate recommendations for real-time allocation of surveillance assets. Ongoing research will develop robust methods to counter the enemy’s strategy no matter what the enemy does.

Collaborative research with Kyle Lin and Michael Atkinson

Models and Algorithms for Probabilistic Search Decisions

Probabilistic Search on an Optimized Graph
Simulation model (binaries)

Analysis of Exhaustive Probabilistic Search

Collaboration with Rachel Silvestrini

Simulation model (binaries)