A Testbed for Investigating the UAV Swarm Command and Control Problem Using DDDAS

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Overview

- **Unmanned Aerial Vehicles (UAVs)**
- **DDDAS**
- **Testbed System - Structure**
  - Console & UI
  - Web Services
- **Target Search Problem**
- **Multi-Agent**
- **Physical UAVs**
- **Future Work**

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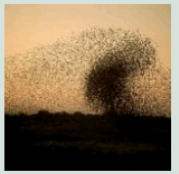
Unmanned Aerial Vehicles (UAVs)

- Airplane-size or smaller
- Small UAVs have advantage
  - Hard-to-reach spaces
  - Good for covert operations

Near Future	Distant Future
4 planes (MQ-X)	 Swarm (Autonomous UAS)

- If the future, missions may be performed by multiple cooperative UAVs – swarms
- Currently each needs pilot
  - Swarm may contain many UAVs
  - Not enough pilots, unless one pilot flies the swarm
- Emergent behavior in swarm, so how to control?

DDDAS

- Dynamic Data-Driven Application System (DDDAS)
- Real-world system provides information to a simulation, which can steer the simulation, and vice versa
- Using a DDDAS approach, we can steer the UAVs in our simulation, based on where real or "simulated real" UAVs are
  - Can easily switch between simulated real and real UAVs
  - Also provide power information and generate targets

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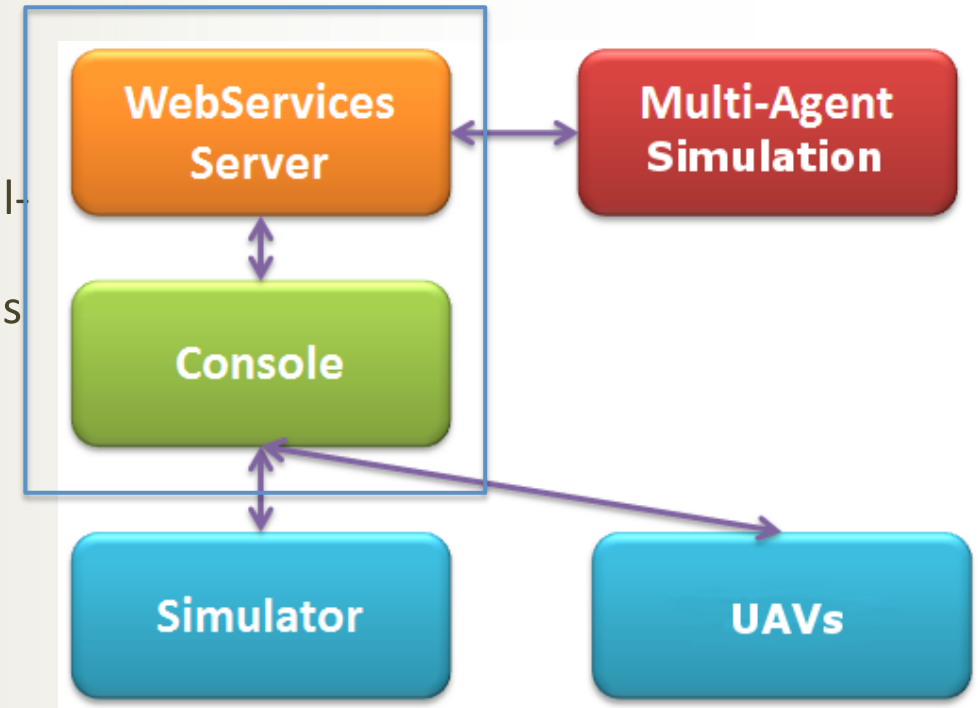
Testbed System - Structure

- Use principles of Dynamic Data-Driven Application Systems (DDDAS)
  - Multi-agent uses real-world data
  - Multi-agent gives feedback to real-world system
  - Can use any multi-agent system as long as uses web services calls
  - Can switch between real-world (UAVs) and simulated-real (Simulator)
- Core of Testbed:
  - Web services allows communication
  - UI and visualization available through Console



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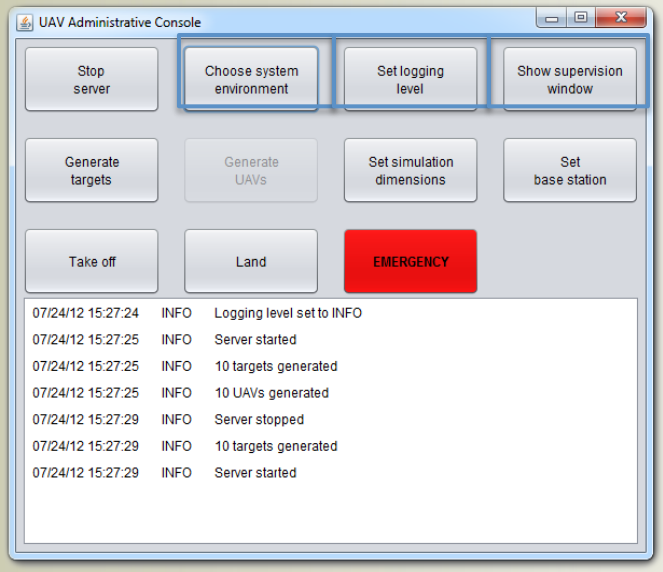
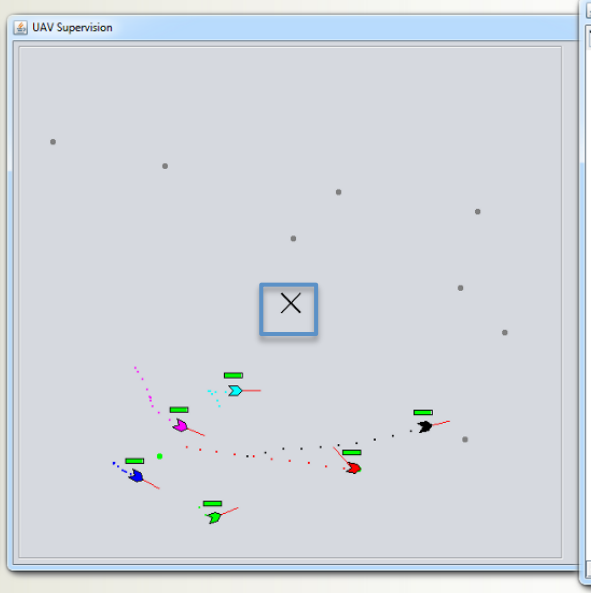
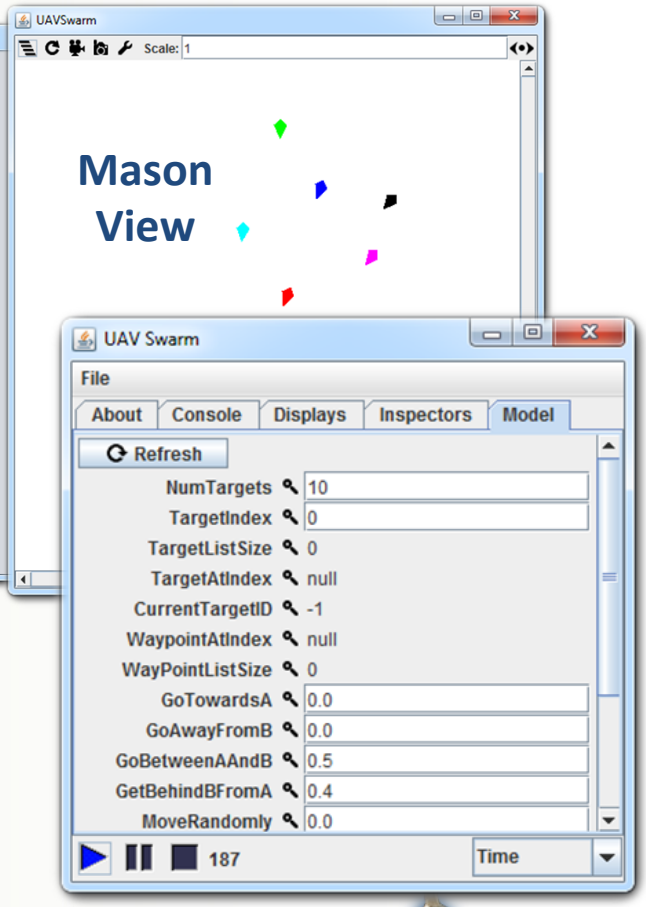
Testbed System – Console & UI



Console



Simulator View



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Testbed System – Web Services

- Runs on Apache Tomcat server plugged into Eclipse
- Communicate using RESTful web services
  - Open-source Jersey API package used to write code
  - Passes messages from multi-agent system to real-world and vice-versa
  - Makes DDDAS possible

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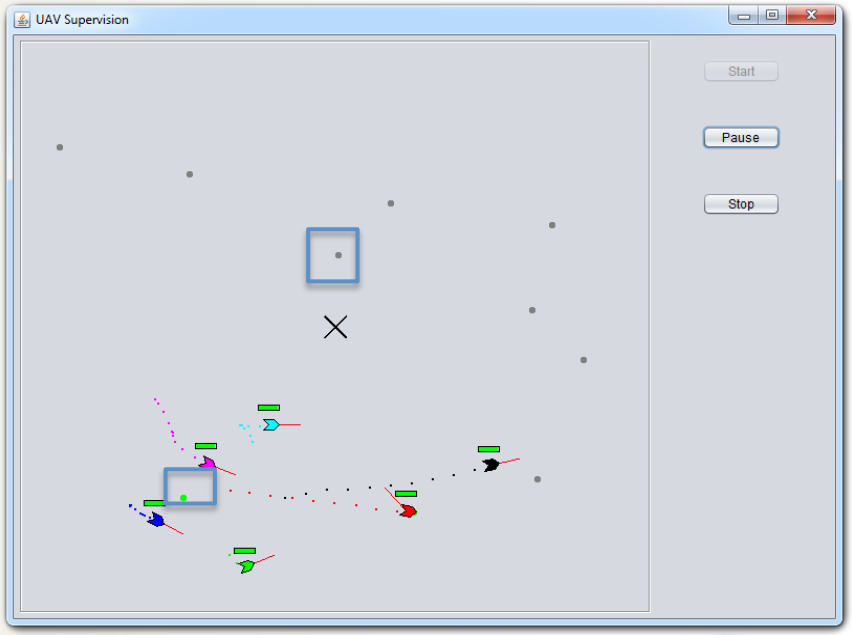
Target Search Problem

- Targets with unknown locations placed randomly
- UAVs must find as many as possible
- One of many possible problems to solve with UAVs
  - Swappable with any multi-agent system, as long as make web services calls



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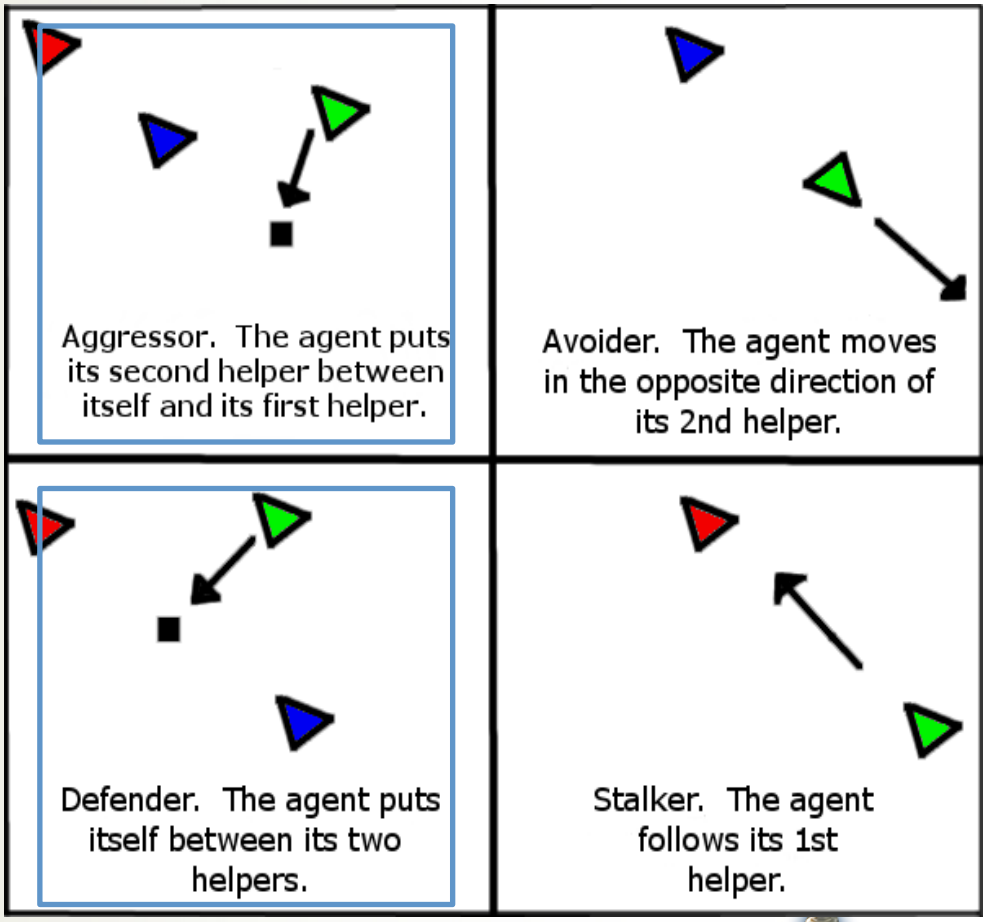
Sample Multi-Agent System

- Have a leader that becomes each agent's first helper
  - Tell leader where to go and others follow
- Implemented using MASON libraries for simulation



Physical UAVs

- Parrot AR.Drone 2.0
- Built-in 802.11n wifi
- Wifi modified with script so that UAVs would connect to laptop access point
- High-level commands API
- Limited Linux environment on each drone
- USB port, used for GPS dongle
- Front-facing camera, though SDK for it not available at time of project

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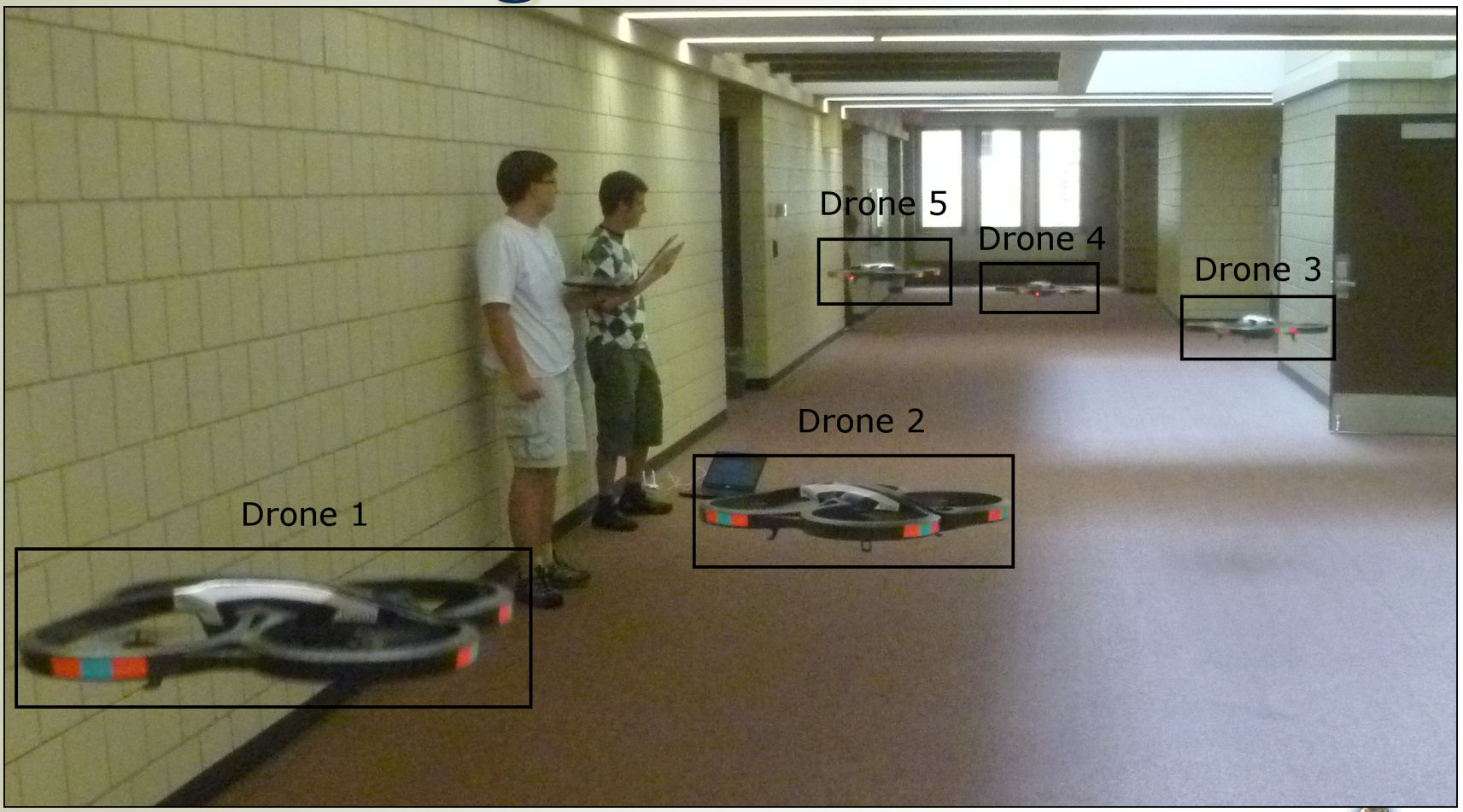
UAVs in Flight



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Future Work

- UAVs can connect and communicate with laptop running testbed
  - GPS does not update fast enough to communicate accurately with simulation
  - Parrot now provides a GPS-enabled geolocator
  - Wireless connection with UAVs is inconsistent
- Possibly incorporate video now that SDK is released
- Easily create other simulations with MASON or other library that communicate with real UAVs or simulated UAVs
  - Make simulation with UAVs
  - Use web services calls for appropriate data

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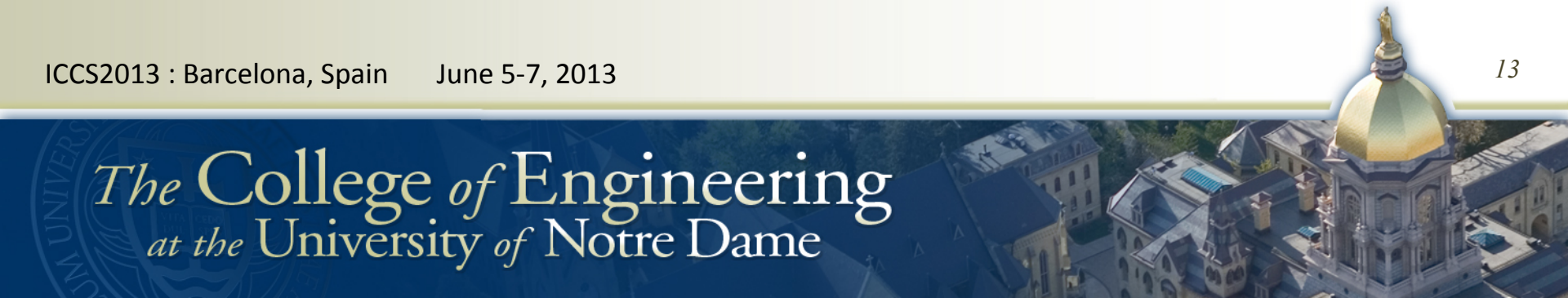
THANK YOU!

Any Questions?