

ICRA 2008 Workshop, Pasadena

# Cooperative Control of Multiple Heterogeneous Unmanned Aerial Vehicles for Coverage and Surveillance

Vijay Kumar

University of Pennsylvania

Marc Steinberg

Office of Naval Research

Peng Cheng

University of Pennsylvania

Karl Hedrick

University of California,  
Berkeley

Ron Arkin

Georgia Inst. Technology



*University of Pennsylvania*



# Goals of the Workshop

## Models

- Multiple UAVs, USVs, UUVs, UGVs
- Heterogeneity
- Dynamically-changing environment, network

## Algorithms

- Search, identification, localization and tracking
- Task allocation and target assignment
- Pursuit-evasion
- Cooperative control
- Fusion



# Agenda

## Sensing, Control and Coverage

- Salah Sukkarieh
- Magnus Egerstedt
- Peng Cheng
- Gaurav Sukhatme
- James Keller

## Control of Distributed Systems

- George Pappas
- Francesco Bullo
- Ali Jadbabaie

## Deployment/Experimentation

- Jonathan How
- Karl Hedrick
- John Clark
- Randy Beard
- Bin Yu
- David Cole
- David Schiedt
- Max Likachev



# Open Technical Questions, Challenges

Information fusion beyond DAGs

Close to real time MTS solution?

Task allocation/assignment solved?

BAA, CBAA, DCOP, ...



# Organization and Architecture

Organization, structure and architecture for complex, multi-UAV systems.

*Is there any convergence to a “standard” UAV architecture?*



# Experimental Platforms

- Cloudcap, Picolo
- Quad-rotors
- Robotic sailboats
- Flying wings
- Many hardware-in-loop solutions available



# Workshop Proceedings

- Slides will be available online

<http://grasp.upenn.edu/~chpeng/icra08workshop/workshop.htm>

- Robotics and Automation Magazine
  - ◆ Special Issue



# Panel Questions

1. Open questions/problems on distributed control, sensing and coverage.

2. Organization, structure and architecture for complex, multi-UAV systems.

3. Challenges in experimentation, integration and deployment.

4. Robotics and Automation Magazine Special Issue



# Open Problems

- Better communication models, beyond discs
- Look to biology and social sciences for groups, coalitions
- Benchmark problems?
- Complex environments (dynamics, communication)
  - performance evaluation
  - analogy
- Grand Challenge with experimental UAVs and human-in-loop simulations

# Open Problems

- Good algorithms for vision on moving platforms
- Auto-3D models of urban environments
- Regulatory issues (FAA, civilian v.s. defense applications)
- Need more emphasis on heterogeneity
- More information on operational constraints needed for V/V
- Minimalist approach for task allocation
- Standards required?

