# Applications of Micro-Autonomous Aerial Vehicles at the University of Pennsylvania GRASP Lab


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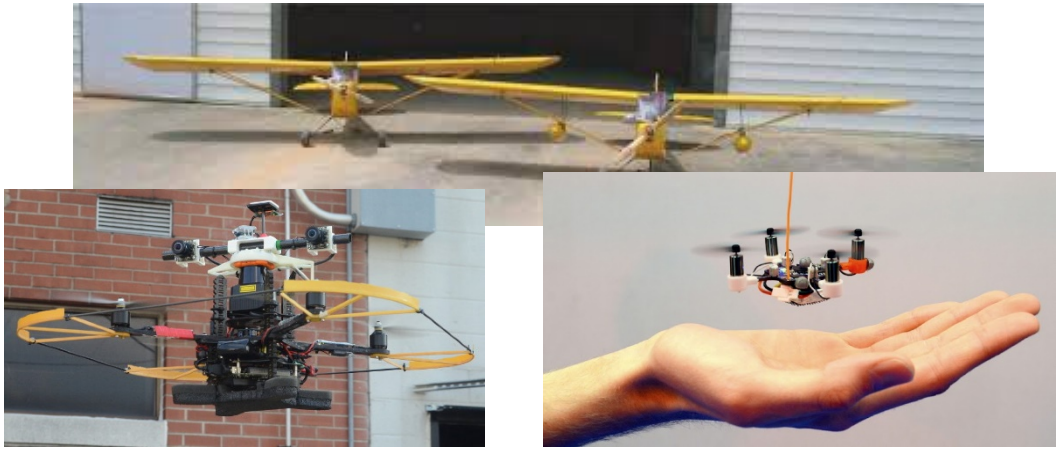
# GRASP Lab Overview

The General Robotics, Automation, Sensing & Perception laboratory at Penn:
18 faculty members (Mechanical Engineering and Applied Mechanics, Computer and Information Systems, and Electrical Engineering Departments)
about 20 postdoctoral researchers
75 PhD students
90 Master's students

Many UAS platforms (indoors and outdoors)
Fixed and rotary-wing to micro-size



# Overview of Applications

Swarm and Formation Flight Control

- Mapping of building and terrain
- Team coordination to facilitate complex missions (form sensor or antenna patterns)
- Reconnaissance/Surveillance mission planning and execution
- Art - high tech audio/visual performance art using swarming drones
- High agility maneuvering flight control concepts for tactical applications

Mapping of Infrastructure

- 3D mapping of buildings inaccessible to humans(earthquake damage monitoring)
- 3D mapping of Hydro-dams (research partnership with Army Corps of Engineers and Bureau of Reclamation to use drones to forecast maintenance requirements)
- Property damage assessment for insurance companies following natural disasters

Smart Agriculture

- Agricultural mapping (detect crop health, pesticide effectivity/insect management)

Construction Aids

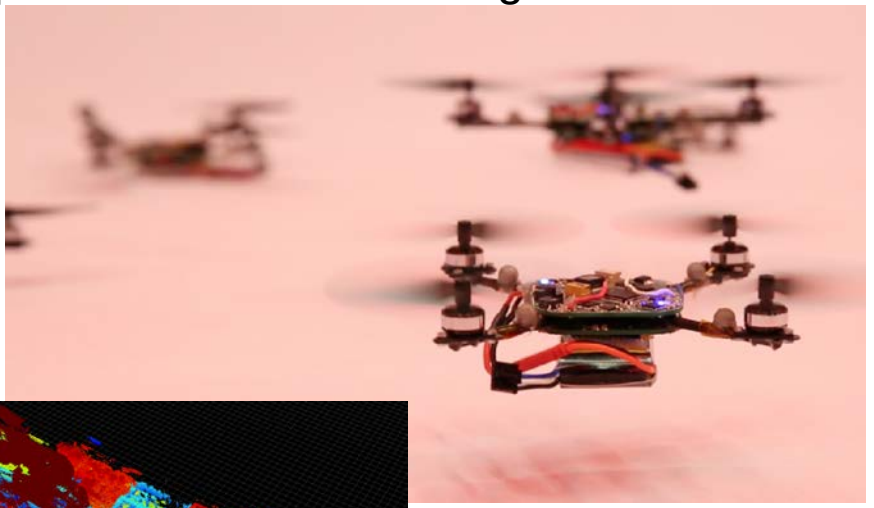
- Aerial placement of structural members in construction process

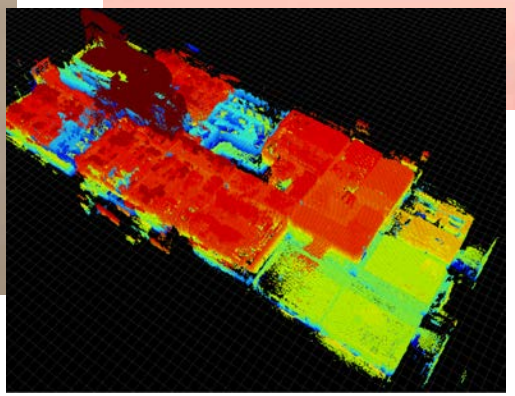
Drone Technology Development

- Smart phone enabled drone
- Micro-drones for aerodynamic educational applications

# Swarm and Formation Control

GRASP customizes a variety of commercially available drone platforms for research purposes and develops its own platforms as required to meet research goals





[Drone performance art at Cannes]

[3D Indoor mapping]

[James Bond drones]

[Agile drones]

# Hydro-dam Infrastructure Inspection

Inspection of Carters Dam, Chatsworth, GA – typical of mid 20th Century Flood Control Embankment Dam


**Specs:**
- **445 ft high**
- **2053 ft long**
- **Penstock (4)**
  - **18 ft. diameter**
  - **835 ft long**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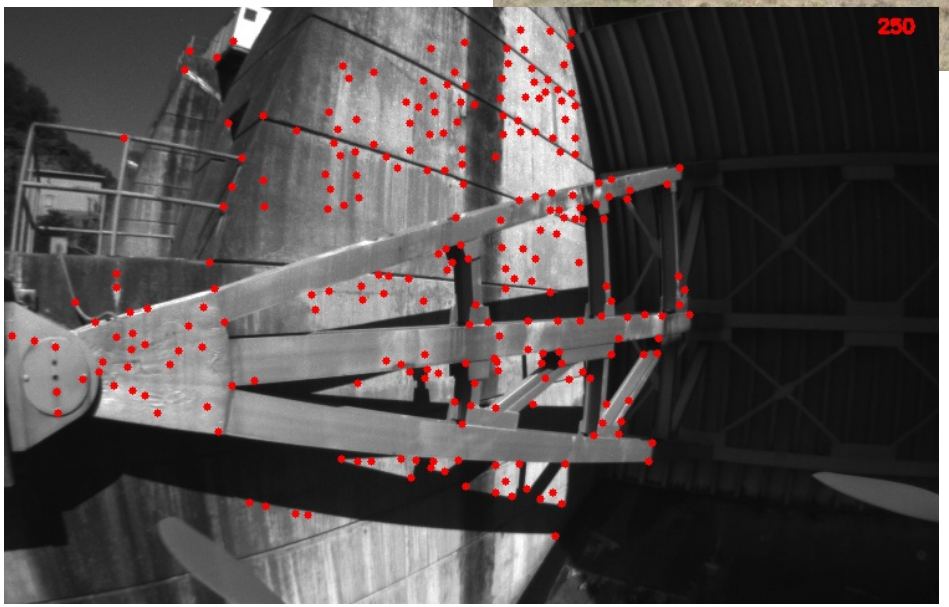
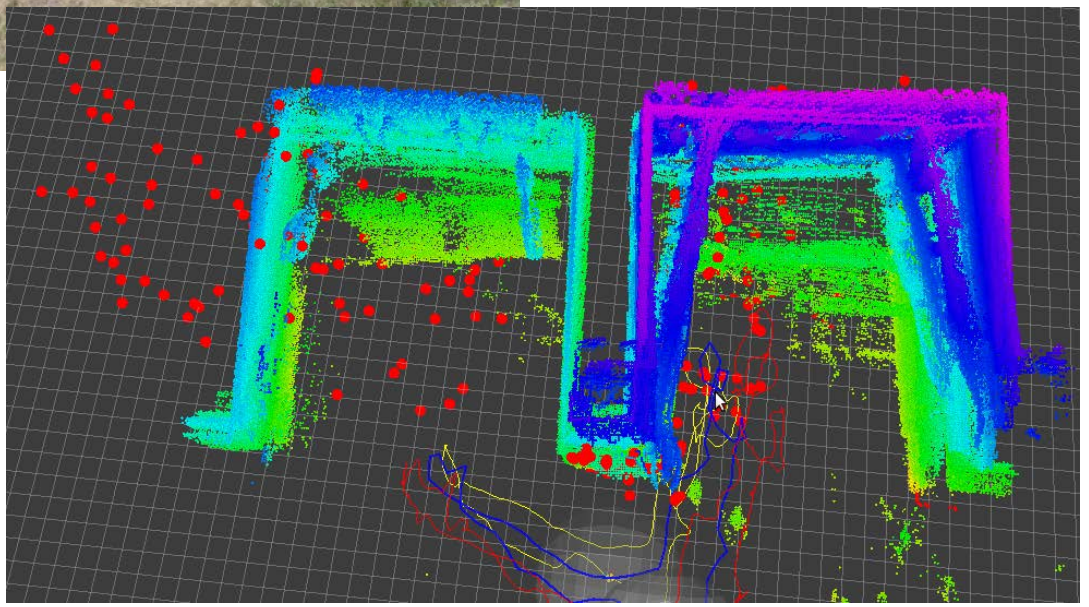
[Quadrotor surveying penstock at Carters Dam]

# Hydro-dam Infrastructure Inspection (exterior inspection of spillway gates)

Cameras ID features which are then used to build a 3D map in conjunction with Laser scanners

Research objective is to have robot autonomously fly the inspection mission

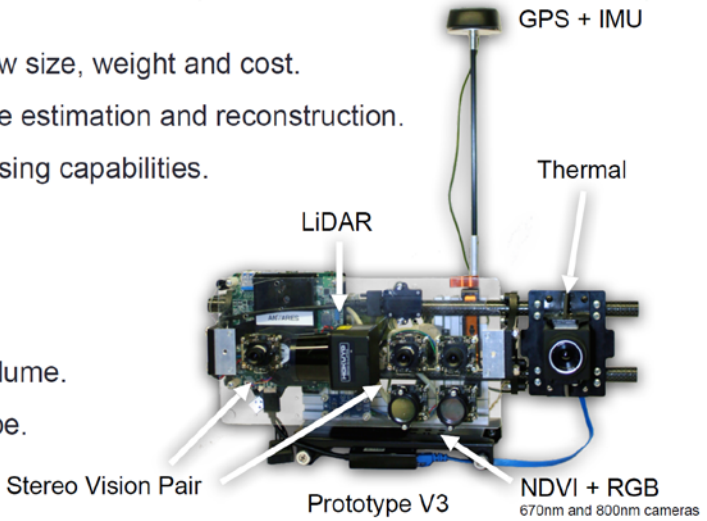


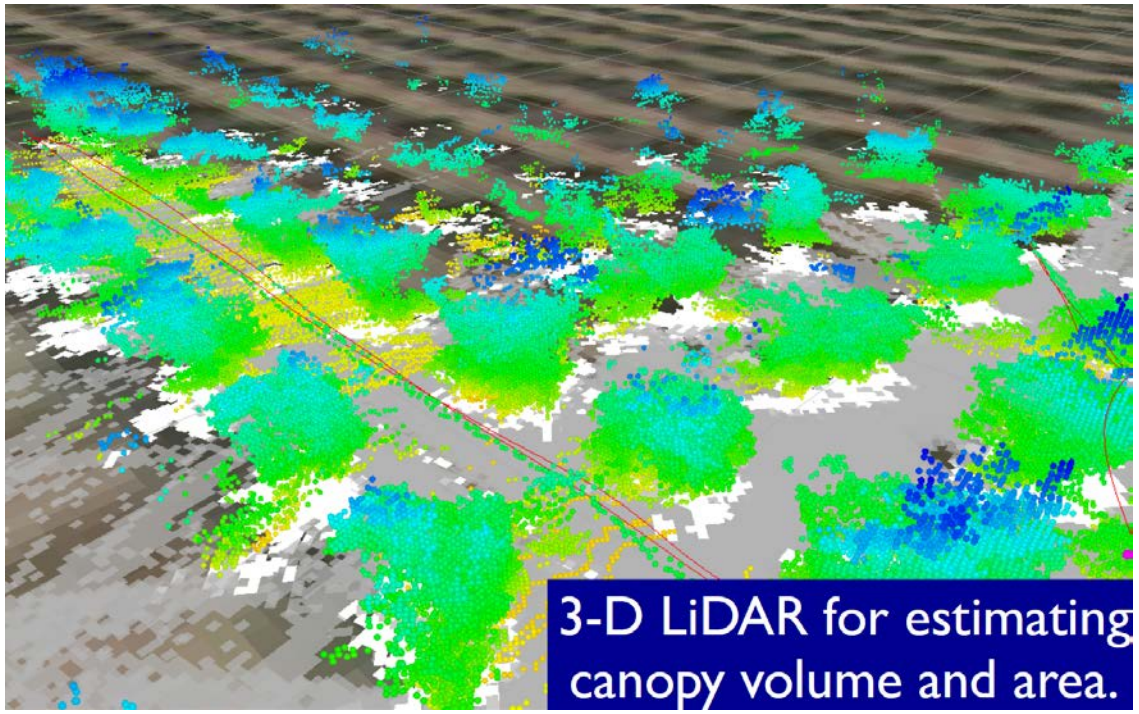



# Smart Agriculture

Sensor module can be carried by a commercial drone

- **Design:**
  - Optimized for low size, weight and cost.
  - Sensors for state estimation and reconstruction.
  - Multi-modal sensing capabilities.
- **Specifications:**
  - 1.5kg mass.
  - Under 0.2m$^3$ volume.
  - $20k to prototype.





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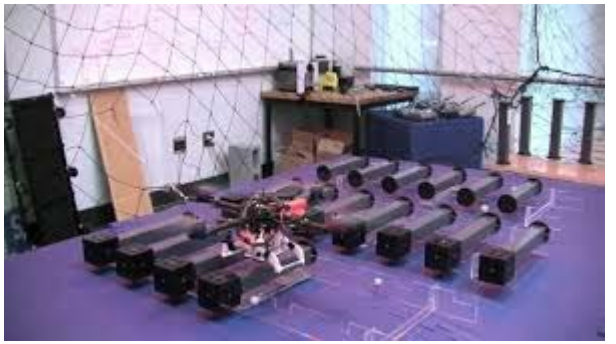
[Smart Agriculture using drones]

# Construction Aids




[Modular construction using drones]

# Drone Technology for Education and Recreation

Pico-drones for rescue and educational applications


Drones controlled via smartphone

[Smartphone control of a drone (at CES)]

["Pico" scale drones]

# Research Sponsors/Partners

Army Corps of Engineers/Bureau of Reclamation
Army Research Lab (ARL)
Defense Advanced Research Projects Agency (DARPA)
Lockheed Martin
Navy Research Lab (NRL)
National Science Foundation (NSF)
Qualcomm

More information can be found at: http://kumar.grasp.upenn.edu/

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