Underwater Robot Swarms and the Challenges for UW Communication

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The Age Old Problem in Sampling the Ocean:

• The Ocean is a dynamic environment in both space and time. How can we sample it?

• Walter Munk: “The 20th century will go down as the century in which we under-sampled the ocean”

Our Solution: A Swarm of Underwater Robots
Autonomous Underwater Explorer: AUE

1.5 liter
Temperature, pressure, acoustic sensors
2 modes of buoyancy control
Deployments up to week
Deployment Oct. 2, 2013:
16 AUEs
5 GPS moored surface pingers
Aue Tracks
AUE data

Temperature Anomaly

Crest

Trough
A few curves to keep in mind

Hardware:
Computer processing and mechanical components

Software:
Cost of computer and mechanical hardware

Environment:
Absorption and Spreading
Selection of Habitat

Benthic Habitats

Pelagic
Examples of the need for UW comms. and the importance for adaptive sampling

- Navigation and concurrent estimation of sampling for a variety of studies
  - Bottom mapping (esp. structure from motion)
  - Acoustic localization (for longer wavelengths)
  - Spatial sampling for toxic algal blooms (for tracking and prediction) to follow gradients (spatial structure is important!!)

- Knowledge of sensor recordings for swarm sensing
  - Optical (microscopes, laser LIDAR systems)
  - Acoustical (passive systems)
  - Chemical (toxic chemical sensors)
The lure of *in situ* classification

- **Advanced data product:**
  Neural net architecture can be run on in situ system. Resultant data can then be simply genera and easily stored or shared via satellite.
We now have 800 million images
next step....

Convolutional Neural Net Architecture
92% success rate in classifying certain species: Eric Orenstein (Jaffe Lab)
Human/Robot ↔ Human/Robot
Underwater Communication via AR/VR

- Expert on sub or ship to diver or robot on site for inspection/repair
- Robot to human communication for remote inspection

Jaffe Lab new 2-Pi Cam
18 Raspberry Pis: 10k x 6k image