NRI: INT: Hybrid Aerial/Underwater RobotiC System (HAUCS) for Scalable, Adaptable Maintenance of Aquaculture Fish Farms: Year 3 Development

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Motivation

An alarming number: $14 billion/yr. – US trade deficit in seafood.

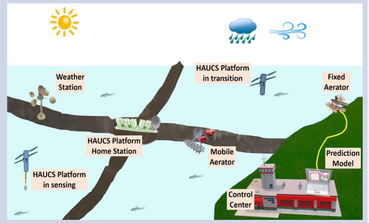
A dilemma: Limited robotics adoption in the fish farm industry suffers from laborious, time-consuming operations and **labor shortage**.

A Key Bottleneck: Effective monitoring of Dissolved Oxygen (DO) in fishponds.

- Traditional approach is slow and labor-intensive and the state-of-the-arts are costly/inaccurate and difficult to maintain

Hybrid Aerial/Underwater RobotiC System (HAUCS):

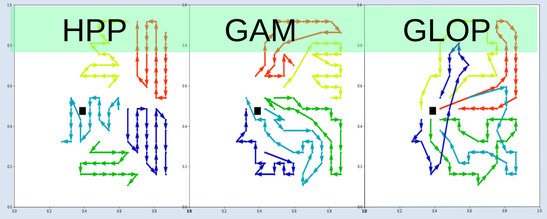
- Converts aquaculture farm to an "Internet of Aquaculture."
- Autonomous Unmanned Platform (AUP) integrated with underwater sensors + land-based infrastructures and machine learning (ML) DO prediction model.



Algorithms Development

Path Planning (T. Davis, S. Mukherjee)

- Developed HAUCS Path Planning Algorithm (HPP) - A two-step heuristic to produce efficient routes for farm monitoring.
- Compared HPP against two Vehicle Routing Problem solutions: Graph Attention Model (GAM) and Google Linear Optimization Package (GLOP).
- HPP outperforms in efficiency and run time for instances larger than 200 ponds.



Pond Farm Phone App (R. Pugh)

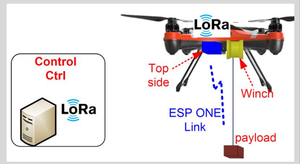
- **First-of-a-kind** phone app for pond farm operations.
- Act as the information center for pond and environmental data, and status of farm equipment.
  - Extracting the pond condition from AWS forecasted by the prediction model.

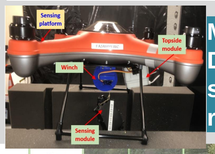
Platform/Infrastructure Development

Field Deployment (L. Lopes)

- **First-of-the-kind** mobile DO sensing robotic system for pond farms.
  - Drone moves into place based on routing from HPP;
  - GPS position activates a winch to lower payload into water to gather data;

  Data is transferred to topside using the ESP-NOW link, then to base station using the LoRA link.
- **Demonstrated on our collaborative Fish farms**



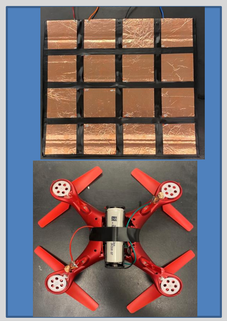


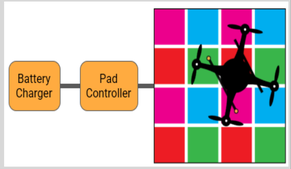
Mobile DO sensing robot

Deployment at Flowers Farm

Wireless Charging (W. Fairman)

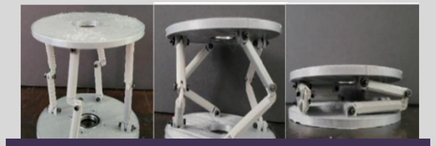
- Extend the range of HAUCS AUPs;
- Critical for fully automated sensing;
- A novel design that is much simpler than the existing designs;
- Adaptive wireless drone charging;
  - Employs a chessboard-style contact
  - A controller determines which 'color' pads are in contact with the battery.
  - Then routes +/- wires of the charger to the contacted pads and initiating charge.





Kresling-kirigami-Inspired Robotic ExtensioN (KIREN) (C. Den Ouden)

- Current payload extension for DO sensing does not require precise motion control
- KIREN will support sophisticated operations requires high stability, i.e., underwater cameras.
- Actuated by a micro-gear system, KIREN has a fold-flat design that can expand multiple times of the collapsed height.



Initial lab prototype supports 4x expansion

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