NRI: INT: Hybrid Aerial/Underwater RobotiC System (HAUCS) for Scalable, Adaptable Maintenance of Aquaculture Fish Farms: Year 2 Development

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Motivation

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

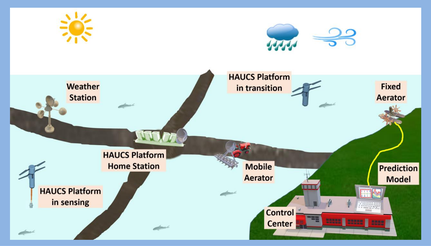
One dilemma: Limited robotics adoption in laborious and time-consuming fish farming.

One Key Bottleneck: Effective monitoring of Dissolved Oxygen (DO) in the fish ponds.

- Traditional approach is slow and labor-intensive and State-of-the-arts are costly/inaccurate.

Hybrid Aerial/Underwater RobotiC System (HAUCS):

- Transforms fish farms to "*Internet of Aquaculture*."
- Autonomous Unmanned Platform (AUP), *integrated with underwater sensors +* land-based infrastructures and machine learning DO prediction model.

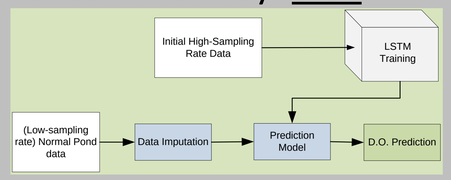


Algorithms Development

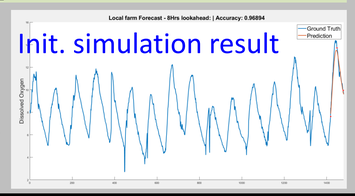
DO Prediction Model

- Goal: Improving prediction for longer window (i.e. 8-hr-look-ahead).
- Exploring hybrid sensing/prediction
  - "seeding" – training model with high sample rate data.
  - Imputing normal operation data (low sampling rate) for prediction.
- Simulation using data from Aqua Blue farm: 8hr-look-ahead accuracy: 0.96

Architecture to support hybrid sensing and prediction

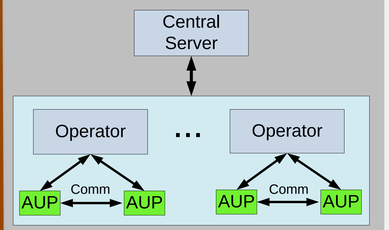


Data collection instrument a t Aqua Blue Farm

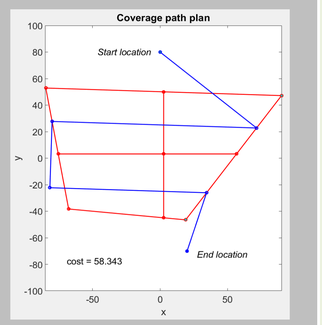


Path Planning

- Developed the baseline algorithm based on a hybrid control system.
  - Generating optimal path plan for the AUP using the rotating calipers algorithm.
  - Adopting Artificial Potential Functions (APF) based collision avoidance.
- Developed a Matlab-based simulator.



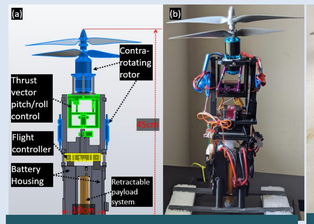
Hybrid Control Architecture



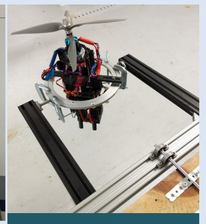
Sample path plan over four ponds

AUP Development

- Developed platform test facilities in the lab
  - 6DOF test stand.
  - Integrated RealFlight + Ardupilot Simulator.
- Exploring coaxial drone-based design.
  - Built a thrust-vectoring based prototype.
  - Test flight the drone in the field.



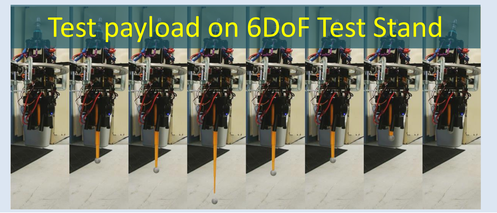
Coaxial drone protype under development



Six-DoF test stand

Integrated RealFlight + Ardupilot Simulator

Drone test in the field



Test payload on 6DoF Test Stand

Impacts and Challenges

- Continue to engage the fish farming industry: Expanded collaboration to two farms: Aqua Blue (FL), Flowers (MO).
- Improving STEM education: 11 undergraduate/graduate students contribute to HAUCS project (4 minority and 3 female students).
  - Three students continued to the IEEE IoT journal publication.
- Engaging the general public: Co-PI Wills discussed HAUCS project in his HBOI Ocean Science Seminar presentation.
- Products: One journal paper accepted by the IEEE IoT Journal. Two conference presentations. Two conference papers were accepted.
- Challenges: COVID-19 impacted the project substantially. Our collaborating farm- Logan Hollow was shut down. Lab works was impacted, especially in Spring/Summer 2020. Hiring was delayed. **But we are coming back strong!**

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