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

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

One dilemma: Aquaculture farming is labor intensive and time-consuming; Fish farms have seen limited robotics development…

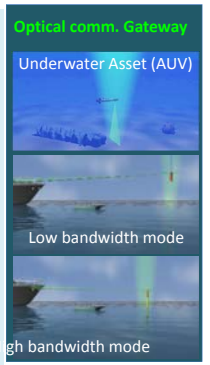
One Key Bottleneck: Effective monitoring of Dissolved Oxygen (DO) in the fish ponds.

- Traditional approach is slow and labor-intensive.
- State-of-the-arts (float mounted sensors) are costly and inaccurate.

Coastal zone environmental monitoring (i.e., *Harmful Algae Bloom*): Complementary to other in-situ sensors: boat/AUV based or stationary;

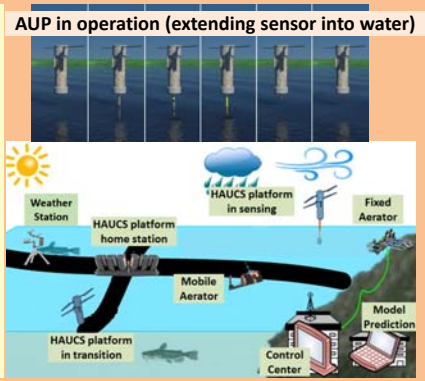
Optical comm. gateway with underwater assets using USV+HAUCS: energy-efficient, long-endurance, extended-coverage range;

Offshore aquaculture environmental monitoring: Extending HAUCS to a more challenging environment.



Hybrid Aerial/Underwater RobotiC System (**HAUCS**):

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



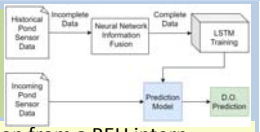
Work done (From Summer 2019 -)

Initial Farm Deployment

- At Logan Hollow farm (Gorham, IL)
- Objectives:
  - ✓ Test LoRa comm.;
  - ✓ Acquire data for prediction model;
  - ✓ **Improving acceptance of Robotic Tech. on the fish farm.**

ML DO Prediction Model

Hybrid NN-LSTM DO prediction model



- Contribution from a REU intern;
- Robust against incomplete data;
- Exciting initial results:
  - ✓ Average accuracy (4-hr look-ahead): **92%** with worst pond at **78%**.
- ✓ Improves farm acceptance

AUP Development

Thrust vectoring Coaxial Drone Design

- Evaluated different platform options;
- Adopting coaxial-drone as the foundation to develop AUP;
- Working on initial prototype

Products: An IEEE IoT Journal paper (invited for revision); A US Patent Application

- Improving the penetration of robotic technology in fish farming industry
  - Deploying intermediate *low-cost* solutions: Logan Hollow Fish Farm **requested a second sensor unit** after experienced the success of the first unit!
  - Establishing a pilot HAUCS aquaculture test site at HBOI/FAU;

- Improving undergraduate STEM education:
  - **Two** NSF REU interns and **three** HBOI summer interns contributed to the project;
  - **Two** interns (one female and one minority) contributed to an IEEE IoT Journal paper (invited for revision);

Mitigating biofouling: Avoiding maintaining sensors in bio-productive water.

More accurate monitoring of pond spatial/temporal variations: Capable of sampling multiple pond locations/depths.

Cost Reduction: ~5x reduction of labor and equipment cost.

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