Intelligent Resource Efficient Pond Aquaculture (IREPA): Cyber-Physical System to Improve the Fish Farms Productivity in the U.S.

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Challenges:

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

A dilemma: Limited advanced technology in aquaculture while the industry suffers from a **labor shortage**.

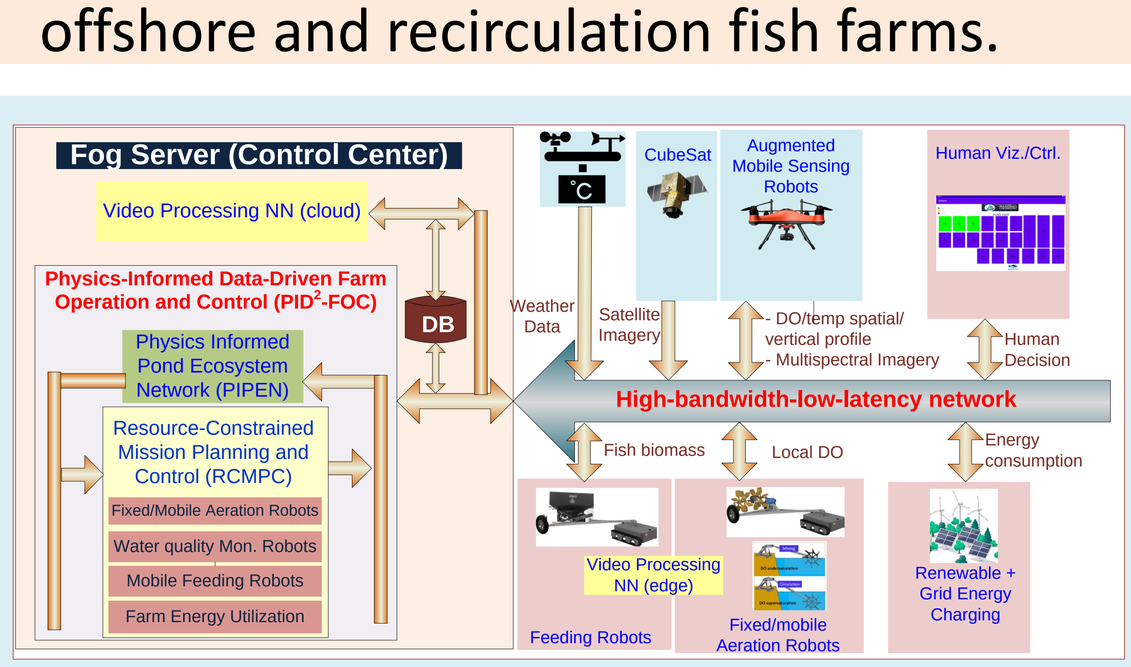
A Key Bottleneck: Current water quality management practice is "reactionary" and inefficient.

Scientific Impact:

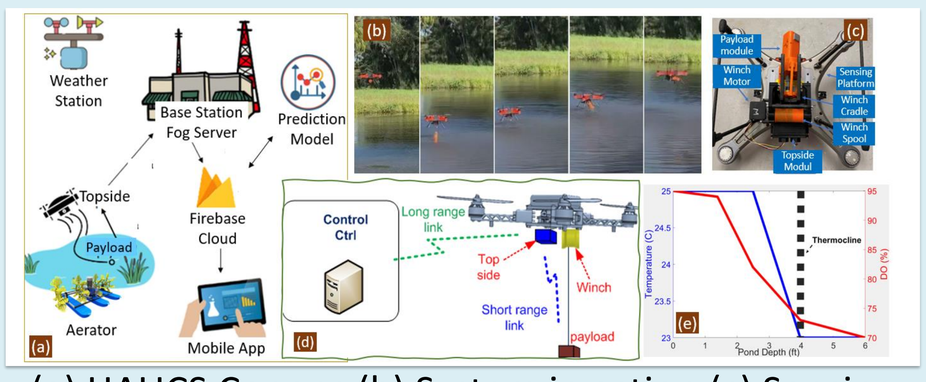
- **Coastal zone environmental monitoring:** Effective integration of remote sensing and in-situ sensors: HAUCS, Autonomous Underwater Vehicle-based or stationary sensors, and cubeSat.
- **Unified CPS solution for diverse aquaculture settings:** Extending IREPA to offshore and recirculation fish farms.

Solution:

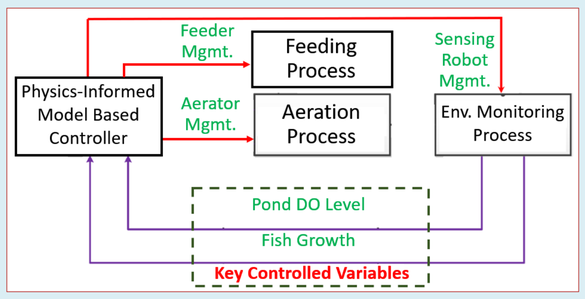
- Leveraging Hybrid Aerial Underwater RobotiC System (**HAUCS**) project funded by NIFA via NRI 2.0 - Developing robotic DO monitoring systems for pond farms.
- **IREPA**: A proactive feedforward CPS framework:
  - Physics-Informed Data-Driven Farm Operation and Control (PID^2-FOC) to support complex and diverse conditions on the fish farms.
  - Heterogeneous robotic systems to relieve the labor intensity of key operations on a pond fish farm.
  - High-bandwidth-low-latency network to accommodate farms with complex aquatic and terrestrial conditions.



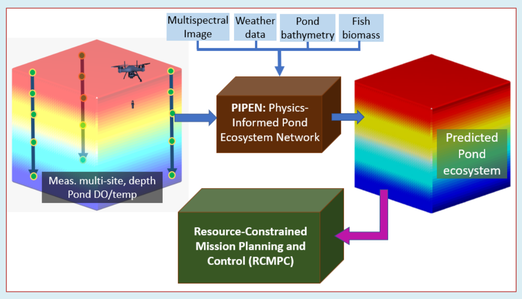
The proposed IREPA framework



(a) HAUCS Conops (b) System in action (c) Sensing Platform Configuration (d) Data flows (e) Sensor data captured pond DO stratification.

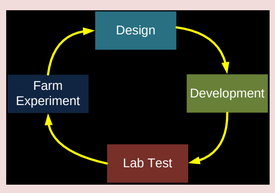


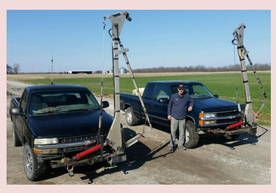
Feedforward control of pond aquaculture farm through IREPA

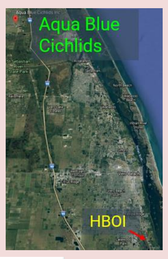


physics-informed data-driven farm operation and control

- Address two essential issues in aquaculture: **labor shortage** and **high operational cost**.
- Engage with fish farmers
  - Logan Hollow Fish Farm (IL) will be integrated in development process.







- Developing the next-generation aquaculture workforce.
  - Developing Logan Hollow into an advanced technology demonstration site.
- Increasing participation of under-represented students
  - Leveraging the robust programs to support under-represented minorities (URMs) at FAU and SIU – FAU is a Hispanic Serving Institute.

	Traditional	State of the Art	HAUCS	IREPA
Water Quality Monitoring	Manual	Pond Buoy + Data Drive ML Model	Mobile Robotic Sensing + Data Drive ML Model	Enhanced Mobile Robotic Sensing+ Physics-Informed ML Model
Aeration	Manual	Automated Fixed aerator	Prediction-informed manual operation	Automated Fixed Aerator + Swarm Robotic Mobile Aerators
Feeding	Manual	Fixed Feeding Station + Biomass Tracking	Manual	Robotic Mobile Feeding System + Biomass Tracking
Harvesting and Fish Selection	Manual	Prediction-informed manual operation (*circulation tank)	Manual	Prediction-informed manual operation

Award: USDA 2024-67022-41580

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