Treat wastewater + Produce biofuel

Cyber-Physical Sensing and Informatics for Smart Biomass Production

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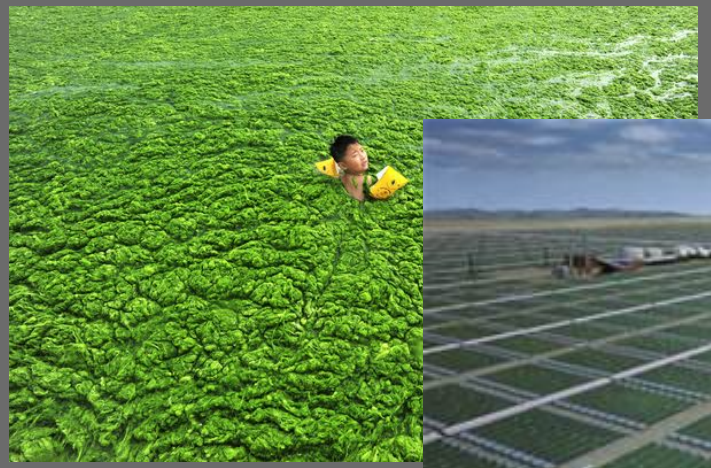
Cyber-Physical Sensing and Informatics for Smart Biomass Production

Motivation

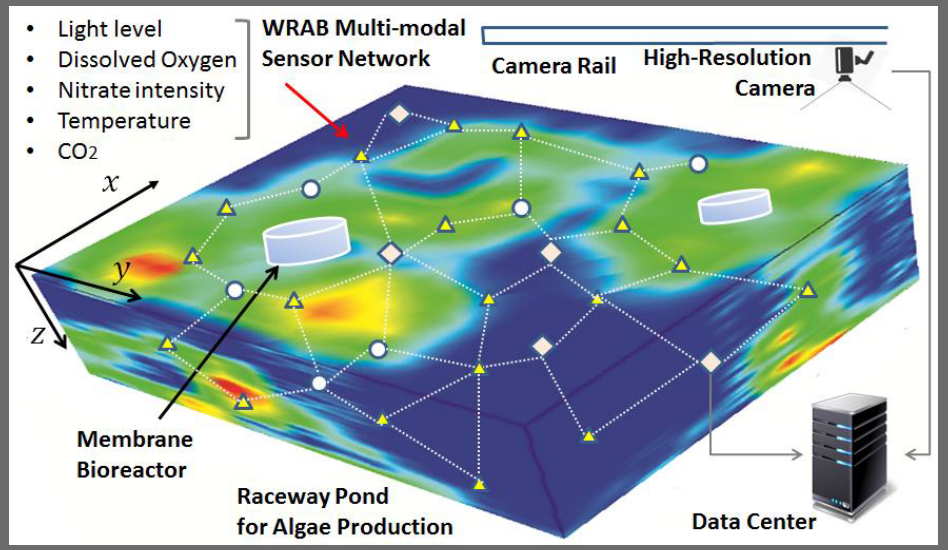
Treat wastewater + Produce biofuel!!



- Algae grows fast in **wastewater** and can remove the nutrients, which are harmful to the environment.
- Algae has been identified by DoD as an **important source for biofuel**.
- Bottleneck is **low algae growth rate** and production efficiency.

Our Solution

- Design **membrane bioreactor** to concentrate algae for faster high-density algae cultivation.
- Use **CPS sensing, signal processing, modeling, and control** to optimize the cultivation process and improve production efficiency.



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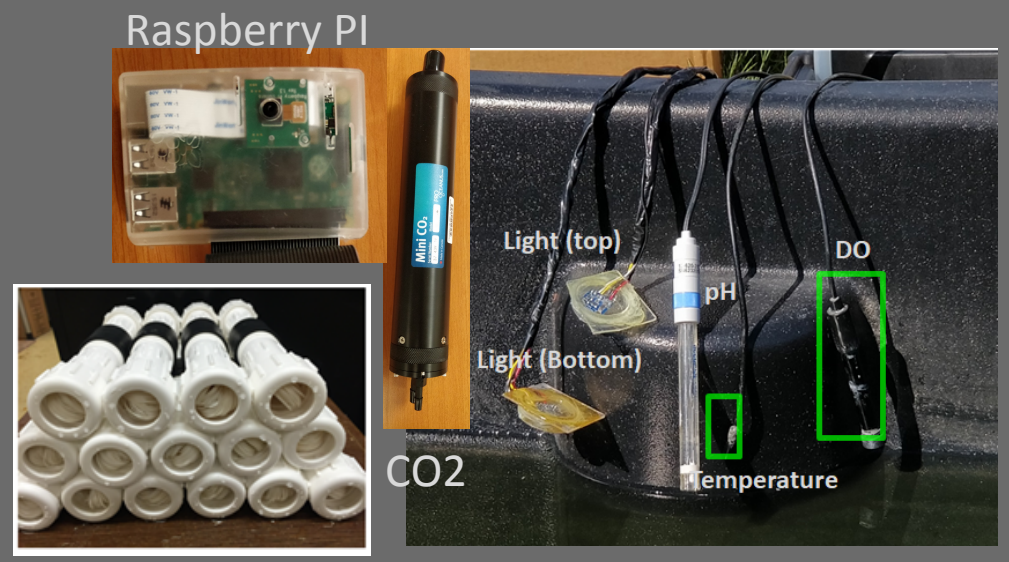
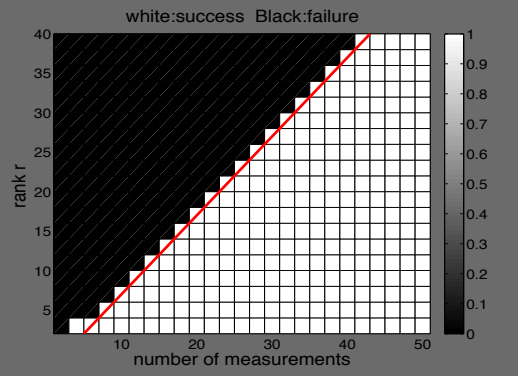
Sensing

- Developed sensor network systems with light level, temperature, dissolved oxygen, pH level, CO_2 sensors, programmed on the Raspberry PI platform.
- Fabricated membrane bioreactor with anti-fouling and self-cleaning capabilities.

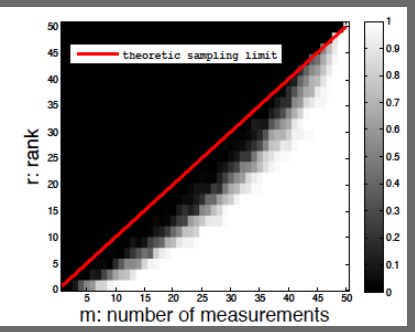


Signal Processing

- **Goal:** Estimate the spatial correlation function of measurements over a **dense** grid of points using physical measurements from a **few** sensors.
- Developed **Generalized Nested Sampling (GNS)** based sensor placement rule assuming a spatially stationary correlation model **(Toeplitz Covariance Matrix) [Qiao & Pal, IEEE Transactions on Signal**
- **Processing, 2017]**
- **GNS** enables reconstruction of correlation values at **N points**, using onlly **O(√N) measurements. [Optimal Compression]**



GNS



Random

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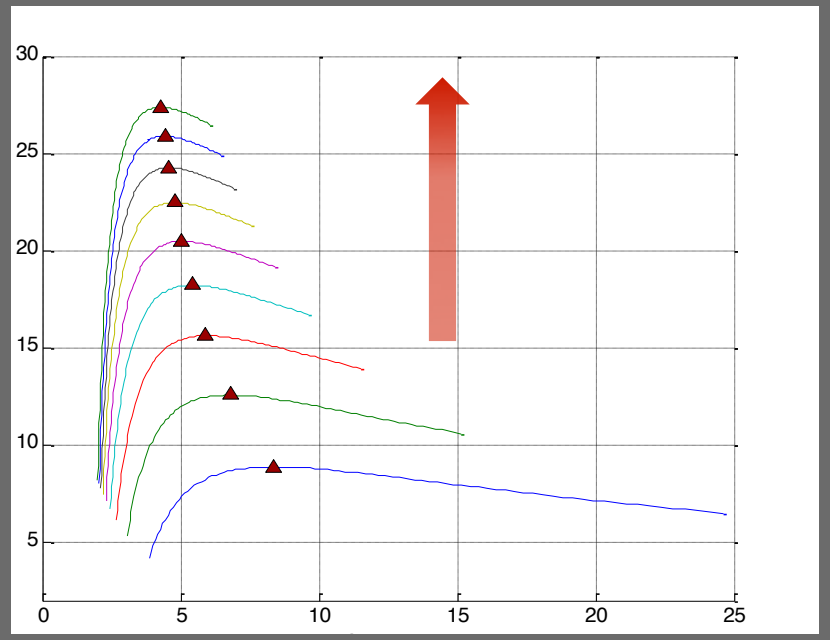
Model and Control

- Developed data-driven algae growth models to predict algae growth rate from the dynamic cultivation environment variables.
- Improved the algae cultivation efficiency and productivity by 40% by optimizing the SRT/HRT (algae density control) based models.



Prediction of maximum productivity under outdoor environment with different sunlight intensity

Field Deployment

- Deployed in the Rocky Fork Waste Water Treatment Plant, Missouri.
- Aim to achieve another 20-30% improvement using CO2 bubbling control in the field environment.
- Combine with GNS for more efficient sensing via judicious sensor placement.