Cyber-Physical Sensing, Modeling, and Control for Large-Scale Wastewater Reuseand Algal Biofuel Production Poster.pdf

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Rapid industrialization and increased pollution impose severe threats to the availability and quality of water resources worldwide. Currently, many wastewater treatment plants are discharging treated wastewater containing significant amounts of nutrients, such as nitrogen, ammonium, and phosphate ions, directly into the water system, posing significant threats to the environment. Finding a solution for effective treatment and safe discharge of wastewater has become an urgent and challenging task. Another grand challenge is non-fossil green energy sources which lie at the intersection of some of our nation's most pressing issues: environment, energy security, and sustainable economic development. Large-scale algal cultivation and production has been recognized by the U.S. National Academy of Science and Department of Energy as one of the most promising and attractive solutions for simultaneous wastewater treatment and biofuel production. The critical bottleneck is low algae productivity and high biofuel production cost.

In our previous work, the research team has successfully developed an algae membrane bioreactor (A-MBR) technology for high-density algae production which doubles the productivity in an indoor bench-scale environment. In this project, we aim to explore advanced cyber-physical sensing, modeling, control, and optimization methods and co-design of the A-MBR system to bring the new algae production technology into the field. Our goal is to increase the algal biomass productivity in current practice (<20 g/m2/day) by three times to >60 g/m2/day in the field environment while minimizing land, capital, and operating costs. Specifically, we will (1) adapt the A-MBR design to address unique new challenges for algae cultivation in field environments; (2) develop a multi-modality sensor network for real-time in-situ monitoring of key environmental variables for algae growth and investigate advanced sparse sampling, optimal sensor node tasking, and scheduling methods to minimize network resource consumption and system complexity; (3) develop data-driven knowledge-based kinetic models for algae growth and automated methods for model calibration and verification using the real-time sensor network data; (4) deploy the proposed CPS system and technologies in the field for performance evaluations and demonstrate its potentials.

This project will demonstrate a new pathway toward green and sustainable algae cultivation and biofuel production using wastewater, addressing two important challenging issues faced by our nation and the world: wastewater treatment and renewable energy.

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