United States Department of Agriculture
Project Initiation

Project Data for Accession Number 1033162

Project Title

CPS: Medium: Controlled Wastewater-Hydroponic Systems for Enhanced Nutrient and Water Efficiency Using Real-Time Sensing and Data-Driven Technologies

Project Details

Sponsoring Institution National Institute of Food and Agriculture	**Project Status** ACTIVE
Funding Source NIFA Non Formula	**Grant Year** 2024
Grant No. 2024-67021-43862	**Cumulative Award Amt.** $875,000.00
Proposal No. 2024-07224	**Multistate No.** (N/A)
Project Start Date Sep 01, 2024	**Project End Date** Aug 31, 2027
Program Code [A7302] Cyber-Physical Systems	

Project Director

Tong, Z.

Recipient Organization

GEORGIA TECH RESEARCH CORP

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Performing Department

(N/A)

Non Technical Summary

We're leveraging the latest innovations in sensors, wastewater treatment, hydroponic systems, and machine learning to develop a new decentralized system that integrates wastewater treatment with hydroponic farming. This system aims to produce vegetables efficiently, using minimal resources and energy, by implementing advanced methods for real-time data collection and system control.Local and decentralized controlled environment agriculture (CEA) can address issues related to water and nutrient shortages, enhancing food security and environmental management. However, current CEAs often struggle with limited data collection, unreliable control systems, and high costs. Our project seeks to overcome these challenges by equipping future CEA facilities with reliable sensing, understanding, and decision-making capabilities, moving towards greater automation.This research is supported by two established experimental setups: a pilot CEA system at Georgia Tech and a hydroponic greenhouse at the University of Georgia.

These setups feature innovative data-gathering devices, such as online membrane sensors and robotic systems for plant monitoring, along with cutting-edge reinforcement learning algorithms for optimizing complex, changing environments.

Animal Health Component

Animal Health Component: 0%

Research Effort Categories

Basic	30%
Applied	60%
Developmental	10%

Classification

Knowledge Area (KA)	Subject of Investigation (SOI)	Field of Science (FOS)	Percent
102	0210	2020	100%

Knowledge Area

[102] Soil, Plant, Water, Nutrient Relationships

Subject Of Investigation

[0210] Water resources

Field Of Science

[2020] Engineering

Keywords

controlled wastewater-hydroponic system, data-driven, nutrient and water efficien, real-time sensing

Goals / Objectives

The project aims to design a new decentralized wastewater-hydroponic system (WWHS) to achieve stable and high vegetable production with minimized resource and energy consumption through the development of novel online data acquisition and system control and optimization methodologies.The project is organized into three thrusts.In Thrust 1, we will focus on wastewater system sensing, modeling, and simulation using our triboelectric (nano-)generator (TENG) adsorption membrane sensor for heavy metal removal and detection (Tong, Chen, Lan).In Thrust 2, we will focus on hydroponic plant system sensing, modeling, and simulation utilizing robotic phenotyping and TENG-waterdrop sensor data for nutrient monitoring (Tong, Chen, Ferrarezi).In Thrust 3, we will develop an integrated system model by combining two hybrid models from previous thrusts and encompassing all physical components and utilities. An RL algorithm developed by Co-PI Lan will enable the control and optimization of system operations considering physical constraints and uncertainty (Lan, Tong).In the end, we will conduct evaluation and validation for both cyber and physical systems.

Project Methods

Thrust 1: Wastewater system sensing, modeling, and simulation.Subtask 1.1: Experimental data acquisition for triboelectric membrane sensor adsorption systemSubtask 1.2: Machine-learning-based heavy metal detection using TENG sensor membraneSubtask 1.3: Hybrid modeling of the adsorptive membrane systemThrust 2: Hydroponic vegetable growing system sensing, modeling, and simulation.Subtask 2.1: Experimental data acquisition and quantification for hydroponic lettuce growing systemSubtask 2.2: Machine-learning-based nutrient monitoring using waterdrop TENGSubtask 2.3: Hybrid modeling of lettuce growing processThrust 3: Reinforcement learning-based membrane sequencing and nutrient control.Subtask 3.1: Process integration in a reinforcement learning frameworkSubtask 3.2: Reinforcement learning algorithm development in continuous state and action spaceSubtask 3.3: Policy training for optimized nutrient, economic, and environmental performance