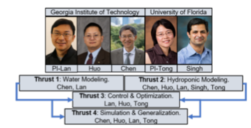
CPS: Medium: Collaborative Research: Robust and Intelligent Optimization of Controlled-environment Agriculture System for Food Productivity and Nutritional Security

PIs: Guanghui Lan (Georgia Tech), Zhaohui Tong (University of Florida)
Co-PIs: Yongsheng Chen (Georgia Tech), Xiaoming Huo (Georgia Tech), Aditya Singh (University of Florida)

Objective: design new optimized controlled-environment agriculture (CEA) systems that can achieve high vegetable productivity in urban areas with low operating cost.

Focus areas: control and data analytics



Challenges:

- Food production in the CEAs must warrant the high cost of land in urban areas
- Highly challenging to control and optimize this complex system of subsystems
- Prediction of vegetable phenotype, yield and nutrient compositions during different growth periods

Solutions:

- Novel control algorithms to optimize the operations of CEA
- Integrated data-driven and model-based prediction for plant growth

Scientific Impact:

- The development of policy mirror descent method integrating policy optimization and online learning
- Employing Bayesian optimization to find optimal design based on machine learning models

New algorithms for reinforcement leaning

- Total sample complexity under a simulator:

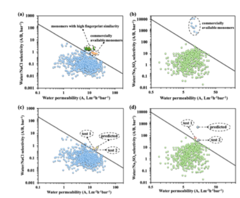
Problem	New bounds	Existing bounds
$\mu > 0$	$\tilde{\mathcal{O}}(\frac{\|\mathcal{S}\|\|\mathcal{A}\|}{\mu\epsilon})$	$\tilde{\mathcal{O}}(\frac{\|\mathcal{S}\|\|\mathcal{A}\|^2}{\epsilon^3})$
$\mu = 0$	$\tilde{\mathcal{O}}(\frac{\|\mathcal{S}\|\|\mathcal{A}\|}{\epsilon^2})$	$\tilde{\mathcal{O}}(\frac{\|\mathcal{S}\|\|\mathcal{A}\|^2}{\epsilon^4})$

- Total sample complexity in situ:

Problem	New bounds	Existing bounds
$\mu > 0$	$\tilde{\mathcal{O}}(\frac{\sigma_F^2}{\mu\lambda_{\min}^2\epsilon})$	N/A
$\mu = 0$	$\tilde{\mathcal{O}}(\frac{\sigma_F^2}{\lambda_{\min}^2\epsilon^2})$	$\tilde{\tilde{\mathcal{O}}}(\frac{1}{\epsilon^3})$

Practical implications: reduce by orders of magnitude the simulation runs or the amount of data to collect.

Machine learning guided breakthrough for membrane design



Broader Impact on Society:

- CEAs will benefit environment control and food security
- The availability of low-cost vegetables and fruits will promote healthy diet

Broader Impact on Education and Outreach:

- Train new generations of scientists and engineers, especially for those under-represented, with interdisciplinary skills

Quantification of Potential Impact:

- 200% reduction in operating cost via value-added product sales
- Achieving 62% reduction in net CO2 emissions vs. conventional wastewater treatment

2021 NSF Cyber-Physical Systems Principal Investigators' Meeting
June 2-4, 2021

Award ID#: NIFA 2020-67021-31526