CPS: Frontier: Collaborative Research: COALESCE: COntext Aware LEarning for Sustainable CybEragricultural systems

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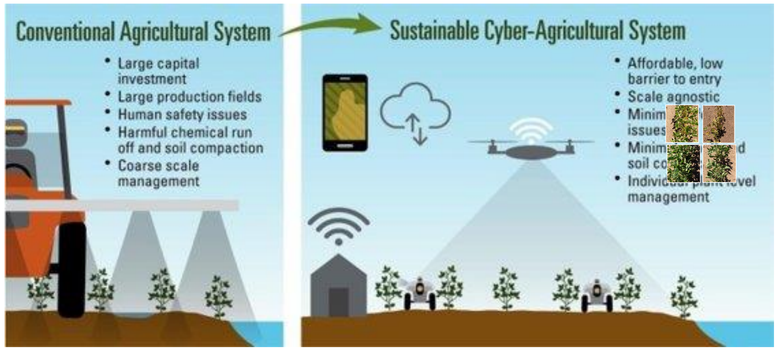
Introduction

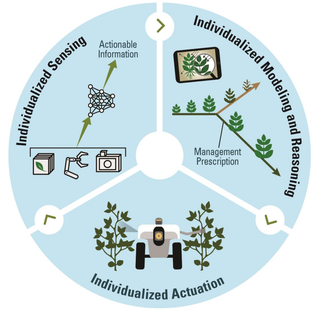
The COALESCE project seeks to transform CPS capabilities in agriculture by developing a novel, context-aware cyber-agricultural system that encompasses sensing, modeling, and actuation to enable farmers to respond to crop stressors with lower cost, greater agility, and significantly lower environmental impact than current practices.

Objectives

- Embed biophysics in machine learning for individualized crop modeling
- To apply multi-modal information fusion and robust learning for Individualized sensing
- To implement data-driven, multi-scale planning and reasoning
- To develop individualized sensing and actuation via autonomous robots with dexterous manipulators



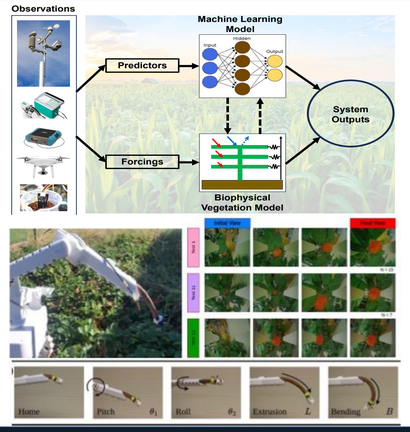
Scientific Impact



- Biological digital twin algorithms
- Efficient decision-making algorithms
- Scalable cyberinfrastructure frameworks
- Soft and dexterous robotic manipulators
- Multi-agent mobile robotics 'in the wild'

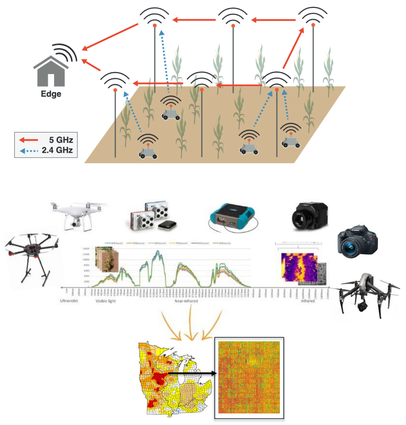
Technical Approach

- Extraction and fusion of cross-modal features for robust perception
- Incorporate biophysical constraints in ML models
- Reinforcement learning for supervisory decision support
- Learning-based control for actuators

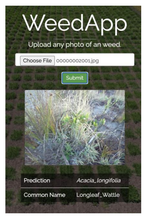


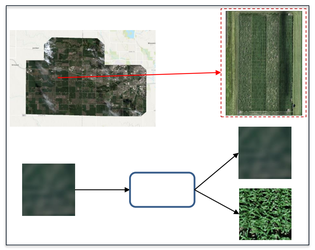
Solution – Year 3

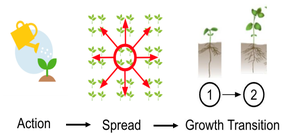
- Farmernetes: Enhanced sensing, communication, and network
- Enhanced autonomy for ground robots in harsh environments
- Individualized actuation using dexterous robots
- Modeling for climate resilient Agriculture
- Data-efficient deep learning algorithms



- Weed Classifier for 1000+ species (mobile app, on-robot)
- Satellite to UAV multimodal generative model
- Ag-Gym environment for designing policies for biotic stress mitigation







Broader Impact

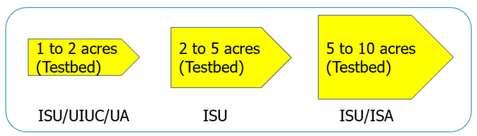
- CPS innovations transferable for diverse applications
- Knowledge dissemination – Cyber-Physical Systems community, farmers, public
- Formal and informal education efforts for next-generation workforce and farming community
- Technology commercialization

Education & Outreach

- Lead PI Sarkar leading the Undergraduate minor on Cyber-Physical Systems at Iowa State that started in Fall 2021
- CPS adoption for farmers through the ISU and ISA extension and outreach network.
- Community building via MLCAS, AIAFS workshops
- Multi-institutional effort to involve women, African American, Hispanic, and Native American students in computing and engineering

Impact Quantification (Goals)

- Reduction in chemical application by at least 30%
- Increase in crop yield by at least 10%
- Reduction in soil compaction by at least 30%



2024 NSF Cyber-Physical Systems Principal Investigators' Meeting

Project website: https://coalesce.me.iastate.edu

Award ID#: 1954556