Future of Cyber-Physical Systems

Challenges and Opportunities

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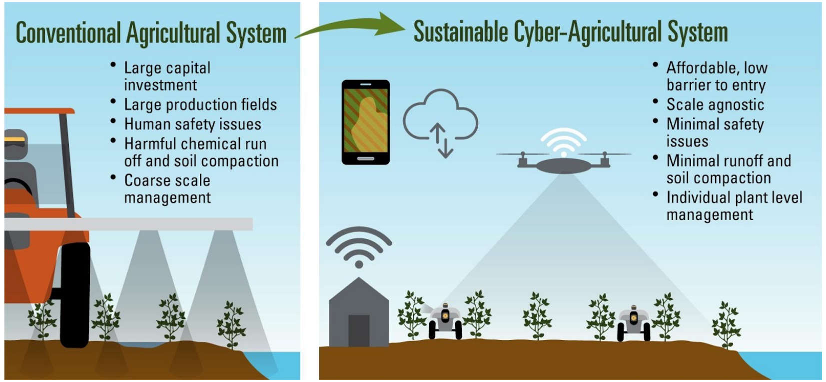
My current CPS research focus

CPS: Frontier: Collaborative Research:

COALESCE: COntext Aware LEarning for

Sustainable CybEr-Agricultural Systems

Disrupt the current agricultural practices with CPS innovations to enhance efficiency, resiliency, sustainability and autonomy



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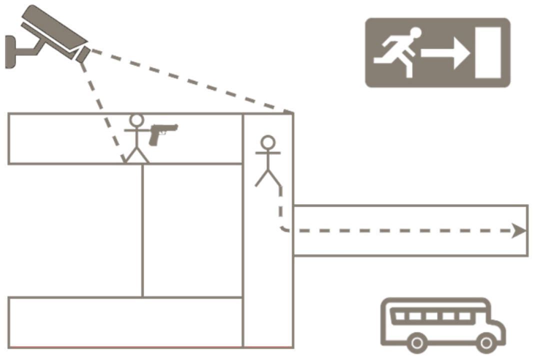

CPS: Medium: Collaborative Research: Active Shooter Tracking & Evacuation Routing for Survival (ASTERS)

Real-time egress optimization with ML based perception and effective communication to evacuees

CAREER: Robustifying Machine Learning for Cyber-Physical Systems

Semantic robustness of perception systems

Vulnerabilities/robustness of RL agents

Research challenges

AI/ML and CPS – bi-directional opportunities

- Robustness/interpretability issues of ML modules – safety under edge cases
- ML is still mostly useful for perception/estimation – CPS tools critical to close the loop
- Integration of knowledge/physics (modeled dynamics) with data for learning
- Dealing with sample complexity of decision-making models
- Effective Sim2Real transfer; transfer of concepts
- Causal modeling and reasoning

Research challenges

Multiagent systems - Significant progress made in multi-agent systems, scalability – gap still exists in understanding and controlling emergent behaviors

Autonomy and ethics - explicit consideration of ethics/biases/fairness in CPS design

Role of humans – human-CPS interaction, transfer of authority, future of work

Technology adoption - Social acceptance, policy/legal questions

Opportunities

- Trustworthy and contextual integration of AI/ML tools in real life CPS
- Under-/Un-explored application domains –
  - ✓ CPS for environmental sustainability, resilience to future climate and rural resilience (goes well beyond Ag-CPS)
  - ✓ CPS tools for societal challenges (e.g., handling misinformation)
  - ✓ New ways to integrate human users/experts with CPS
  - ✓ CPS in highly unstructured, uncertain, partially observed environments
- Sustainable computing – moving away from brute force computing approaches via sophisticated reasoning

Lessons learned

- Issues in adoption by the domain practitioners and industry – lack of consideration of cost, true pain points, legacy domain practices
- Benchmarking and comparison – lack of testbeds (far more complex than benchmark data sets, needs innovation, democratization) and widely usable CPS tools
- Lack of ‘CPS in the wild’ testing – not really a mistake, more like a next step!

Transition to practice

- Connection with other application focused funding agencies is helping this cause, e.g., USDA-NIFA, DOT
- New mechanisms to emphasize transition to practice, leveraging the TIP directorate, encouraging GOALI projects, building connections with follow-up PFI, SBIR programs
- Greater involvement of industry researchers in preparation of solicitations, panels
- Some domains are riper for certain CPS innovations – e.g., high-level autonomy in less regulated, less safety-critical Ag industry over aerospace or self-driving cars