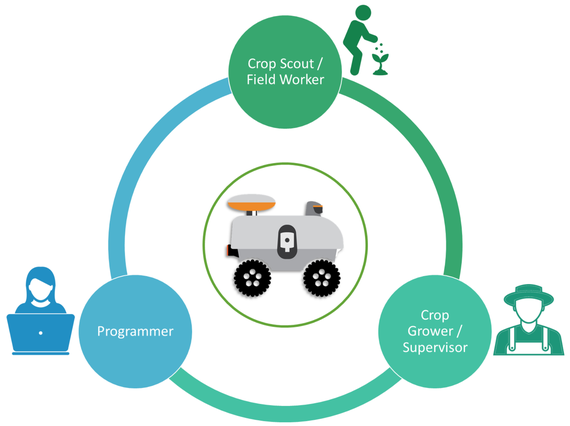
Increasing the Level of Autonomy for Agricultural Robots:
Effective Interaction and Programming Paradigms

Katie Driggs-Campbell, Girish Chowdhary, Roy Dong, Sayan Mitra, and Sasa Misailovic
University of Illinois at Urbana-Champaign

We aim to enable agbots to autonomously operate with minimal interventions from human supervisors. These robots will be resilient on the field through improved contextual awareness and runtime monitoring, allowing users to command large fleets. Our work will be evaluated on an experimental farm and we will work closely with farmers to remove barriers to adoption.

We aim to develop agbots that are:

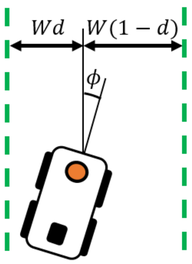
- easy-to-use by non-experts
  → Requires innovations in autonomous robotics
- enable runtime monitoring for correct development and resilient deployment
  → Requires integration with verification and validation
- able to smoothly communicate and interact with users
  → Requires insights from HRI and HCI
- designed with adoption in mind
  → Requires economic and behavior models



Proposed Levels of Autonomy for Field Robots.
Level – Description
0 – manual operation (hands on)
1 – within line of sight (hands off)
2 – operator nearby (eyes off)
3 – onsite fleet operation (mind off)
4 – remote supervision (monitoring off)
5 - Robots adapt (development off)

We aim to increase the level of autonomy by developing and implementing:

- Robust autonomous frameworks
- Agriculture-specific autonomy schema for task specification and abstractions in Koord
- Effective interaction and communication schemes under different deployment cases (e.g., one-to-one vs. one-to-many)
- Socio-ecological models to understanding usability and adoption decisions

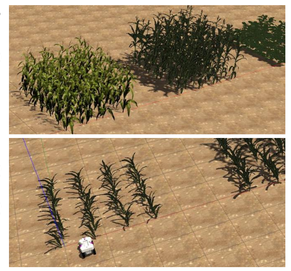


We can autonomously follow rows for over 500m, improved through image-based state estimation and learning from human interventions. We aim to extend this by:

- Learning recovery maneuvers
- Optimizing interactions when asking for help from the human

We are integrating with Koord, a programming language built for verification, to allow programmers (not necessarily roboticists) to effectively implement and deploy the methods. We are currently:

- Integrating our agbot into Koord and CyPhyHouse
- Developing a software pipeline for testing and approximate reasoning, by first identifying "good" abstractions of the perception and approximately verifying performance



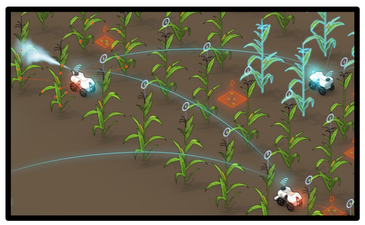
Broader Impacts

The outcomes of this project will provide new insights for many robotics application domains (e.g., manufacturing).

- The software engineering tools developed will broadly improve accessibility and deployment of robots
- Insights about users and potential adopters will provide guidelines for modes of interaction in HRI
- The autonomous stack we develop aims to be both robust and generalizable, so it may by used on many different robot systems and settings

Broadening Participation

- ***Education:*** Using PrairieLearn, an online platform developed at UIUC, we can provide a *mastery* driven approach to teaching robotics concepts
- ***Outreach:*** We are connecting with the local community and K-12 schools to encourage interest STEM and Ag robotics



Potential Impact

- Developing simple, reliable, and usable autonomy will improve robot adoption by farmers
- These agbots will help alleviate the labor crisis and reduce the reliance on unsustainable practices, like overuse of fertilizers and pesticides while improving soil health
- We are positioned for real-world impact through the Center for Digital Agriculture, which connects academia, industry, and farmers and access to our Autonomous Farm

2021 NRI & FRR Principal Investigators' Meeting
March 10-12, 2021

Award ID#: 2021-67021-33449