Results of the "Intelligent Robotic Systems for Reducing the Cost and Ecological Impacts of Agriculture"

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Sabbatical 2021-2022

Abstract

Agricultural practices involve the heavy use of chemical fertilizers, fungicides, insecticides, and herbicides. Broad application of such chemicals has given rise to health concerns and to resistant strains of the targeted organisms. Precision application of such chemicals provides a highly-desirable alternative to traditional broad application methodologies.

Precision application requires two basic capabilities: 1) the accurate determination of plant pathologies or deficiencies; and 2) the precise application of agricultural chemicals to the affected plants. Each capability presents several significant challenges in sensing, analytics, mapping, navigation, and manipulation.

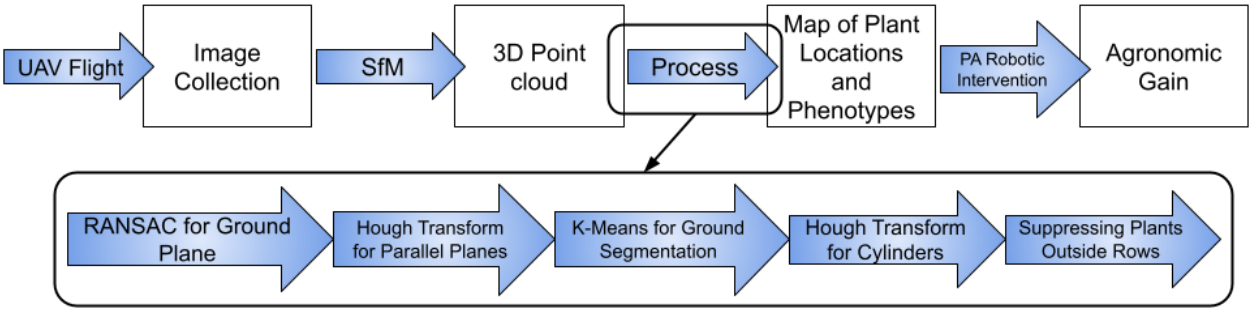
The goal of this sabbatical was to characterize these challenges and to begin to develop robust solutions for them.

Activities

Agricultural robotics

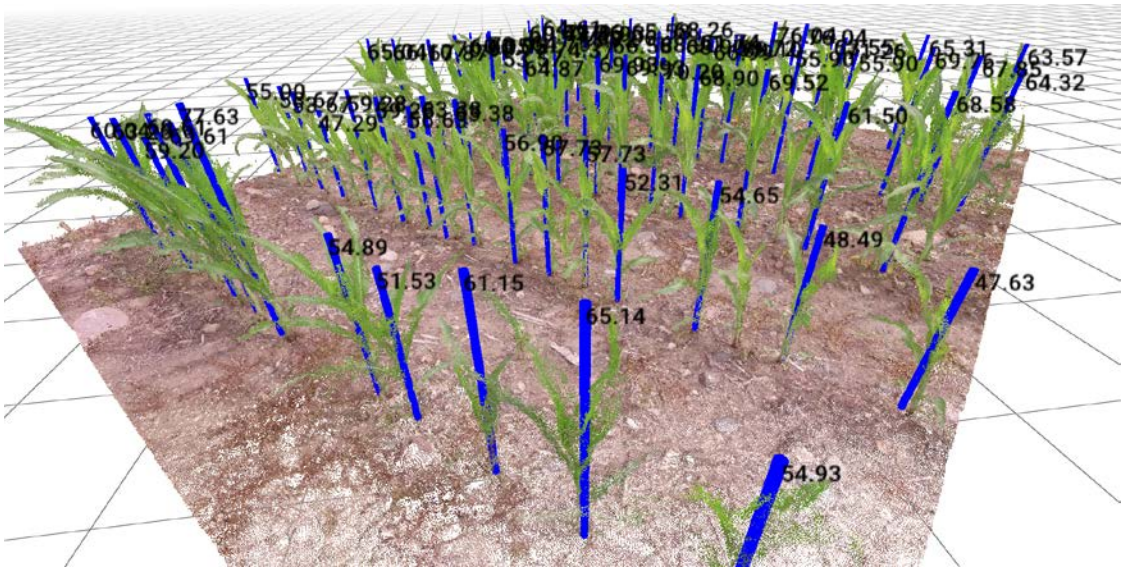
Starting in May of 2021 and continuing for the foreseeable future I have attended weekly research group meetings held by the Minnesota Robotics Institute. COVID actually helped facilitate this since during the summer and fall of 2021, the University of Minnesota banned virtually all on-campus meetings, therefore the research groups meetings were held remotely via Zoom.

Through my participation in these meetings, I began a collaboration with members of the group on one of the significant open problems. The problem was the localization and measurement of corn plants in unstructured drone video. Several techniques were adapted and several others developed to address this problem. A data analysis pipeline architecture was used to model the solution process:



where the research we conducted fell into "Process" portion of the above pipeline.

Our developed techniques allowed the accurate (within 2.5 cm) localization of over 90% of the corn plants in an Agricultural School test plot. Furthermore, we were able to produce plant height estimates of the localized plants as shown in:



where the superimposed blue bars are placed at the derived locations. Each bar is scaled to the derived height of each specific plant.

This work resulted in the acceptance of a peer-reviewed publication (see reference (1)).

Energy Use Modeling and Prediction

An unexpected opportunity arose during my sabbatical involving the DTE Energy Challenge. Starting in September of 2021, I have worked as a Co-PI on the "DTE Energy Challenge: Intelligent Modeling and Control of Steam Plant Operations to Reduce Energy Consumption" with Dr. Mahmud (Principal Investigator) and Dr.'s Baumann, Jones, and Sarda (Co-Principal Investigators).

The continuing work requires extensive data collection from Metasys (Johnson Controls Inc. proprietary building management software), additional sensor installed at LSSU for this specific project, and the National Oceanic and Atmospheric Administration. The collected data is being used to train artificially intelligent supervised learning models to attempt to accurately predict the energy needs of the campus on a day-to-day basis, allowing more efficient boiler operations via steam pressure manipulation.

While not in my sabbatical planned activities, this certainly resulted in significant research during my sabbatical period.

Other Activities

- Served on a National Science Foundation Major Research Instrumentation Review Panel
- Attended (virtually) a seminar "The Role of Analytics and Academia to Support Water Resources and Sustainability" held by the Chronicle of Higher Education
- Contributed to a University of Wisconsin survey of AI experts "AI and its potential social impacts"
- Attended (virtually) a forum "The Changing Credential Landscape" held by the Chronicle of Higher Education
- Invited to serve on a review panel for IEEE Senior Member applications
- Served as a reviewer for SIGCSE's Birds-of-a-Feather session proposals

References

1. H. Nelson, C. Smith, A. Bacharis, and N. Papanikolopoulos, “Robust Plant Localization and Phenotyping in Dense 3D Point Clouds for Precision Agriculture,” to appear, *IEEE International Conference on Robotics and Automation*, London, England, May 2023.