Evaluation of 3D reconstruction methods with application to plant phenotyping under field conditions

Bio-Sensing and Instrumentation Lab

Team Member: Piyush Pandey
Major Professor: Changying Li

INTRODUCTION

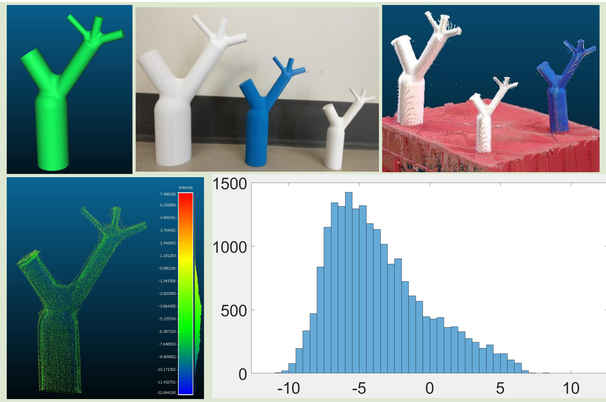
3-dimensional plant phenotyping under field conditions faces numerous constraints due to variable environmental conditions. Multiple technologies are available for obtaining point cloud data in the field, and a difficult choice of the scanning method for a specific scenario has to be made each time a reconstruction needs to be performed [1]. Among the different environmental factors, wind introduces significant variability in the plant structure. In this study, the effect that wind velocities have on 3D reconstruction of plant structure is studied by simulating wind conditions in the laboratory.

To obtain an objective measure for the quality of 3D scanning, the scanning methods are first used to create 3D point clouds of 3D printed objects. As a measure of their efficacy in plant phenotyping, traits are acquired from reconstructed models and correlated with ground truth measurements.

OBJECTIVES

1. Quantitatively evaluate the accuracy of 3D point cloud data obtained from multiple technologies used for 3D plant phenotyping
2. Evaluate the performance of reconstruction methods in presence of wind by acquisition of structural phenotypic traits

METHODS



Clock-wise from top left: 1. Computer aided design of a branch 2. 3D printed branches at different scales 3. 3D point clouds created from the 3D printed objects 4. Histogram of distances for the point cloud data from the original mesh 5. Visualization of distances

Objective evaluation of 3D reconstruction:

1. Multiple objects at different scales printed using a 3D printer
2. 3D point clouds of the printed objects created using multiple scanning techniques (FARO Focus3D S70, Multiple-View Stereo)
3. Point clouds processed for removal of ground plane, scaling, and alignment with the original CAD model
4. Accuracy of the point cloud data evaluated using distance measures [2]

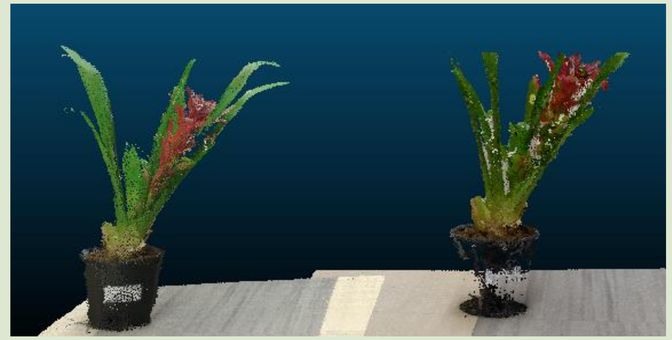
Evaluation of the phenotyping application:

1. Plants scanned at multiple simulated conditions in the laboratory
2. The usefulness of reconstruction methods evaluated through correlation of point cloud derived traits with ground truth traits

3D point clouds obtained using the FARO Focus3D S70 at (i) 0 mps (ii) 1 mps (iii) 1.5 mps

RGB image

PRELIMINARY RESULTS



MVS reconstruction (right) and laser scanning (left) have been found to have comparable accuracy in normal conditions without wind. The correlation with ground truth in this example (leaf length) shows R^2 values of 0.87 for the laser scanner and 0.82 for MVS.

FUTURE WORK

Relevant future work would be to develop systems and algorithms that are capable of adjusting to windy conditions. Being able to eliminate, or at least reduce, the noise introduced by the movement of plant parts would help to enhance the quality of acquired data, and would also increase the efficiency of data acquisition.

References:

[1] Wang, Y., Wen, W., Wu, S., Wang, C., Yu, Z., Guo, X., & Zhao, C. (2019). Maize Plant Phenotyping: Comparing 3D Laser Scanning, Multi-View Stereo Reconstruction, and 3D Digitizing Estimates. Remote Sensing, 11(1), 63.

[2] Seitz, S. M., Curless, B., Diebel, J., Scharstein, D., & Szeliski, R. (2006, June). A comparison and evaluation of multi-view stereo reconstruction algorithms. In 2006 IEEE computer society conference on computer vision and pattern recognition (CVPR'06) (Vol. 1, pp. 519-528). IEEE.

College of Engineering
UNIVERSITY OF GEORGIA

Sponsors: National Robotics Initiative (NIFA grant No: 2017-67021-25928) and Georgia Cotton Commission.