UAV Phenotyping in Sunflower

Brian Smart, Brock Zenzen, Brady Koehler, Michael Grove, John Nowatzki, and Brent Hulke
North Dakota State University and USDA-Agricultural Research Service

Abstract

Accurate and robust high-resolution phenotypic status collected in a timely manner and tracked over time can provide breeders, agronomists, and producers with valuable insight into agronomic and breeding challenges. Unmanned Aerial Vehicles (UAVs) have proven to be versatile, capable instruments for phenotypic data capture in other major crops thus far, and this technology will greatly improve data driven decision-making for sunflower breeders, crop consultants, and producers. This project aims to produce guidelines for UAV implementation in sunflower breeding and production, focusing on the use of RGB and NDVI cameras with high-resolution.

Figure 1: DJI Phantom 4

Introduction

According to Cobb et al. 2013, "phenotyping is quickly emerging as the major operational bottleneck limiting the power of genetic analysis and genomic prediction." This bottleneck has only expanded in recent years.

Remote sensing has the potential to rapidly provide a suite of phenotypic information pertinent to breeders such as the height, lodging, physiological status, and disease information of each breeding line, thus reducing the operational bottleneck. More uniquely, UAV systems can provide physiological status across time, with regular executions of a custom flight plan.

For producers and agronomists, this new tool set can provide more comprehensive, accurate, and timely data when surveying a field to help make appropriate decisions. (Araus and Cairns, 2014).

Objectives

1. Testing the effectiveness of UAVs equipped with high-resolution RGB and NDVI cameras in collecting phenotypic information, such as stand count, height, lodging, plant health, estimated yield, and maturity.
2. Identifying the ideal image processing software parameters for sunflower, as well as creating custom software solutions where needed.
3. Beyond year 1, evaluating the ability to use UAVs in large scale applications, such as sunflower yield trials and production fields.
4. Utilizing NDSU extension and other outlets to communicate customized image analysis programs about UAV and image processing for the sunflower industry.

Figure 2: UAV view of the USDA Glyndon nursery post-maturity

Methods

1. For phenotypic data collection, our team utilizes a DJI Phantom 4 equipped with a gimble stabilized camera capable of 2 mm/pixel resolution. During flyovers, custom coded flight software guides the UAV along the observation plot, taking pictures every meter. Ground control points, which are specialized location markers, are used to improve accuracy in measurements.
2. For image processing, our team uses a custom-built workstation at NDSU and stand-alone photogrammetric processing software to stitch together 3D mosaics that allow for accurate phenotypic observations and measurements.
3. Finally, our team will share the phenotypic data and/or upload the data to our custom built and maintained lab database for use in our breeding program.

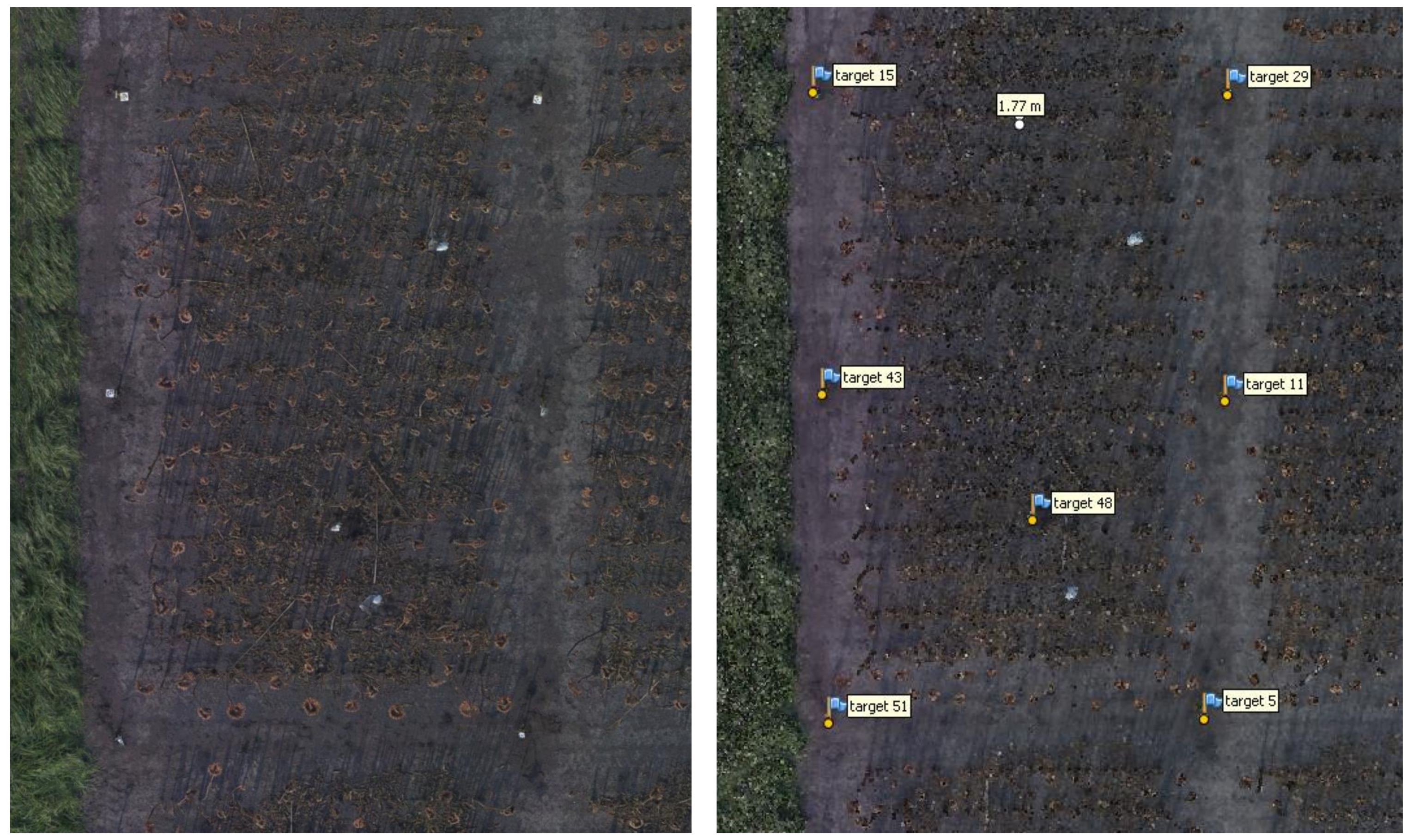

Figure 3: Bird's eye view (left) and 3D point cloud (right) of test plot. 21.33 feet.

Results

On October 31, 2017, our team successfully conducted a UAV fly-over of a test plot in our Glyndon nursery. Despite the inadequate conditions (substantial wind, low plant surface area, and low contrast to soil), we were successful in generating a 3D model and gathering some preliminary test measurements to be compared with ground truths. A computer-generated 3D point cloud was utilized for such measurements (Figure 3 right). A near identical visual image is available for comparison with the point cloud (Figure 3 left). With an R^2 value of 0.99, the point cloud measurements accurately predicted physical height (Figure 4). With successful preliminary results, productive discussions with UAV experts, and the skills necessary for implementing a UAV phenotyping program, we are confident that this project will greatly benefit the entire sunflower community.

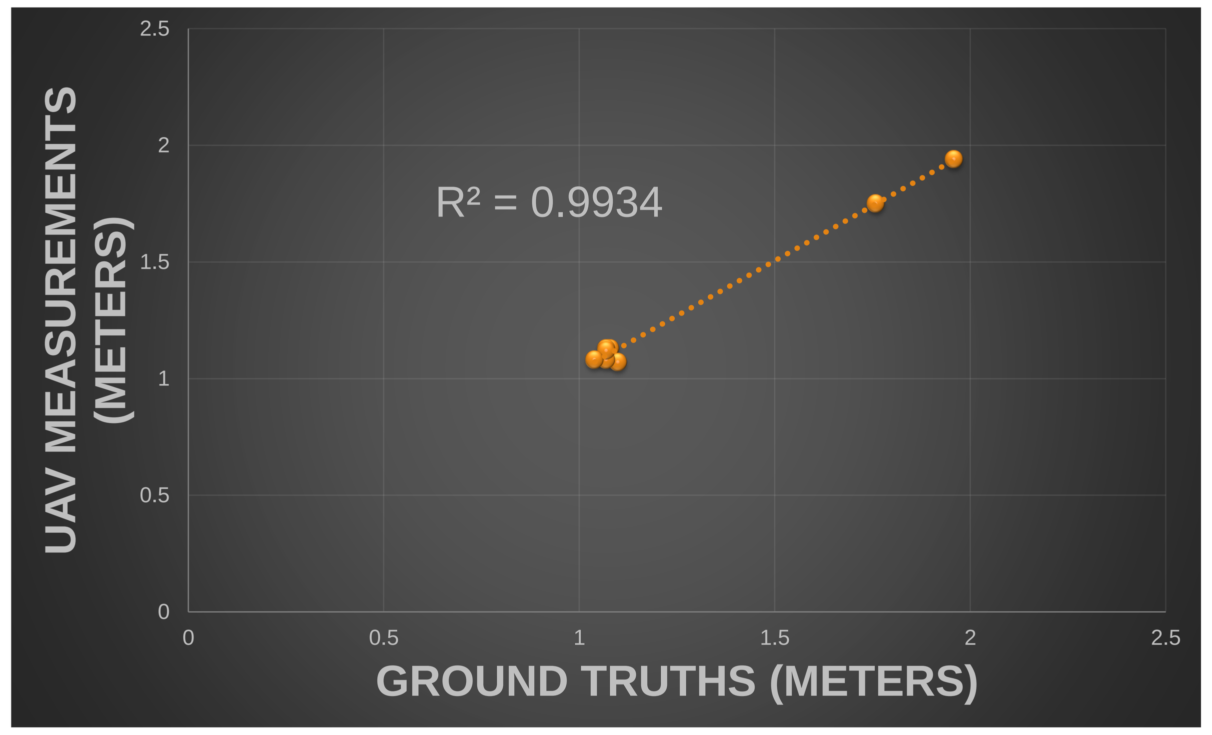

Figure 4: Linear Regression Model of Ground and UAV Measurements

Contact:

Brian Smart
Email: brian.smart@ndsu.edu
Website: hulkelab.org
Phone: (847) 409-3908

Brock Zenzen
Email: brock.zenzen@ndsu.edu
Phone: (320) 429-0115

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