Introducing Unmanned Aerial Vehicle (UAV) Imaging and Machine Learning Application for Plant Phenotyping

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Introduction

Background of the study
- Remote sensing imagers can improve efficiency and effectiveness of monitoring and controlling agricultural operations (Huang et al., 2018).
- Coarse spatial and temporal resolutions of satellite images are always a challenge for agriculture applications (Veysi et al., 2017).
- Autonomous flight capability (Klemas, 2015), spatial and temporal resolution flexibility (Doughty and Cavanaugh, 2019), and cost-effectiveness (Singh and Frazier, 2018) have given UAV more popularity (Jang et al., 2020).
- UAV images could efficiently replace the traditional crop scouting and phenotyping, which is often laborious, time-consuming, and subjective process (Zhang et al., 2022).
- The ML algorithms could improve and fasten the process of detecting the relationships between plant phenotypic parameters (Linaza et al., 2021).

Objectives
- To evaluate the applicability of UAV-based imaging and machine learning algorithms to estimate sweet corn (Zea mays var. saccharata) plant height, yield, and biomass.

Methods

Research site
- This experiment was conducted at Tropical Research Education Center.
- Sweet corn was grown on 16 plots (9 m x 5.5 m) from 24 Nov 2020 to 19 Feb 2021.

Estimating plant height using UAV imageries
- Plant height and biomass were collected bi-weekly.
- At the end of the experiment, grain yield.
- High-resolution multispectral imageries were collected daily using a RedEdge-MX sensor (Fig. 1).
- DSM and DTM are generated using Pix4Dmapper.
- The pixel level difference between two models has given CSM (Fig. 2).

Figure 1. DJI Matrice 210 v2 UAV an sensors

Figure 2. Schematic of DSM, DTM, and CSM

Figure 3. Scatter plot between measured plant heights and estimated plant heights

Estimating sweet corn biomass and yield from UAV images
- A positive linear relationship between the measured total fresh biomass and UAVH was found with adjusted r2 and RSE of 0.88 and 230 g m-2, respectively.
- The adjusted r2 and RSE of 0.90 and 51.5 g m-2 were found between measured fresh leaf biomass and UAVH.
- Comparable results were observed for fresh stem biomass and total dry biomass, where the adjusted r2 and RSE were 0.87 and 185.9 g m-2 and 0.78 and 87.87 g m-2, respectively.
- A positive correlation between the measured yield and UAVH was found with adjusted r2 and RSE of 0.63 and 77.49 g m-2, respectively.

Figure 4. Box plots for estimated biomass against measured respective biomass

Conclusions

- Monitoring plant phenotypes is critical to take timely corrective actions to address problems before crop growth is affected, and yield loss is incurred.
- Field sampling and data collection are often very costly and time-consuming.
- Findings from this study demonstrated that UAV-based multispectral imaging and machine learning algorithms can be effectively used to estimate sweet corn height, biomass, and yield with reasonable accuracy.
- The result could be used to make informed decisions at plot and field levels.

References

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