UAV-Based High-throughput Phenotyping of Plant Height in Seeded Centipede Grass and Ornamental Plants

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Introduction

• GIS – you know where your data was taken
• Remote sensing – rapidly measure plant characteristics (nondestructive)
• Data science – data is relevant to your goal (yield, plant health, weed pressure, disease pressure)
Introduction

• Convention field phenotyping
  • Low capacity (limited sub-samplings & limited frequency)

• Unmanned Aerial Vehicles
  • Inexpensive and flexible in the spatial and temporal resolution
  • High efficiency
• High throughput phenotyping
  • Two-dimension
    • Color, green cover, health, plot uniformity, seasonal change, etc.
  • Three-dimension
    • Plant height, biomass and yield
Introduction

• Estimating plant height using UAV-based platform
  • Corn – Geipel et al. (2014)
  • Cotton – Chu et al. (2016)
  • Vineyard – Weiss and Baret (2017)
  • Sorghum – Hu et al. (2018)
  • Olive tree - Jiménez-Brenes et al. (2017)
Objective

• To assess the use of UAV-based visual imagery on estimating the plant height in centipedegrass (*Eremochloa ophiuroides*) and some ornamental plants

Red trispecific *Pennisetum* hybrids

Pride of Barbados (*Caesalpinia pulcherrima*)

Little bluestem

Fountain grass (*Pennisetum alopecuroides*)

*Miscanthus sinensis*
Flight

- 3 pm, Sep. 24, 2018
- Phantom 4 Pro V2
- Double grid flight plan with 75% overlap
Plant Height Map

- Create point shapefile
- Extract elevation information from DSM to points
Plant Height Map - Interpolation

- Digital Terrain Model
- Interpolation – Inverse Distance Weighting
  - Deterministic method
Plant Height Map

DSM

DTM

Canopy Height
Value
High : 3.27
Low : -0.31
Individual Plant Height – Zonal Statistics

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<th>ID</th>
<th>Min</th>
<th>Max</th>
<th>Range</th>
<th>Mean</th>
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<td>0.64</td>
<td>1.30</td>
<td>0.14</td>
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UAV-derived and manually measured plant height

Red trispecific Pennisetum hybrids: $R^2 = 0.90$, RMSE = 0.12

Little bluestem: $R^2 = 0.03$, RMSE = 0.12

Miscanthus sinensis: $R^2 = 0.62$, RMSE = 0.07

Pride of Barbados: $R^2 = 0.85$, RMSE = 0.07

Pennisetum alopecuroides: $R^2 = 0.85$, RMSE = 0.10

Species combined: $R^2 = 0.88$, RMSE = 0.19
Manually Measured and UAV-derived plant height
Summary

• Plant heights can be estimated accurately for red *Pennisetum* hybrids (RMSE = 12 cm) and Pride of Barbados (RMSE = 7 cm).

• UAV-derived plant height underestimated measured plant height in fountain grass.

• Plant heights in little bluestem were poorly estimated
  • Low height and thin stand

• Future interests
  • Characterize canopy architecture
Centipede grass

Ortho-mosaic

DSM
Digital Surface Model with Ground Points

Digital Elevation Model

Plant Height Map

IDW

CanopyH_IDW

Value

High: 0.49
Low: -0.10
Zonal Statistics - Means

Centipede grass

$R^2 = 0.25$
$RMSE = 0.05$

Crabgrass

$R^2 = 0.42$
$RMSE = 0.10$
• ~15 cm difference in mean between measured and UAV-derived plant height
Summary

• Plant heights in centipedegrass were poorly estimated using UAV and RGB camera
  • ~15 cm difference between measured and UAV-derived plant height
  • Low height (20 – 40 cm) and small size of seed heads
  • Vegetation height vs. Seed head height

• Future
  • Multi-temporal images at different growth stages using both RGB and multispectral camera
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