Image processing considerations for improving acquisition of crop physiological parameters

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Dana Sullivan, TurfScout
Agenda

// Bayer Agronomic Solutions Phenomic Systems Assessments for Fungicide, Herbicide, Biologics and Seed Growth treatments.
//  Static Mount
//  Vehicle Deployed
//  UAV Deployed

// TurfScout Data Management
//  Processing non-imagery data
//  Processing imagery data
//    Improving image registration
//    Preserving data integrity
//    Correcting spectral distortion

/// Image processing considerations for improving acquisition of crop physiological parameters/// Schlemmer and Sullivan /// 6 Aug 2019
Bayer Agronomic Solutions
Phenomic Systems

Introduction to a variety of deployed high-throughput field phenomic sensor systems.
Static Mounted Thermal Imaging

SmartField Parameters.

Static Mounted Smartfield FIT:
Continuous measurements of canopy temperature using an elevated forward looking infrared imaging system with associated weather station.

Parameters measured and derived:

- Diurnal measure of Plot means of canopy temperature with the Imaging system (FIT).
- Ambient temperature.
- Precipitation
- Wind speed and direction.
- Atmospheric Pressure.
- Relative humidity
- Total incoming radiation.
Vehicle Mounted Field Phenomic Sensor

Holland Scientific Phenome Parameters.

Vehicle Mounted Holland Scientific Phenome:

- Non-imaging system that collects point parameter data at a rate of 5Hz. 14 variables measured to derive additional 4 parameters and 10 indices related to plant characteristics.
- Deployed to stations across Europe, North and South America.
- Data managed and analyzed by TurfScout web GIS.

Parameters measured and derived:

- Reflectance from 3 bands, 10nm FWHM: \( R(680\text{nm}), \text{RE}(730\text{nm}), \text{NIR}(780\text{nm}) \)
- Select Optical Indices - NDRE, and NDVI.
- Additional Indices – RVI, RVI RE, CI RE,.....
- Canopy Chl Content, CCC (g/m²).
- Green Leaf Area Index, LAI (m²/m²).
- Distance to Target (DIST), via optical methods. Canopy Height is the difference between known sensor height and Distance to Target.
- Downwelling PAR (I_PAR) and Upwelling PAR (R_PAR) used to calculate Fractionally Absorbed PAR (fAPAR) and LAI adjusted Fractionally Absorbed PAR (fadjPAR).
- Relative Humidity (RH).
- Atmospheric Pressure (PRES).
- Ambient Temperature (AIR_TMP) and Canopy Temperature (CAN_TMP) difference can calculate Temperature Departure (\( \Delta T \)).
SpectAir

Imaging with Non-imaging System

Drone development: Multi-sensor system with precision positioned flight. Provides elevated stand-off and close proximity flight with the aid of an on board RTK GPS.

// High resolution RGB camera for measures of morphological parameters. Stand count, Vegetative fraction, Plant height, Canopy volume can be derived.

// Multispectral imager: MicaSense Red Edge for measures of physiological parameters. Explore the modelling of Canopy Chl, other plant pigments, and LAI.

// Thermal imaging: Provides canopy temperature. With ground ambient sensors providing Temp, Pressure, and RH we can model ΔT, and vapor pressure deficit.

// Holland Scientific Talon: Provides same parameters as the vehicle mounted Phenome. Flight operations are in the boundary layer, different from the imaging flights.
TurfScout provides a web-based GIS to process and visualize non-imaging data with advanced image processing of UAV image data.

TurfScout Data Management
Processing of Sensor Data

Using Web Served Geographical Information System (GIS).

// Pre-Processing system for geo-located point data to plot mean values (TurfScout maps from non-imaging points to plot means).

// Function to Upload Sensor and Manual Assessment data to TurfScout for analysis.

// Integrated Analytical Rstats for quality control, data exploration, modeling, and other mathematical expressions.

// Additional analytic options with Export of point and plot mean data.

// Same environment for UAV imagery.
RGB Image Processing

Improved positioning and spectral clarity

SPATIAL ALIGNMENT AND DATA INTEGRITY
- Turfscout image output offers improved spatial accuracy and aligns well to digitized plot boundaries.
- RTK GPS and individual gimbal characterization improves positioning. Only 2 GCP’s required, we use the 4 corners of the trial.
- Clarity improvement as a function of better band to band registration and modifications to camera model prevent image artifacts.
MicaSense RE
Improved band to band registration and spectral clarity
Preserving data integrity to improve feature clarity

INDUSTRY

TURFSCOUT
MicaSense RE
Preserving data integrity

INDUSTRY

TURFSCOUT
MicaSense RE
Frame to Frame Spectral Distortion

INDUSTRY TURFSCOUT

SPECTRAL AND DATA INTEGRITY
- Spectral banding can indicate impact of Bidirectional Reflectance of non-Lambertian surfaces, Vignetting, and other optical distortions.
# SPECTRAL AND DATA INTEGRITY

- Position of pixel within each overlapping frame has a differing Sun-Target-Sensor angle.
- Digital Values from frames #90 and #89 were compared to the NADIR frame.
- Constraint of values nearest NADIR will reduce distortion.

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Spectral Solutions

SPECTRAL AND DATA INTEGRITY
- Improved Spatial and Spectral processing produces differing results compared to Industry standard
- Vegetative fraction calculated with similar thresholds produces different results
- Mis-classification will result in inaccurate assessments

DERIVED FROM INDUSTRY IMAGE

TURFSCHOOL
Spatial and Spectral Resolution Impacts on Vegetative Parameters

### Vegetative Fraction

- **TURFSGOUT**
- **INDUSTRY**

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<th>Treatment</th>
<th>Percent Cover (%)</th>
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<td>0</td>
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<td>19</td>
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### Soil Adjusted Chlorophyll Index

- **TURFSGOUT**
- **INDUSTRY**

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VISUAL DATA EXPLORATION
NDVI Map and Summary Results Overlay

TurfScout Map
Layer

0.00–0.30
0.30–0.36
0.36–0.42
0.42–0.48
> 0.48

Industry Map
Layer

TurfScout Data
Summary

Low
Medium
High

Industry Data
Summary
VISUAL DATA EXPLORATION
Chlorophyll Index Map and Summary Results Overlay

TurfScout Map Layer
- 0.00–0.40
- 0.40–0.80
- 0.80–1.20
- 1.20–1.60
- > 1.60

Industry Map Layer

TurfScout Data Summary
- Low
- Medium
- High

Industry Data Summary
Chlorophyll treatment summaries were normalized for comparison purposes.

Treatments were ranked using the TurfScout Chlorophyll index results from low to high.

Results are presented to demonstrate how image processing techniques can influence results.
Thank you!