Optimal Narrow Spectral Bands for Precision Weed Detection in Agricultural Fields using Hyperspectral Remote Sensing

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Outline

• Precision Weed spraying
  – How it works
  – Monitoring
  – Current Technology

• Spectral Profiles
  – Wide vs Narrow Bands

• Sensors
  – Multi vs Hyperspectral

• Research
  – Goals
  – Methods
  – Expected Results
Precision Weed Spraying

- Sensor activates solenoid
- Only Weeds are sprayed
Precision Weed Spraying

• Cost reduction to producers
• Environmental Benefits
  – Less runoff of herbicides
  – Built in weed monitoring
Monitoring

- Integration of GPS with sprayer can create a weed map.
- Allows year to year comparison
- Weed population dynamics
- Feedback on the management effectiveness
Current Technology

• Systems exist and are in use
• Examples WeedSeeker® and WEEDit®
• Most use active sensors
Issues

• System effective in fallow, pre-plant spraying, post-harvest weed control

• Hard to differentiate between crop and weed

http://www.weed-it.com/
Spectral Profiles

Wheat Profile

Visible

Red Edge

NIR

Green Bump

SWIR

Atmospheric H₂O
Spectral Profiles

- Similar spectral profiles
- Distinct differences
  - Green
  - IR
  - Red Edge?
Narrow and Wide Bands

• Wide Bands
  – Can limit differentiation of similar signatures
  – Multispectral sensors

• Narrow Bands
  – Gain high spectral resolution
  – Hyperspectral sensors
Sensor Differences

- **Multispectral**
  - Wide bands (20nm-100nm)
  - Different regions of spectrum

- **Hyperspectral**
  - Narrow bands (2nm-10nm)
  - Continues across spectrum
MultiSpec Vs Hyperspectral

Wheat Profile

ASD 2151 Channels

Pika II 80 Bands

Landsat 8 Multispectral Bands for comparison
MultiSpec Vs Hyperspectral

Vegetation curve derived from Landsat 8 Multispectral Bands
Sensors

• Current hyperspectral sensors cannot feasibly be mounted to tractors
  – Cost
  – Large Data sets
  – Sensor/computer pay load

• Solution
  – Fly with current hyperspectral technology and apply findings to on-tractor designs
  – Use hand held sensor for ancillary data
Sensors

• Pika II
  • Arial platform
  • ~0.5m pixels
  • Hyperspectral
  • 80 channels
  • 424nm - 929nm

• ASD
  • Back pack mounted
  • FOV 1m @ 2m
  • Hyperspectral
  • 2151 channels
  • 350 nm - 2500 nm

http://kestrelaerial.com/services/hyperspectral-scanning/
Optimal Band Selection

- Reduced data processing time
- Can apply it to future technology
Distance Metrics in Spectral Separability

- Point a single point on the spectral curve
- Spectral response for a band on one axis

![2D Scatterplot](image)
Distance Metrics in Spectral Separability

- Each band adds a dimension
Distance Metrics in Spectral Separability

• For multiple bands this can get very complicated

• Different metrics to quantify these distances
  – Euclidean
    • $D = \sqrt{\sum_{i=1}^{n} (d_i - e_i)^2}$
  – Divergence
    • Based on means and covariance
  – Transformed Divergence
    • Scaled version of divergence
  – Jefferies-Matusita
    • Mean, covariance, and natural log

http://sacred-activations.com
Goals

• Identify portions of the electromagnetic spectrum to identify weeds in dryland wheat.

• Analytical methods can be applied to other cropping/weed systems.
Questions

• Can narrow spectral band combinations identify weeds *in situ*, given the variability of plants?

• How many bands necessary?
  – Compare band combinations across multiply classification techniques

• Can a set of narrow bands be widened and still accurately identify weeds?
  – Wider bands can cut cost of sensors or filters.
Methods: Data Collection

• Tarps
  – Solution to roll, pitch, yaw
  – Used for Atmospheric correction

• Field Data
  – Azimuth, weed type, patch size, etc.

• GPS
  – Tarp and weed patch center
Methods: Processing

- Swaths – Georectified
- Combined using tarps and GCP
- Exported flat
- Combined and Exported
- Lab by Cooper McCann
- Exported to usable file format for analysis

False color IR Hyperspectral Image of wheat field
Methods: Analysis

• Extracted and combined spectral data from infested and un-infested locations
• Used 4 spatial distance metrics
• Used 11 classification techniques
• Compared using kappa statistic and McNemar’s test
Statistics

• Kappa z-test
  – Kappa measures agreement taking into account random chance of correct classification
  – Popular in the literature but though by some to be undesirable

• McNemar’s Test
  – Uses 2x2 matrix
  – Null states same proportion of pixels will be correctly classified by method 1 and method 2
  – Found to work with smaller samples than kappa

Expected Outcomes

• Answer to, does it work?
• Wider bands, cost efficient work
• Method that can be applied to other crop/weed systems
• Commercial collaborators can apply findings and methods to adapt sensors regionally
• Dead weeds
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Questions??