Recent advancements in application of UAVs and remote sensing for precision agriculture and high-throughput phenotyping

Francelino Rodrigues, Urs Schulthess, Ivan Ortiz-Monasterio, Bruno Gerard

CIMMYT, Mexico - Sustainable Intensification Program
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Introduction

- Big data era!
  - Access to data
  - Flexibility
  - Higher resolutions
    Spatial, temporal, spectral
- Agricultural research

+ New technologies + Decision support tools

Increase food productivity,
Ensure global food security
And decrease poverty!
NEW TECHNOLOGIES ON RS

Tetracam - Multispectral 6-band camera

MiniMCA (Tetracam)

Thermal camera
Optris PI 400

MultiSpectral (550, 660, 735, 790 nm)
- 1.2 MPx

Thermal - 640 x 512 pixels

Hyperspectral camera

Zarco-Tejada 2012
UAV's Options

General features
- RGB cameras
- Multi, Hyperspectral and thermal cameras
- Resolutions - <1 cm to 1 m
- Endurance - 10' to 3 h
CASE STUDIES...

Measuring small scale variability due to non-homogenous irrigation - Irrigation Scheduling

LAND USE INTENSITY - SOUTH OF BANGLADESH, WINTER 2013-14

- surface irrigated, smallholder farmers
- low efficiency
CWU Estimation Using Remote Sensing

Daily CWU can be estimated using the “spectral crop coefficient” approach:

\[
\text{CWU} = K_{sp} \times \text{PET} \times F_{\text{stress}}
\]

- \(K_{sp}\) is the spectral crop coefficient (value 0-1)
- PET is the potential ET (Penman-Monteith Eqn.)
- \(F_{\text{stress}}\) is a stress factor (value 0-1)

\(K_{sp}\) is numerically equal to the crop ground cover (GC).

Details of the procedure can be found in:

Model for Irrigation Scheduling

PANI - smart phone app for irrigation scheduling

It forecasts irrigation needs for maize and wheat one week ahead of time, taking forecasted weather conditions into account.

PANI Input / Output from user's perspective

**Input**
- Crop management information:
  - Field location; Sowing date; Crop type; Irrigation
  - % Ground cover
  - Satellite / UAV; RGB photos taken with smartphone

**Output**
- SMS message: Irrigation needed in the next 7 days; Yes or No
  + bed planting and laser leveling = better N use efficiency !!
HIGH-THROUGHPUT PHENOTYPING FOR TAR SPOT COMPLEX (TSC) OF MAIZE USING REMOTE SENSING TECHNOLOGY

- One of the most important disease of maize in tropical areas
- Phenotyping for TSC is mostly conducted by visual observations by breeders/pathologists
  - Depends on personal experience and results may vary due subjectiveness
High-throughput phenotyping through UAV may facilitate TSC evaluation

CIMMYT’S Experimental Station - Agua Fria, Mexico

- Multispectral (550, 660, 735, 790 nm) images - 6 cm/pixel
- Thermal images - 12 cm/pixel
HIGH RESOLUTION HYPERSONTICAL IMAGERY FOR PRECISION AGRICULTURE:
ASSESSING WITHIN FIELD VARIABILITY OF WHEAT GRAIN YIELD AND
PROTEIN CONTENT

WHY?!
- Selective harvesting!
- N management targeting yield AND grain protein content (GPC)
Data mining:
- Spectral
- Spatial
- Temporal
Yield

14 February 2014
19 February 2014
27 February 2014
11 March 2014
17 March 2014
28 March 2014
07 April 2014
15 April 2014
25 April 2014
07 May 2014

GPC

14 February 2014
19 February 2014
27 February 2014
11 March 2014
17 March 2014
28 March 2014
07 April 2014
15 April 2014
25 April 2014
07 May 2014

Normalized Difference Spectral Index - NDSI

$NDSI(i,j) = \frac{R_i - R_j}{R_i + R_j}$
GREENSAT: ON-LINE N MANAGEMENT TOOL FOR WHEAT

Example of a field with N rich strip line

Info from:
- 15 fields
- 30 points

GreenSeeker
NDVI x SPOT-6 satellite image (GreenSAT)
Screenshot of GreenSat
INSIGHTS

- UAVs and RS have become a game changer for on-farm research.
- Easily acquire reliable data - monitoring effects of non-optimal management practices at the field and plot level.
- On Breeding: Accelerate the breeding progress - many more lines can be screened in a given time period.
- Constrains: use of UAVs for large area assessments - regulations generally require that they are being operated within sight.
- Fortunately, satellite data are also getting cheaper and better and can be used to generate decision support tools, such as GreenSat for the N management of wheat.
Thank you very much your attention!
Muito obrigado pela atenção!

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