Paul Spaur (Pix4D) - Real Data, Real Results.

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About Me

> Educational background: Environmental focused B.S. in Biology at Cal State Channel Islands and did research using UAVs.

> Experience: Project Manager for university research team using drones to map coastal land and vegetation for environmental monitoring and management.
About Pix4D

Professional Drone Mapping Software

DEVELOPER OF DRONE PHOTOGRAMMETRY PRODUCTS

> Pix4Dmapper desktop software line
> Pix4Dcapture flight planning app
About Pix4D

FOUNDED 2011 IN LAUSANNE, SWITZERLAND
BASED ON 10+ YEARS OF RESEARCH
NOW 60+ EMPLOYEES

CEO & FOUNDER
Christoph Strecha

CO-FOUNDER
Olivier Küng
8,000 Active users / month

PROCESSING 80,000 PROJECTS
Why is Precision Ag Important?

> By 2050 the planet’s population is expected to be 9.7 billion.

To meet this demand, production must increase 70%. Higher yields will be the solution as most arable land is already being farmed.

“If agriculture is to continue to feed the world, it needs to become more like manufacturing. Fortunately, this is already beginning to happen.” Geoffrey Carr, The Economist.
UAV/UAS Benefits to Ag Operations

1. Timely field scouting
   > Time consuming
   > Limited perspective
   > Lack of data repository

2. Provide data to identify specific problems (disease, under-performance, etc)
   > Traditionally time consuming
   > Spatially constrained
   > Crops damaged in testing

3. Fertilization, irrigation and disease treatment decisions
   > Based on point vector data
   > Dependent on limited sampling
Using Drones in Precision Ag:

1. Field scouting is very time consuming

   > RGB orthomosaics provide perspective of whole field, making scouting more spatially aware and less time consuming.

*Pix4D recommends multispectral data be assessed by crop experts, agronomists, or other Ag-related experts.*
Using Drones in Precision Ag:

2 Humans are limited to the visual spectrum of light

a > Most vegetation information lies outside the visible spectrum.

b > Multispectral imagery gives growers access to information once limited to large operations using satellite imagery.

c > Create popular and tailored index maps for enhanced field scouting with the index calculator.

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Real Data – Utilizing the Invisible

> A good end product, requires good components

> Using the right tools for the job, ensures that the job is done right.

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Reflectance

From Images to Reflectance
Spectral Bands
SAMPLE SPECTRAL SIGNATURE & SEQUOIA MULTISPECTRAL BANDS

Visible range: small differences

Beyond visible range: big differences

Reflectance (%)

Wavelength (nm)

Healthv Plant  Stressed Plant  Soil
Reflectance Computation - Environment

*Direct* vs indirect light
Radiometric Calibration / Illumination Sensor

Used to calibrate the images when the total incoming energy (light) changes.

Important for projects with multiple flights.

Target should be straight up, not tilted, and should avoid shadows.
Not all Cameras are Created Equally

**Dark current**: not all pixels on the sensor respond in the same way. A black image would not trigger all pixels equally, camera manufacturers apply filters to adjust.

**Vignetting**: edges of the lens transmit less light.

**Band sensitivity**: sensitivity of the sensor depends on the bands.

**Aperture Number/ISO/Exposure time**: camera parameters to take into account. Better to keep ISO/Aperture constant and let the camera adjust exposure time.
Data Capture: Cameras

A wide range of cameras are supported by Pix4D. Popular Ag subset below

**Modified:**
- Index maps
- Qualitative information

**Multispectral:**
- Index maps
- Quantitative information
- Calibrated

**RGB:**
- High resolution orthomosaics
- Digital scouting
**Data Capture: Cameras**

**Specially designed cameras (absolute accuracy*)**

*Multiple Sensors:*
- Parrot Sequoia
- Micasense RedEdge
- Airinov Multispec 4C
- SlantRange 2i/2p
- And more

*Single Sensor:*
- Rikola
- Gamaya

**Modified cameras (relative accuracy)**

Digital (non linear) physical filters are applied. Skews measurements Broadband

*if it has proper radiometric calibration
Data Capture: Cameras

Sequoia: Multispectral Imagery, Designed for Ag

**Index Maps + Orthomosaics:** Both from one flight, with the multispectral sensors and the high resolution RGB camera.

**Unique compatibility with Pix4D software:** Leverage the full radiometric and geometric accuracy of the camera.

**Built for every drone, designed for Ag:** Integrate Sequoia on your fixed-wing or multirotor platform

**Radiometrically precise:** Avoid contiguous band contamination with narrow band discrete Red, Green, Red-Edge and Near Infrared bands.

**The sunshine sensor:** Correcting for illumination differences on real time. Generate absolute and comparable values

**Calibration report:** Bundle adjustment details, internal camera parameters and camera rig relatives. Checked for every camera.
NDVI is one of Many Useful Indices

NDVI: NIR-Red / NIR + Red
Useful to measure plant health
Other Indices

Atmospherically Resistant Vegetation Index (ARVI)
Difference Vegetation Index (DVI)
Enhanced Vegetation Index (EVI)
Global Environmental Monitoring Index (GEMI)
Green Atmospherically Resistant Index (GARI)
Green Difference Vegetation Index (GDVI)
Green Normalized Difference Vegetation Index (GNDVI)
Green Ratio Vegetation Index (GRVI)
Green Vegetation Index (GVI)
Infrared Percentage Vegetation Index (IPVI)
Leaf Area Index (LAI)
Modified Non-Linear Index (MNLI)
Modified Simple Ratio (MSR)
Non-Linear Index (NLI)
Normalized Difference Vegetation Index (NDVI)
Optimized Soil Adjusted Vegetation Index (OSAVI)
Renormalized Difference Vegetation Index (RDVI)
Soil Adjusted Vegetation Index (SAVI)
Simple Ratio (SR)
Sum Green Index (SGI)
Transformed Difference Vegetation Index (TDVI)
Visible Atmospherically Resistant Index (VARI)
WorldView Improved Vegetation Index (WV-VI)
Moisture Stress Index
Normalized Difference Infrared Index
Normalized Difference Water Index
Normalized Multi-band Drought Index
Water Band Index

and more!
Real Results:

3 The deliverables give you the tools to make decisions
   > Orthomosaics, index and prescription maps
     > Index values & rates as polygon shapefiles (SHP) with grid size
     > Colored index maps (GeoTIFF) and GeoJPG (JPG)

> Using purpose built multispectral sensors, you can make comparisons over time, using absolute data, and show changes from year to year.

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Workflow: What is the process?

> Collect data

> Process images: Pix4D offers a dedicated Ag template with one-click processing

> Generate an Index Map

> Classification and prescription maps
Workflow: Processing

> Goal-specific: the best geometric and radiometric accuracy for your project

Pix4D algorithms obtain geometric accuracy for orthomosaics & radiometric accuracy for reflectance maps.

**Orthomosaics** generated from RGB sensors are optimized based on geometry, for a field view that’s as realistic as possible.

**Reflectance Maps** from modified or multispectral sensors, on the other hand, are radiometrically optimized since these are the building blocks for index maps, where each pixel value matters.

*Note: reflectance maps from modified cameras provide qualitative data, while reflectance maps from multispectral cameras (like Sequoia) provide quantitative data. Pix4D algorithms are optimized to process calibrated narrow-band multispectral information, which provides the most reliable results.*
Workflow: Local or Cloud Processing?

- Local processing allows large datasets to be processed faster in remote locations, and also allows more control over the data.

- Cloud processing allows for a more “hands-off” experience, and does not use local computer resources.
Workflow: Local or Cloud Processing?
Deliverables: Orthomosaic
Deliverables:
Digital Surface Model (DSM)
Deliverables: Reflectance Map

Sequoia 4 Multispectral Bands
Deliverables: Index Map
Deliverables: Prescription Map

Drone-to-tractor streamlined: Index maps can be converted into prescription maps
Deliverables: Sharing
Real World Application:
Keeping the K in Carrots: Drone Technology to Uncover Potassium Variations

- Carrots are an important Dutch crop, with net yields up to 100 t/ha, which requires high nutrient rates, especially potassium (K)

- Organic carrot farmer and agronomy firm (Agrifirm) asked Aurea Imaging to acquire multispectral imagery. Aim to assess carrot health, quickly detect problem areas for improved yield

- Grower found K deficiency in his field that was not visible from the ground or previous yield reports
Real World Application: Keeping the K in Carrots: Drone Technology to Uncover Potassium Variations

NDRE index map that helped uncover deficiencies.

Once soil samples were collected and analyzed, it was concluded that red regions correlated with problematic K concentrations and greener areas with positive K concentrations.
Real World Application:
Keeping the K in Carrots: Drone Technology to Uncover Potassium Variations

Prescription map generated in Pix4D for adjusted K fertilization application (specific amounts of fertilizer not defined).

Grower benefits:
- Early nutrient deficiency detection prevented yield loss
- Variable fertilization rate saved on input costs.
- Prevented K percolation, which pollutes underground water reservoirs.

More info here
Real World Application:
Soil Analysis and Seeding Rate Optimization

> Soil sampling of areas that share similar soil properties, such as soil pH, salinity, texture, slope, etc., plays an important role in agriculture. Many properties can be estimated based on the results.

> This project delineated a field according to two important soil properties: the presence/quantity of organic matter and soil texture.

> RGB images from drones were used with Pix4Dmapper to capture these visual differences for further analysis (goal to achieve better yield).
The RGB orthomosaic (left) was used to generate a seeding rate map (right), with an algorithm that uses the different shades of brown color information to create zones.

**Grower benefits:**
This seeding rate map was directly uploaded to a tractor for planting guidance. This will translate into a more optimized yield at the end of the year.

More info here
Real World Application:
Other Fields of Application

> Forestry
> Environmental Monitoring
> Conservation Assessments
> Research
Thank you!