Capturing high-resolution 3D multispectral data at research accuracies in changing environments

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To create high-quality multispectral maps for an agribusiness in an area with dynamic weather conditions, Drone Imagery & Data Expert (DIDEX) turned to the new MicaSense RedEdge-P multispectral sensor used in combination with Measure Ground Control software for flight mission planning. The sensor's panchromatic sensor allows pansharpening that increases the resolution of its five multispectral bands to enable 3D multispectral mapping which was crucial for this project.

Project details

Missions: Plague detection, aerial grid, yield forecast of pear harvest

Area: ± 15 acres per field

Drone: DJI M210 v2 & Zenmuse X4S

Sensor: MicaSense Rededge-P

PPK/RTK: PPK with Emlid Reach RS2 + Emlid Reach M2

Outputs: NDVI and NDRE filtered for tree views only

Flights: 2 flights of 20 minutes at 60 m AGL

Total images: 1100 images RGB, 1500 captures 6 bands MSP

Accuracy: RGB ±2 cm/px, MSP ±3.8 cm/px

Processing software: PIXDfields & QGIS

Based in Belgium, **Drone Imagery & Data Expert (DIDEX)** offers multispectral and thermal data and processing services to research institutes, floriculture businesses and landscape contractors.

In May 2022, **Proefcentrum Fruitteelt** npo (pcfruit), an applied scientific research center for fruit cultivation, commissioned DIDEX to produce Normalized Difference Vegetation Index (NDVI) and Normalized Difference Red Edge Index (NDRE) maps of its pear tree experimentation acreage.

pcfruit used this data to develop a yield prediction model that will support harvest worker recruitment to match labor to production needs. pcfruit also investigated whether the maps could be used for applications of precision farming such as variable root pruning. The roots of trees that grow too fast are pruned based on a task map, to ensure a sufficient amount of the tree's energy goes into its fruits rather than only its growth.

Challenges: Accurate data from multiple sensors in varying terrain under changing weather conditions

While the orchards are generally small (±15 acres), the terrain can vary greatly between flat areas and hillsides. DIDEX previously used DJI's Ground Station Pro flight planning software, but recently switched to **Measure Ground Control** flight planning for the app's terrain following capabilities that ensure consistent data capture and resolution.

Weather conditions pose another challenge, explains Yves Lantin, DIDEX's CEO. This fruit growing region is intermittently cloudy and windy. In addition to the usual challenges these conditions pose to drone flights, they pose challenges unique to multispectral data capture: Variable clouds produce variable shadows, which skew the NDVI and NDRE values in the data. Wind creates mis-aligned objects (like leaves) in multi-sensor data capture typical of multispectral workflows which require separate RGB imagery to create DSMs and DTMs. The misalignment occurs since the sensors capture data at different rates.

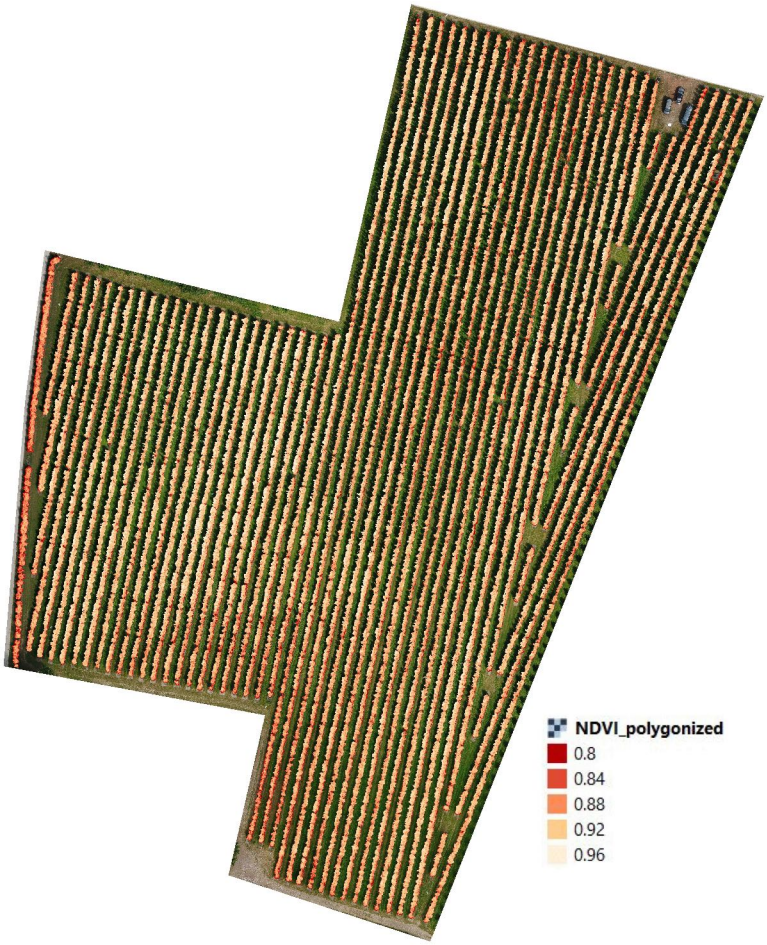
The polygonized orchard. The RedEdge-P was critical for distinguishing the pear trees from the same coloured grass background.

Well-aligned DSMs and DTMs are important to DIDEX's work for producing high-quality 3D multispectral data products. Three-dimensional multispectral data allows more accurate and detailed crop canopy analyses, and allows better differentiating between homogenous terrains such as trees and grass of a similar color. On projects like this one, 3D multispectral data can be used to filter the pear trees from their surroundings.

Solution: Integrated multispectral sensor with pan-sharpening for improved 3D data accuracy

Lantin chose MicaSense's **RedEdge-P sensor** for its five narrow multispectral bands and high-resolution panchromatic band for a pan-sharpened output resolution of 2 cm/px at 60 m (0.8 inch at 200 ft).

Narrow band sensors allow highly detailed analyses, but are typically too low resolution for creating DSMs and DTMs from the RGB bands. That is why multispectral cameras are usually accompanied by RGB cameras: to create DSMs and DTMs. However, the panchromatic band on the RedEdge-P sensor helps to vastly improve the resolution of the five lower resolution narrow bands.



The polygonized orchard, colorized according to NDVI values.

This improved resolution eliminates the need for a separate RGB camera to create the 3D models, DSMs and DTMs necessary for vectorizing trees and other crop data. Furthermore, with the RedEdge-P all the data output are now geographically aligned since all the imagery is captured in the same sensor with a global shutter.

The RedEdge-P thus optimizes drone operations and flight time by eliminating the need for additional payloads, and also simplifies the post-processing workflow.

Speed and ease of use were DIDEX's main data processing considerations in choosing the RedEdge-P. "It is unbelievable how the stitching algorithms evolve so that large projects can still be processed on an inexpensive desktop with 16 GB RAM. We would like to continue to process the data ourselves instead of using online platforms."

"With the RedEdge-P, we can create ortho maps and DSM/DTMs with pan sharpening. This saves us time because we can do everything in one post-processing run."

The sensor's narrow bands with scientific-grade filters make it useful for calculating multiple vegetation indices and composites. It also makes it suitable for projects requiring high accuracy.

To ensure consistent data even in changing lighting conditions, DIDEX uses the DLS 2 incident light sensor. The sensor measures the ambient light and sun angle for each of the camera's five multispectral bands, information which is then used for radiometric calibration in post-processing. (MicaSense users also have the option to enhance radiometric calibration by using the CRP2 Reflectance Panel, a compact ground control panel.)

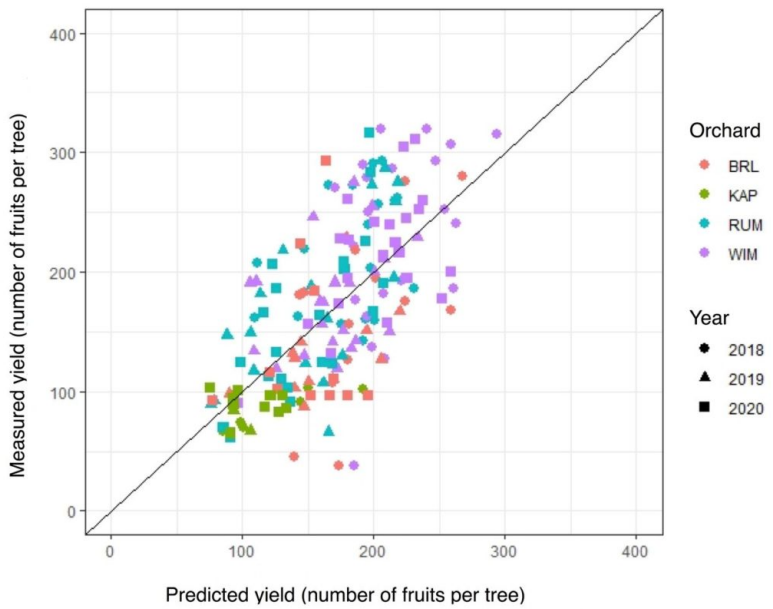
Until now, the company ensured data accuracy by using ground control points. However, the integrated PPK on the RedEdge-P reduces the number of GCPs to 2 instead of 5 or more that need to be distributed over the orchard. DIDEX now uses the sensor with their Emlid Reach RS2 and Emlid Reach M2 for PPK corrections.

Results: High accuracy 3D multispectral data capture in a dynamic environment

For this project, NDVI and NDRE maps were created with the background (grass and soil strips) filtered out so that only the rows of trees remained – something for which the height data in the 3D models were important.

The panchromatic band on the sensor makes it possible to vectorize the (pansharpened) data. Capturing all the data with the same sensor and generating all 2D and 3D models from it is Lantin's favorite feature of the sensor.

The initial data processing was done using PIX4Dfields, and QGIS was used for polygonization and calculating zonal statistics.



The yield chart based on the NDVI data.

On the one hand, pcfruit was primarily interested in zonal statistics, which were presented in table format. pcfruit compared the indices with a series of underlying parameters such as weather conditions and irrigation schemes. On the other hand, pcfruit develops applications based on the indices derived at tree level such as yield prediction models and the generation of task maps for applications of precision agriculture.

A key tool at the core of a new workflow

The RedEdge-P has become a regular tool in the company's arsenal, and DIDEX has already used it for projects on fruit, maize, beets, vegetables like asparagus and floriculture for research institutes and

agronomists. In floriculture, plant height, diameter and health measures are equally important, making the RedEdge-P sensor ideal for data capture as it makes the need for an RGB sensor redundant.

DIDEX's CEO Yves Lantin with the MicaSense series RedEdge-P mounted on a DJI drone.

When they received the RedEdge-P sensor at the beginning of this fruit season and used it on the pear tree study, the DIDEX team did not have enough time to discover all its features and benefits. Today, every feature of the sensor has become a most-used feature, Lantin says. For the next fruit season, DIDEX will optimize its entire workflow around the use of the RedEdge-P.

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