

Lightweight Hyperspectral Mapping System and a Photogrammetric Processing Chain for UAV-based Sensing

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Hyperspectral Mapping System (HYMSY)

The traditional hyperspectral pushbroom sensors that are commercially available weigh 3kg or more which produces challenge for fitting them in Unmanned Aerial Vehicles. Thus we have developed our own lightweight *Hyperspectral Mapping System* (HYMSY) specially designed for UAV-based mapping.

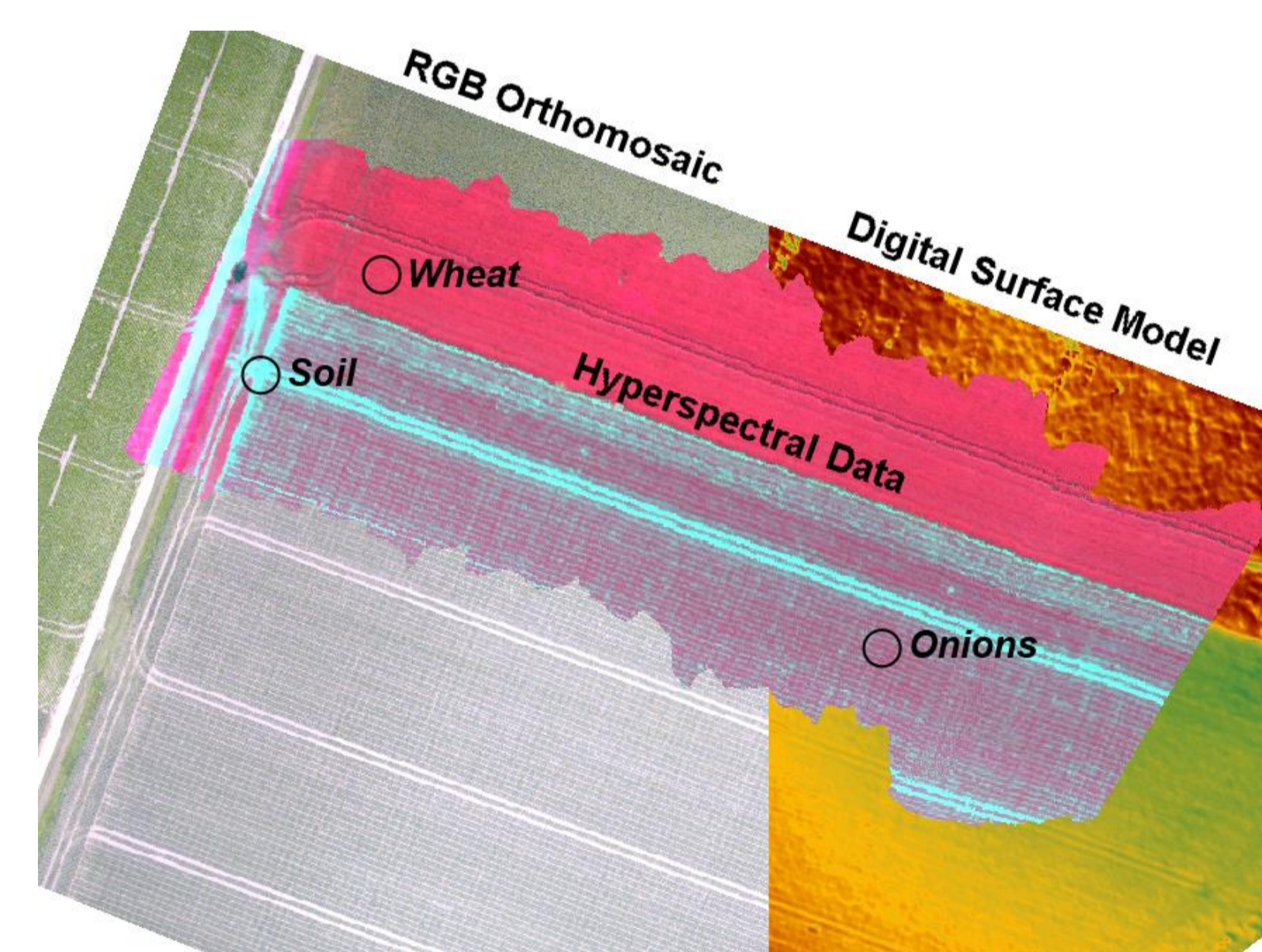
The HYMSY consists of a custom pushbroom spectrometer (range 450–950nm, FWHM 9nm, ~20 lines/s, 328 pixels/line), a consumer camera (collecting 16MPix raw image every 2 seconds), a GPS-Inertia Navigation System (GPS-INS), and synchronization and data storage units. The weight of the system at take-off is 2.0kg allowing us to mount it on a relatively small octocopter.

Table of HYMSY technical specifications.

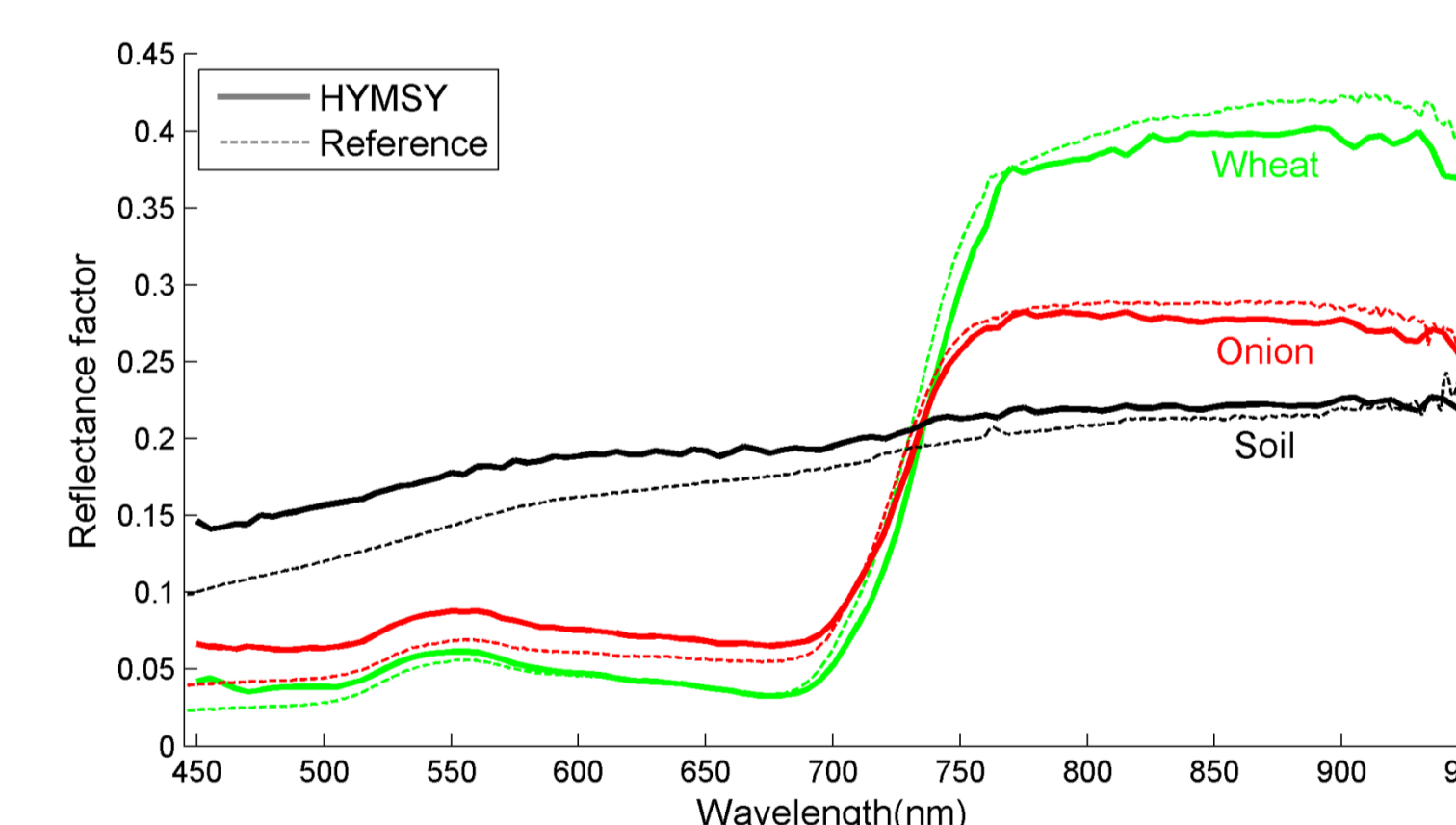
System	
Components	<ul style="list-style-type: none"> Custom spectrometer: <ul style="list-style-type: none"> PhotonFocus SM2-D1312, Specim ImSpector V10 2/3", 12mm lens XSens MTi-G-700 GPS-INS + antenna Panasonic GX1 + 14 mm pancake lens Raspberry PI data sink Synchronization electronics Carbon fiber frame 12V Battery
Total weight (ready-to-fly)	2.0 kg
Power intake	10 W @ 12 V
Spectrometer (SM2 + ImSpector)	
Spectral range	400–950 nm
Spectral resolution (FWHM)	9 nm
Cross-track pixels	328 (1312 unbinned)
Swath width	0.8 x flight altitude
Scan rate	~20 lines/s
Signal-to-noise ratio	300:1 (for unbinned pixel at full well)
Camera (Panasonic GX1)	
Image size	4608 x 3464 pixels [1.2 x 0.9] x flight altitude
Max frame rate	0.7 Hz @ raw format
GPS-INS (XSens MTi-G-700)	
Roll & pitch accuracy	0.3°
Yaw accuracy	Nominal: 1° Observed: >5°
Spatial accuracy	4 m



WageningenUR HYMSY mounted on a Aerialtronics Altura AT8 v1 octocopter



A collage image of HYMSY dataset from a single flight at 120m altitude in Dronten, Netherlands. **(Left background)** An orthomosaic at 34 mm GSD generated from the aerial images. **(Right background)** A Digital Surface Model at 77 mm resolution visualized with hillshading effect **(Front)** A hyperspectral dataset of the first flight line at 320 mm GSD visualized at [800, 650, 550] nm bands.

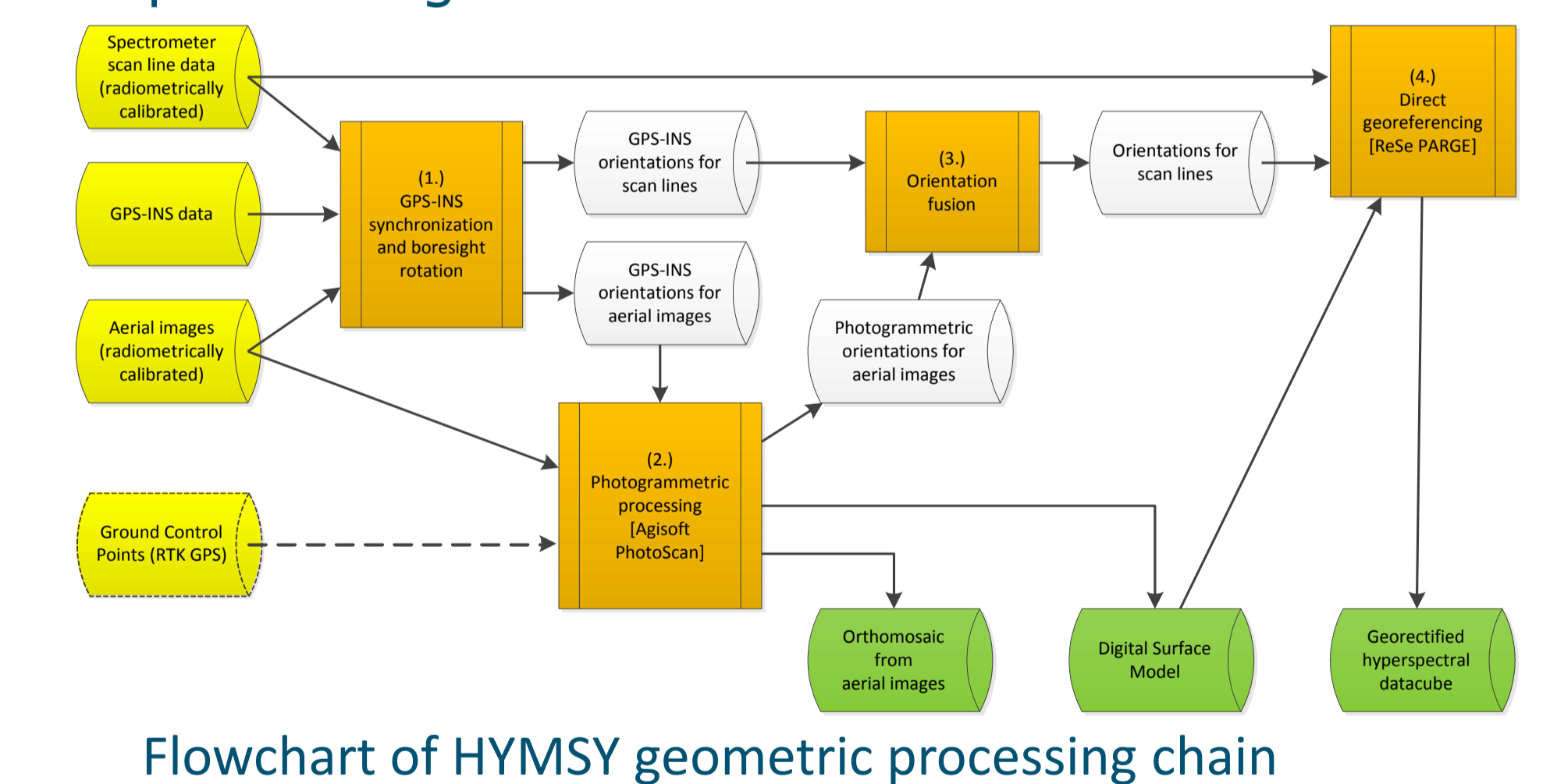


Comparison of HYMSY and ground reference (*ASD FieldSpec HandHeld 2*) spectra. The HYMSY spectra were picked from the datacube shown in figure X-1 by averaging pixels over a small area close to the estimated location of the ground reference spectra. The sampled areas do not match perfectly and thus some deviation is to be expected especially with soil and onion samples.

Photogrammetric processing chain

Traditionally georectification of pushbroom data is done solely based on the GPS-INS orientations and data is projected over a external Digital Terrain Model. This method requires an accurate, heavy, and expensive GPS-INS system and still fails to take vegetation and manmade objects in to account in georectification.

To improve this we have developed a photogrammetric processing chain for georectification of pushbroom data. At first stage aerial images are processed in a photogrammetric software producing a high-resolution RGB orthomosaic, a Digital Surface Model (DSM), and photogrammetric camera orientations. These photogrammetric camera positions are then used to enhance the internal accuracy of GPS-INS data. These enhanced GPS-INS data are then used to project the hyperspectral data over the photogrammetric DSM, producing a georectified end product. The presented photogrammetric processing chain allows fully automated georectification of hyperspectral data using a compact GPS-INS unit while still producing in UAV use higher internal georeferencing accuracy than would be possible using the traditional processing method.



Results

During 2013, we have operated HYMSY on 150+ octocopter flights at 60+ sites/days. On typical flight we have mapped a 2–10ha area producing a RGB orthomosaic at 1–5cm resolution, a DSM in 5–10cm resolution, and a hyperspectral datacube at 10–50cm resolution. The targets have mostly consisted of vegetated targets including potatoes, wheat, sugar beets, onions, tulips, coral reefs, and heathlands. Some of these results can be found in the posters in this session.

