Hyper-Spectral Imaging for Earth Observation

Science and Technology Facilities Council

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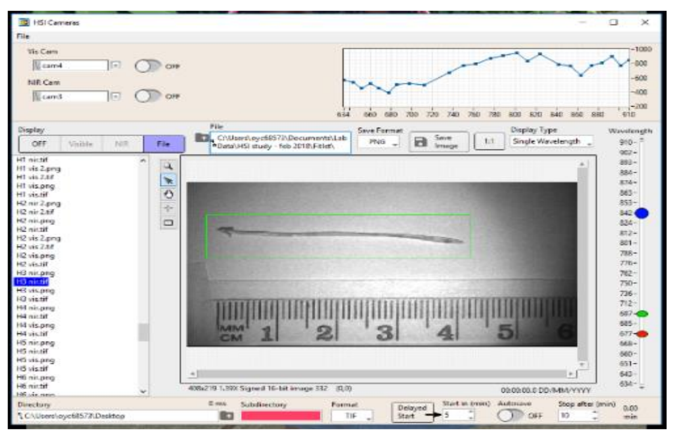
Introduction

Here we present a hyper-spectral imaging (HSI) system with a spectral window from 470-970 nm which meets the demands of static sampling and remote sensing when mounted on an Unmanned Aerial System (UAS).

The system comprises two HS cameras, a compact industrial PC and a battery pack. It has a total weight of <1.8kg, including the bracket for mounting to an active DJI Ronin gimbal.

Raw Data Acquisition

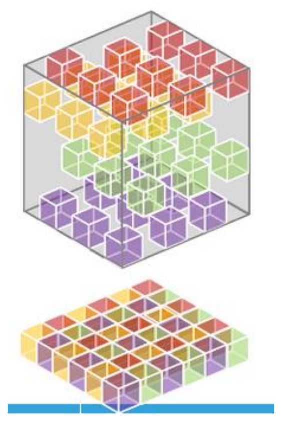
We have developed a labview interface to collect, process and analyse the images from both HS cameras. The software also provides an intensity spectrum at a single point or the averaged spectrum over a rectangular area of the image.



The HSI System

UAS: DJI Matrice 600 pro
HSI Camera: Ximea Snapshot Mosaic
Per-pixel design
Visible: 4x4: ~470-630 nm
NIR: 5x5: ~600-950 nm

Wavelength range, nm	Number of bands	Number of pixels per channel	max Frame rate (Hz)
460 – 630	16	511 x 272 (~0.14MPix)	170
690 – 975	25	408 x 217 (~0.08MPix)	170

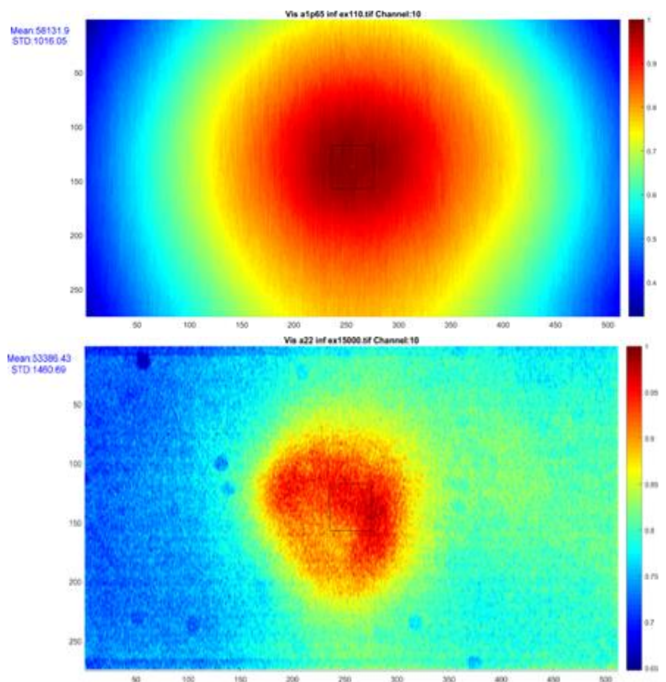


Field of view
~10° along the long axis
~5° along the short axis

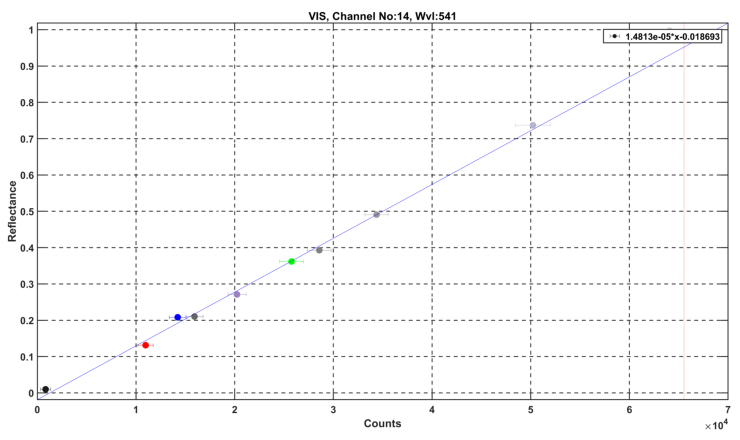
Resolution at 120 metres
- RAW image: ~2 cm/pixel
- Visible single wavelength images: ~10 cm/pixel
- NIR single wavelength images: ~11 cm/pixel

HSI Data Analysis

Reflectance Generation



Uniformity and stray light correction for the 10th channel of the VIS camera at different aperture, focus and exposure time settings.



Linear regression line for the absolute calibration of the sensor's channel.

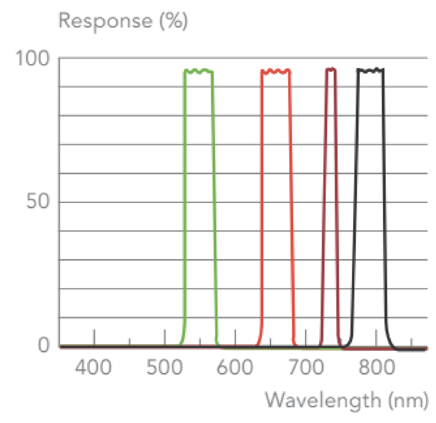
Geometric and Absolute Calibration

- Intrinsic and extrinsic parameters derivation
- Linearity checks
- Spectral response characterisation
- Electric gain and offset correction
- Uniformity and stray light correction
- Spectral response correction
- Absolute calibration through reference reflectance standards
- Reflectance data cube reconstruction

Application on Aerial Imagery

Changes in Illumination Conditions

- Use of a Sequoia Parrot multispectral Imager (MSI) for the sensing of the solar illumination on field.
- All systems have a common frame rate.
- Correction of variable localized illumination conditions using UAS irradiance measurements collected concurrently with the HSI imagery.



Spectral response of the 4 channels of the Sequoia Parrot.

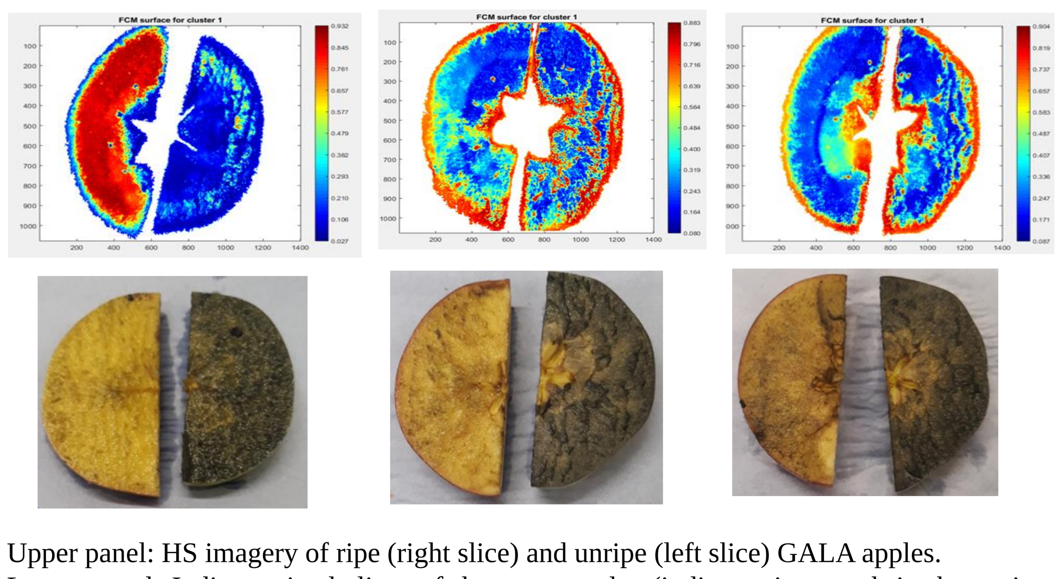
Variable illumination conditions were present during the UAS data acquisition.

Applications

Laboratory Based Studies

Detection of fruit ripeness

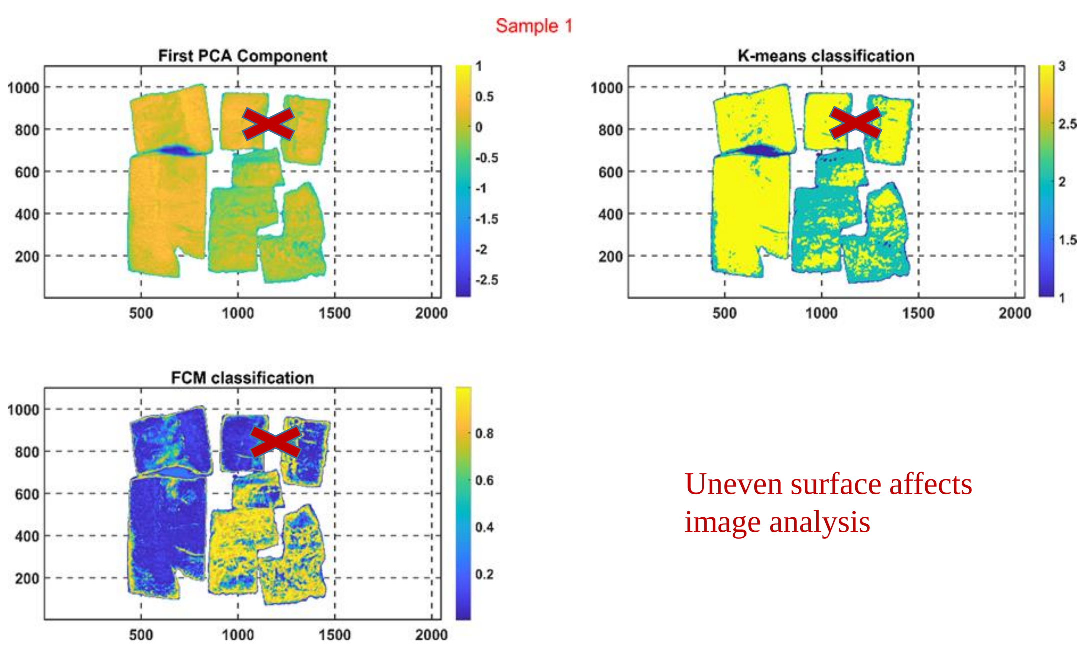
Apples



Variable results due to wetness of surface

Upper panel: HS imagery of ripe (right slice) and unripe (left slice) GALA apples.
Lower panel: Iodine stained slices of the same apples (iodine stains starch in the unripe samples).

Bananas



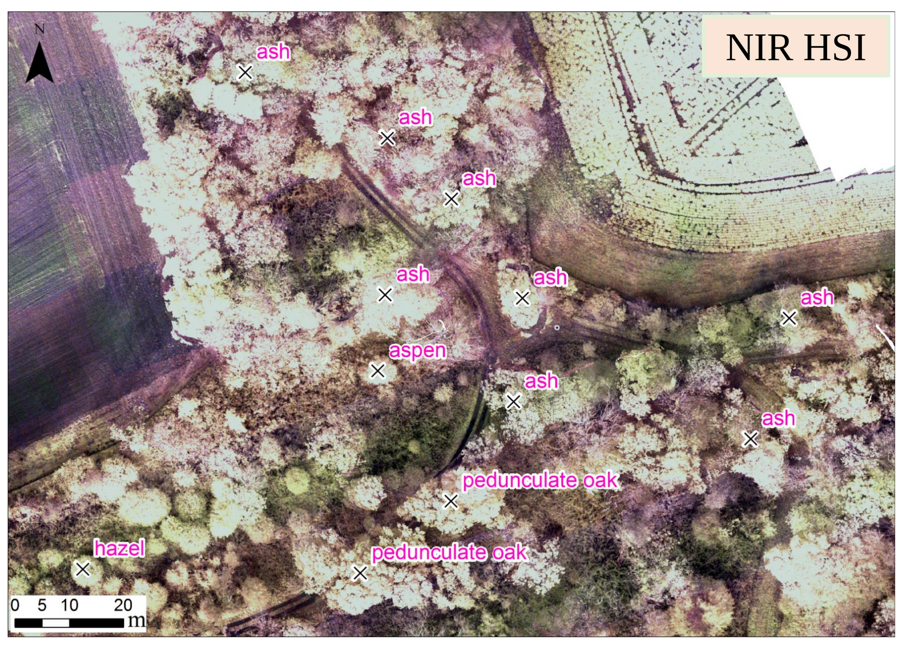
Uneven surface affects image analysis

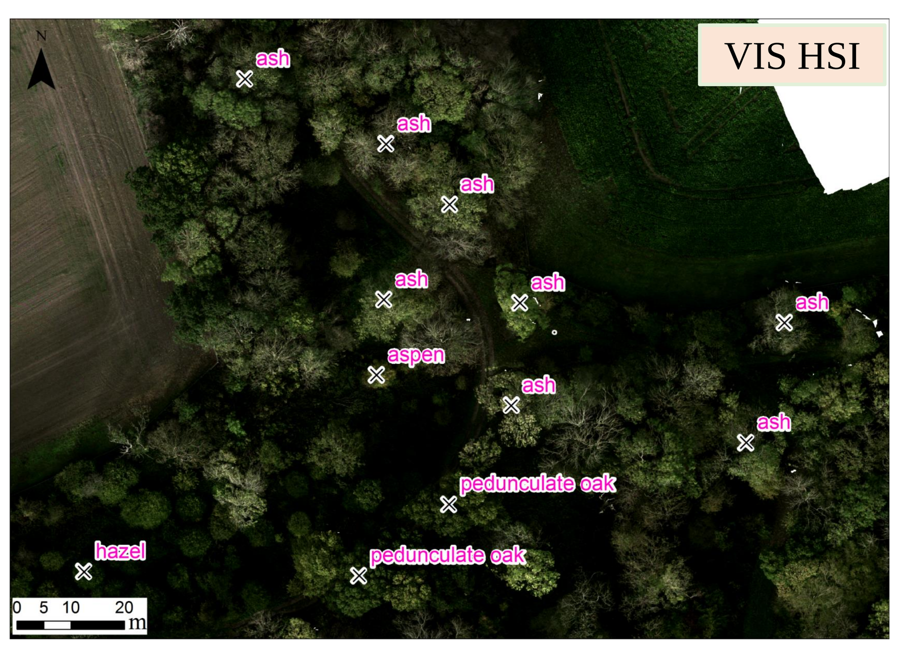
HS imaging of dried bananas samples, ripe and unripe ones. PCA, K-means and FCM were used to classify the findings.

UAS Surveys

Creation of orthomosaic maps from aerial imagery

- Combined HSI and Sequoia+ data along with the GPS information.
- Creation of survey maps.
- Application of classification algorithms trained on ground-based data .





UAS hyperspectral imagery was acquired on 31st October 2018 over a mixed deciduous and conifer woodland at Big Wood, Suffolk, UK. The tree species ground truth was collected in a separate field campaign on 30th October 2018.

Conclusions

Hyperspectral remote sensing technology has advanced significantly in the past two decades. It offers unique spectral and spatial resolutions enabling numerous applications which require detailed identification of materials or estimation of physical parameters.

We have developed a lightweight HSI system which can used in various environments. The system is dynamic allowing us to move forward with the increasing demands for HSI systems which can be deployed on UAS surveys. Furthermore, the calibration processes and data analysis techniques are constantly updated to meet international requirements and push the accuracy of the techniques to the highest standards.

Acknowledgment

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