EPSC Abstracts
Vol. 11, EPSC2017-1012, 2017
European Planetary Science Congress 2017

A Novel Method for Forming a Hyperspectral Image

C.E. Huntly (1), D. Langstaff (1), M. Gunn (1), R. Cross (1), L. Tyler (1), A.P. Gay (2), C. Cousins (3)

(1) Institute of Mathematics, Physics and Computer Science, Aberystwyth University.
(2) Institute of Biological, Environmental and Rural Sciences, Aberystwyth University
(3) Earth and Environmental Science, University of St Andrews

Introduction

Spectral imaging is the combination of the fields of spectroscopy and imaging; there are two non-distinct areas of spectral imaging classified by the number of spectral bands the imager is capable of taking. Multispectral imagers capture discrete areas of the spectrum, typically selected for specific science outputs. Hyperspectral imagers build up sufficient spectral bands to form a contiguous spectrum. The data is stored in a three dimensional image cube, where each pixel contains a complete spectrum. The dimensions in an image cube represent the traditional x and y dimensions in the two dimensional spatial frame, with the third dimension, λ, representing the spectral information.

There are multiple existing techniques that build up these image cubes, as shown in Figure 1. Those detailed here are:

- **Whiskbroom**
  A single point is scanned across the x and y frames by moving either the sample or the detector. [Li et al., 2013]
- **Pushbroom**
  A line scan is gathered across one axis and spectral information is obtained by spectrally dispersing the image creating a 2D image with spatial information on one axis and spectral on the other. A series of scans is then taken to complete the image cube. [Aiazzi et al., 2006]
- **Staring**
  A dispersion element such as a fixed bandpass filter or a liner variable filter (LVF) is used to capture a narrowband of the spectrum. A series of 2D images build up the image cube. [Gupta, 2011]
- **Snapshot**
  Both spectral and spatial information is recorded in one exposure using a slicer stack and a series of lenses and detectors. [Li et al., 2013]

Multispectral and Hyperspectral Imagers are particularly useful for space applications; for example, in planetary exploration where spectroscopy studies can be more easily carried out by camera systems than by spectrometer

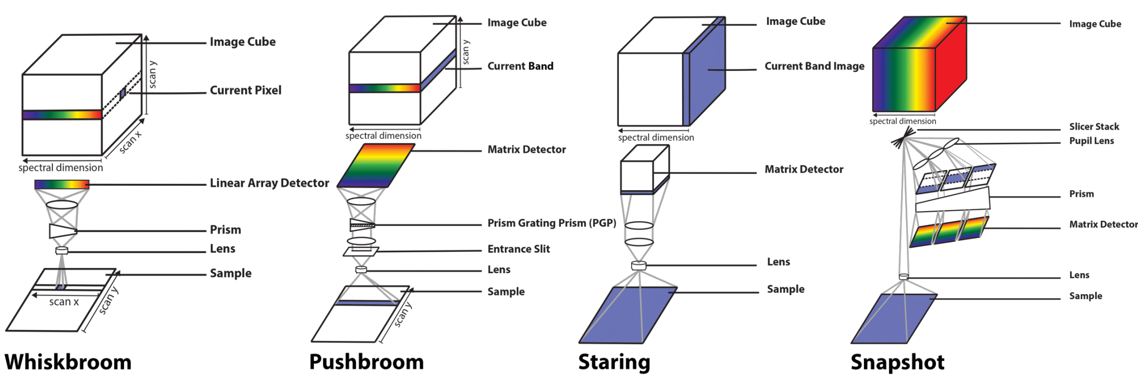

Figure 1: Existing Spectral Imaging Techniques. Adapted from [Li et al., 2013]

equipment primarily held in the body of a rover. The relatively small data sets are sent back to Earth and processed through existing imaging processing pipelines. Hyperspectral Imaging was however developed initially for remote sensing purposes; still it's primary use today [Goetz, 2009].

Instrumentation

The proposed new technique of hyperspectral imager being developed in Aberystwyth is a windowing-pushbroom camera system, SPEC-I. It is fitted with a LVF in an actuator making it possible to cover a wide range of wavelengths in a small imaging system.

The image can be built up in two ways, shown in Figure 2, the first is to fix the linear variable filter over a desired wavelength range and then either move the camera or the subject. The second method of gaining a hyperspectral image set is to scan the LVF across the optical path, keeping both the camera and the subject stationary. The image cube is built up over a series of 2D frames.

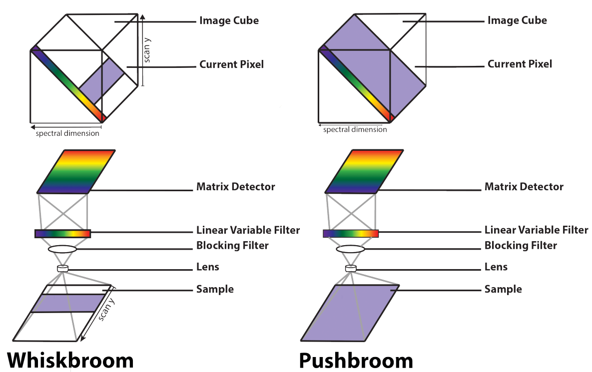

Figure 2: Aberystwyth Novel Hyperspectral Imager - SPEC-I

Application Area

SPECI-I is a hyperspectral imager that has been delivered as part of continued collaborative work with the UK Space Agency under Crest 2. It is a functioning field camera designed with agricultural purposes in mind. As such it has a spectral range that includes the Near Infrared, essential for plant diagnostics. NIR is essential because of the "red-edge" that can be used as a diagnostic tool in plants, to the level where farmers can pin-point levels of nitrogen or water required at a plant specific level. [Boggs et al., 2003]

Preliminary Results

Back down to Earth SPEC-I has been initially tested in partnership with the Institute of Biological, Environmental & Rural Sciences. A plant that had both healthy and damaged material was imaged from 500 – 1100nm. The healthy spectrum shown in Figure 3 is indicative of a healthy "red edge". It is clear from the damaged spectrum that it does not adhere to the "red-edge" and has peaks that may be indicative of certain causes of damage.

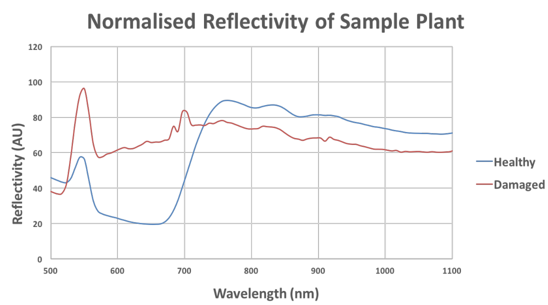

Figure 3: Initial Results from Plant Damage Investigation

Reference:

1. [Li et al., 2013] Li, Q., He, X., Wang, Y., Liu, H., Xu, D., and Guo, F. (2013). Review of spectral imaging technology in biomedical engineering: achievements and challenges. *J Biomed Opt*, 18(10):100901.
2. [Aiazzi et al., 2006] Aiazzi, B.,et al.(2006). Noise modelling and estimation of hyperspectral data from airborne imaging spectrometers. *Annals of Geophysics*, 49(1):1-9.
3. [Gupta, 2011] Gupta, N. (2011). Development of staring hyperspectral imagers. pages 1-8.
4. [Goetz, 2009] Goetz, A. F. H. (2009). Three decades of hyperspectral remote sensing of the Earth: A personal view. *Remote Sensing of Environment*, 113(SUPPL. 1):S5-S16.
5. [Boggs et al., 2003] Boggs, J. L., et al. (2003). Relationship between hyperspectral reflectance, soil nitrate-nitrogen, cotton leaf chlorophyll, and cotton yield: A step toward precision agriculture. *Journal of Sustainable Agriculture*, 22(3):5-16.