Real-time hyperspectral Imaging – realising the potential of simultaneous, co-registered, 2D spectral capture at video rates

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Novel full frame, non-scanning, real-time imaging spectrometers combine the simplicity of a point and shoot camera with the precision of hyperspectral imaging. A new range of real-time spectral imagers has been developed with the capability of measuring between 4 and 125 spectral bands. In all cases the spectral information is captured simultaneously at all pixels in a snapshot mode with no need for push broom scanning. Integration times as fast as 1 ms are achievable which enable true video-frame imaging. The implications of this technology will be discussed with reference to a range of applications including remote sensing of crops, medical/life science imaging and food analysis.

In this contribution, we provide an overview of the three technical approaches used to create the different categories of hyperspectral full-frame cameras manufactured by Cubert GmbH. These include techniques based on multiple sensors, mosaic filter arrays and more traditional imaging spectrometer designs using micro-lens arrays.

We shall present details of a validation study using the Cubert UHD185 Firefly imager in a UAV-based remote sensing application. The potential of UAV-based imaging in agricultural applications is already well known for monitoring crop growth, behaviour, crop vitality, and crop stress. In this case, the camera uses the microlens array technology to record hyperspectral full-frames with 137 wavebands in a spectral range of 450 nm – 950 nm. A silicon CCD chip captures an image with 1000 by 970 grayscale pixels as well as 50 by 50 hyperspectral pixels. At a flying altitude of 30 m the grayscale image has a ground resolution of about 1 cm and a pure hyperspectral ground resolution of about 20 cm. The latter may be pan-sharpened to the resolution of the grayscale image. Results from the hyperspectral images are compared to related spectra collected with a portable field spectroradiometer.

We shall also present similar UAV based images obtained from a newly developed imager using the filter on chip technology producing improved spatial resolution. The ButterflEYE imager operates at high frame rates on UAV's to generate 160 spectral waveband (450 to 950nm) hyperspectral maps with a ground resolution of up to 9cm (from 180m altitude). As a result, the system allows single plant monitoring in, for instance, small experimental field plots of a few m^2 within an area of approximately 1 ha. Examples of the ButterflEYE image processing software will be presented including true colour, false-colour image composites, spectral index maps and digital surface models (3D model of the terrain's surface).

The ability to produce video-rate hyperspectral images without the need for scanning (such as with push broom imagers) opens up many other applications in areas such as medical or life science imaging and food quality/safety. We shall present images from some of these applications obtained using cameras based both on the mosaic filter and microlens array technical designs.