A NOVEL HYPERSPECTRAL IMAGING SYSTEM FOR LOW LIGHT APPLICATIONS

Antonio Perri[1], Giulio Cerullo[1,2,3], Dario Polli[1,2,3], and Fabrizio Preda[1]

[1]NIREOS S.r.l., Via G. Durando 39, 20158 Milan (Italy)
[2]Dipartimento di Fisica, Politecnico di Milano, Piazza Leonardo da Vinci 32, I-20133 Milano, Italy
[3]Istituto di Fotonica e Nanotecnologie (IFN)-CNR, 20133 Milano, Italy

ABSTRACT

We present a novel patented hyperspectral camera in the visible and near-infrared regions (0.4–1 μm) based on a Fourier Transform (FT) approach. It employs a bidimensional CMOS sensor in combination with an objective and a common-path birefringent interferometer (CPI), which generates two delayed replicas of the image with remarkable accuracy and stability. The CPI also overcomes the limitations of other prism-based imagers (based on Wollaston or Savart configurations), providing negligible chromatic dispersion and small geometrical separation between the interfering replicas, leading to a high degree of coherence at each pixel and a strong interference modulation. The objective (with 25mm focal length and maximum aperture f/1.85) collects the light and creates an image on the silicon monochrome CMOS camera (1.3 Mpixel, 12-bits) with a few-millisecond exposure time. The three-dimensional data is collected in the time-domain, by stacking together multiple images acquired at different positions of the interferometer. An FT at each pixel of the image provides the final hyperspectral data-cube, with spatial resolution only limited by the objective and the sensor. As a result of an FT, each pixel yields a continuous spectrum, with a virtually unlimited number of bands, not defined by the hardware.

The employed optical system ensures a high spectral accuracy and a spectral resolution, proportional to the wavelength as in any other FT techniques, corresponding to 3 nm at 600 nm. Thanks to the absence of aperture slits and gratings, and to its 10-mm clear aperture, the presented hyperspectral camera is specifically designed to provide an extremely high light throughput, making it the ideal device for low light conditions or delicate samples, both in reflectance and fluorescence modalities. As examples of application, this device has successfully been employed in biology and vegetation studies, and in the study of works of art and cultural heritage, where low-illuminance conditions are recommended in order not to damage the samples. In this field, it has been used to investigate on the attribution and the dating of paintings, to monitor their state of conservation and to assess their authenticity.

Finally, the good spectral resolution and broad spectral coverage provided by the CPI allows a straightforward extension of the camera to the SWIR region (up to 2.3 μm), simply by employing a suitable detector and objective. Preliminary measurements obtained with the SWIR hyperspectral camera prototype on food applications will be presented.