A Polarimetric Hyperspectral Imaging Sensor*

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This paper reports recent development of a polarimetric hyperspectral imaging (PHSI) prototype sensor system that uses an acousto-optic tunable filter (AOTF) as a wavelength sorter and a polarizing beam splitter. The objective of this work is to evaluate the AOTF technology for remote sensing applications.

AOTF is a high resolution, rapidly tunable spectral bandpass filter which uses the diffraction of an incident light beam at a moving grating produced by an acoustic wave in a birefringent crystal. An AOTF instrument is capable of observing two orthogonally polarized images at a desired wavelength at one time. The selection of operating wavelength is done by tuning the frequency of a RF power supply to a transducer mounted on the crystal. Therefore, the filter can operate in a sequential, random (wavelength hopping), or multiple wavelength mode, providing a unique operational flexibility. Furthermore, AOTFS can provide high spectral resolution ($\lambda/\Delta\lambda$) of 102-104. This high resolution capability gives opportunities to characterize materials through the remote sensing of reflection, absorption, or emission spectra.

A PHSI prototype system using a $Te0_2$ AOTF was, for the first time, developed and tested in outdoor field experiments. It operates in a wavelength range of 0.48-0.76 microns. The system was put together with the out-of-the-shelf items. It is capable of providing needed information to illustrate the potential of the AOTF technology for remote sensing applications.

Each data set was formulated into a number of image-wavelength cubes for exploiting the advantages of this technology. They include the cubes in first and second spectral derivative, and polarization ratio domains. The results illustrate the system capabilities to measure polarizing scattering of aerosol in atmosphere, polarization and spectral signatures of natural and manmade objects.

Spectral signature of an object depends on reflection spectra of its surface materials, whereas polarization signature relates to geometric structure of the surface, Simultaneously measuring of polarization and spectral signatures can provide a powerful technique for remote sensing applications. Because polarization signature can vary with light incident and viewing angles, the technique come with complexity, requiring an in-depth understanding of the mechanisms involved. Our field test results have illustrated that polarization-spectral imaging can enhance distinction of man-made objects from natural substance,

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