Wang, Yi, "Multispectral Laser Based Optical Sensing"

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Multispectral laser sensing is a growing research area with applications in robotic/ machine vision, nondestructive testing, environmental monitoring, military remote (stand-off) sensing, and medical imaging and diagnostics. Lasers of diverse wavelengths beyond the human visible spectrum can be used to acquire object spectral signatures, i.e. "colors" that are far more distinctive and informative than the object natural emission.

A 7-λ near-IR and a 4-λ mid-IR imaging sensing systems using semiconductor lasers have been developed for this research. Unlike the conventional one-transmitter (Tx)/one receiver (Rx) design, the system is based on the scalable network concept, in which multiple transmitters and receivers can be deployed with arbitrary any-to-any connectivity to allow NxM information scaling rather than linear N scaling. For signaling, the code-division-multiple-access (CDMA) architecture was used to allow ease of scaling as well as robustness against interference. Wavelength-division-multiplexing technique was used to combine the multi-spectral beams. An optical galvanometric scanner was used to generate 2D rasters on the target. A digital signal processor was built to perform all-digital signal and image acquisition and processing.

Experimental results include fast detection of contaminants in turbid media, simultaneous multispectral and multi-perspective acquisition of a scene, detection of an invisible gas that is rendered visible with image fusion, and various target spectral discrimination in the mid-infrared. In particular, wavelength modulation imaging (WMI) experiments employing a tunable mid-infrared laser theoretically and experimentally demonstrated the importance of both spectroscopic and geometrical aspects of a target signature. A synthetic imaging approach combining 2nd order WMI of CO gas and passive imaging technique allows chemical visualization with clutter rejection capability. Application of WMI to low-spectroscopic targets shows its capability to reveal features in higher order images not evident in the 0th order image. For the mid-infrared region, which is rich of molecular spectral fingerprints, the system was capable to resolve and distinguish small spectral differences among a diverse group of targets that consisted of both man-made and natural materials and objects at a stand-off distance from 13–40 m.

Colorless (black or transparent) objects in the visible become “colorful” in the mid-IR. A demonstration of 3D multispectral imaging was also obtained. The results suggest that laser-based multispectral imaging can be a unique and powerful technology for target discrimination and visualization.