National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Sensors

Multi-Spectral Imaging Pyrometer

Solid-state broadband infrared imaging system with high dynamic range

Innovators at NASA Langley Research Center have developed a multi-spectral imaging pyrometer utilizing tunable optics. The system uses a conventional infrared imaging camera as the basis and then incorporates an ultrafast, all solid-state, tunable optical filter combined with unique data processing algorithms to function as a multi-color ratio pyrometer but with true imaging capabilities.

Currently, there is no way to provide automatic, independent, emissivity-based temperature corrections at the pixel level for infrared cameras that operate with broadband detectors. Multiwavelength pyrometric systems can make emissivity-corrected temperature measurements but are not imaging devices and lack the ability to view surface gradients and other subtle variations. Optical systems that measure at several discrete wavelengths require the use of multiple optical filters and are slow, bulky and require high power.

BENEFITS

- Improved reliability: Solid-state design with no moving parts and small form factor
- Expanded dynamic range: Controlling the Q factor prevents saturation and underfill of detector pixels, enabling detection of temperature over a wider range.
- Enables improved accuracy of temperature measurements: The ability to accurately calculate emissivity as well as gradients over a 2D scene improves the quality of critical temperature information while simplifying data acquisition.
- Broadband capability: The system operates within the wavelength range of 2-10 μm enabling measurement of temperature for a wide range of materials with varying emissive character; the tunable filter may also have applications in detection of multiple known chemical threats that have absorption peaks in this range of wavelength.

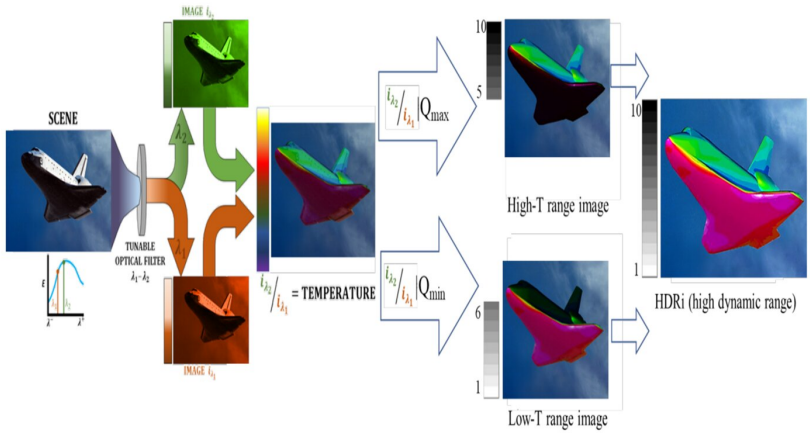
APPLICATIONS

The technology has several potential applications:

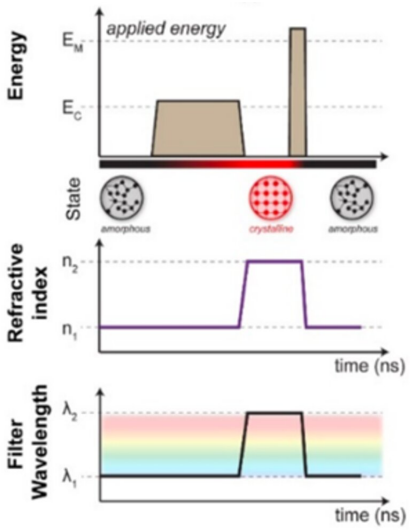
- Aerospace: Imaging and analysis of rocket plumes, combusting flows, and heat shields
- Metals Manufacturing: Process monitoring the melting of metallic ores in mixed states or the formation of surface slag
- Welding: Accurate imaging of weld pool temperatures
- Kiln Processing: Process monitoring in cement kilns

THE TECHNOLOGY

This NASA technology transforms a conventional infrared (IR) imaging system into a multi-wavelength imaging pyrometer using a tunable optical filter. The actively tunable optical filter is based on an exotic phase-change material (PCM) which exhibits a large reversible refractive index shift through an applied energetic stimulus. This change is non-volatile, and no additional energy is required to maintain its state once set. The filter is placed between the scene and the imaging sensor and switched between user selected center-wavelengths to create a series of single-wavelength, monochromatic, two-dimensional images. At the pixel level, the intensity values of these monochromatic images represent the wavelength-dependent, blackbody energy emitted by the object due to its temperature. Ratioing the measured spectral irradiance for each wavelength yields emissivity-independent temperature data at each pixel. The filter's Center Wavelength (CWL) and Full Width Half Maximum (FWHM), which are related to the quality factor (Q) of the filter, are actively tunable on the order of nanoseconds-microseconds (GHz-MHz). This behavior is electronically controlled and can be operated time-sequentially (on a nanosecond time scale) in the control electronics, a capability not possible with conventional optical filtering technologies.



Representation of the algorithm used to create a high dynamic range infrared (HDRi) image.



Caption: Phase change material (PCM) filter device concept: An all solid-state spectrally tunable bandpass filter is achieved through integration of PCM as an "active" cavity in a Fabry-Perot filter.

PUBLICATIONS

Patent Pending

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

Langley Research Center

Mail Stop 020
Hampton, VA 23681
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

www.nasa.gov

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