High-Speed Infrared Imaging for Characterizing Combustion Processes

Interview conducted by Mychealla Rice Mar 29 2017

Marc-André Gagnon, Field Application Scientist at Telops, talks to AzoOptics about the characterization of combustion processes using infrared radiation and the future of infrared imaging in combustion sciences.

Can you give a brief overview of the company and the work you do?

Telops is a leading supplier of scientific, high-performance infrared cameras for defence, industrial, and academic research applications. We provide hyperspectral, multispectral, high-speed, as well as high-dynamic range thermal infrared cameras to scientists and industrial researchers all over the world. Telops also offers R&D services for optical systems technology development in order to respond to the specific needs of its customers.

As a Field Application Scientist at Telops, I am responsible for providing expert knowledge on thermal infrared imaging to my team as well as help and support to our clients or potential clients. Training and vulgarizing constitute the main part of my job.

What is infrared radiation and how can it be useful for the combustion community?

All objects spontaneously emit heat radiation within the 2 and 12 microns, which refer to the mid-infrared spectral range. By establishing a correlation between the heat picked up by the detector of an infrared camera and the temperature of a known reference material, we can, technically speaking, measure the temperature of objects from a distant location. However, since infrared self-emission results from molecular vibrations, and since all materials are not made from the same molecules, different materials and/or molecules will have different infrared signatures.

Can we identify the chemical nature of gases using a thermal camera?

Yes, but we need some spectral information in order to do so. The amplitude of the infrared signature of infrared-active gases is function of wavelength. These molecules typically absorb and emit infrared radiation over very narrow spectral ranges, much narrower than the sensitivity range of typical broadband infrared detectors. For example, a midwave infrared (MWIR) detector provides a single response for all contributions, whatever their nature (solid, gases...) within the 3-to-5 micron range. Hot methane gas only emit infrared radiation within the 3.1-to-3.5 micron range, while carbon monoxide (CO) emits in the 4.1-to-5 micron range. Both signals can be picked up by a MWIR detector. Therefore, if we want to discriminate hot methane from hot carbon monoxide using infrared imaging, we need some kind of infrared response.

How can we do that?

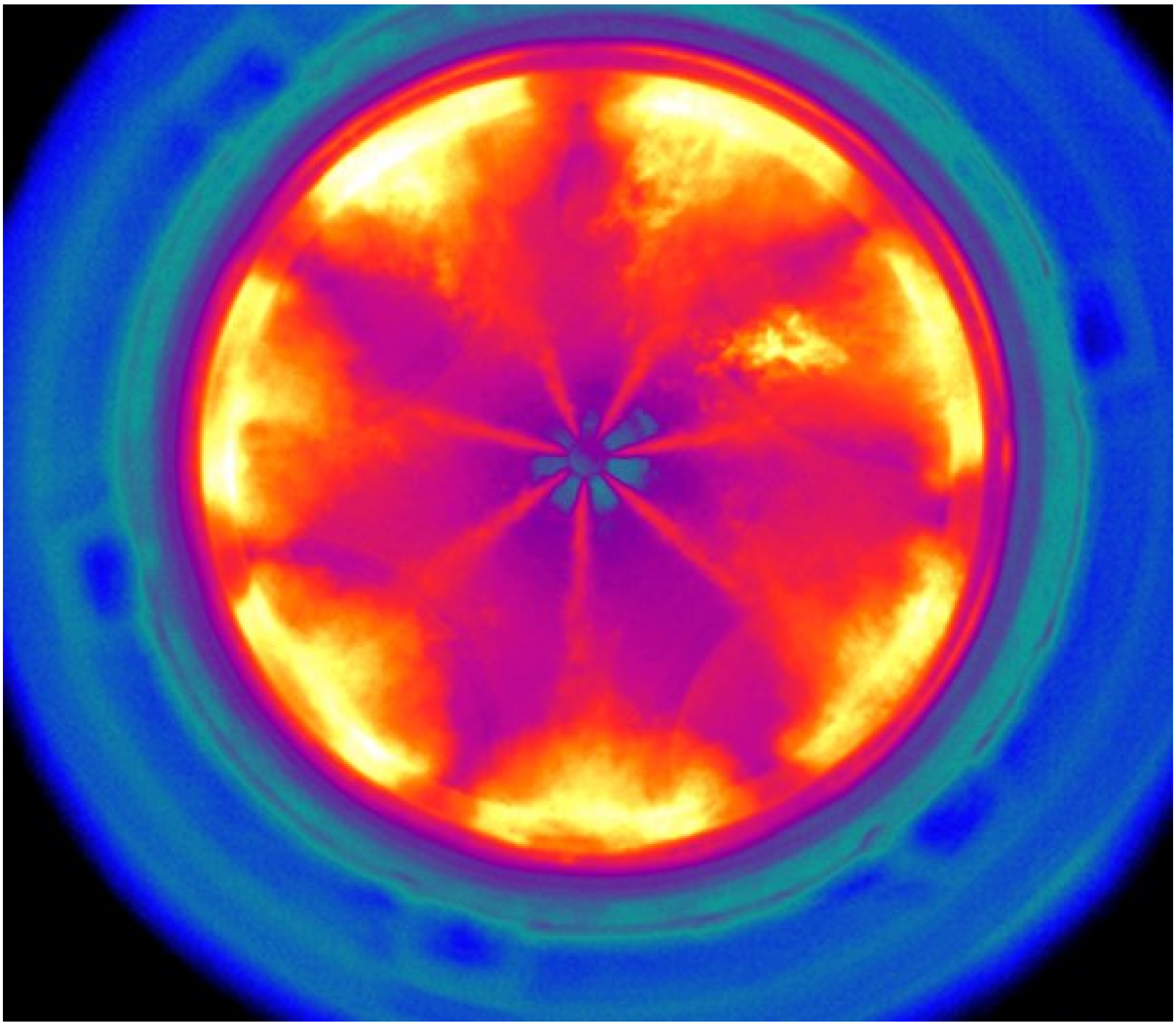
There are different strategies. The simplest one is called narrowband imaging, which consists in adding a bandpass filter to the optical system. By temporarily narrowing down the spectral range of the camera's detector to a specific spectral band, the image's contrast will be highly representative of the presence and the amount of a specific chemical. In order to scan different spectral bands as a function of time, we can carry out imaging in combination with a spinning filter wheel. This is called multispectral imaging. Finally, we can use hyperspectral imaging, which uses a very different technology to obtain hundreds and even thousands of spectral bands.

Can all these technologies be used for characterizing combustion processes? Under what conditions?

Yes. For very fast events and/or periodic processes, like fuel injection, narrowband imaging should be used. The same experiment can then be performed repeatedly using a different spectral filter each time. For unsteady systems like a detonation, multispectral imaging performs best, and provides the best combination of spatial, spectral and temporal resolution. The time needed for a hyperspectral imaging sensor to provide a full high-resolution spectrum for each pixel is somewhat incompatible with turbulent processes. For this reason, this technology performs best in steady conditions like laminar flames.

Are these techniques essentially qualitative, or can we get quantitative results?

This is a very good point. Most research scientists are interested in having quantitative information. The physical quantity measured by a narrowband or multispectral infrared sensor is in-band radiance with units of $W/sr.m^2$. This quantity can be expressed in terms of thermodynamic temperatures (K or °C), and/or column densities (ppm × m), using a proper radiative transfer model. Hyperspectral sensors provide spectral radiance data, which is even better for achieving this task.



What is in store for the future of infrared imaging in combustion sciences?

Most combustion processes require high acquisition framerates as the phenomena take place over very short time frames. Whether you are interested in the spray pattern of an injector, the spark during an ignition sequence or the turbulence patterns in a gas turbine, you need high framerates for proper imaging. For this reason, the combustion community can only benefit from technological improvements in this domain. Telops has established itself as a leader in high-speed infrared imaging by bringing innovative products on the market year after year. Combining high-speed imaging with multispectral capabilities provide performance and flexibility for scientists in combustion research.

Telops' new M2*k* fast multispectral camera is among the most versatile and efficient product on the market for achieving such tasks – its 8-position fast-rotating filter wheel combined with the fastest infrared detector on the market makes it the ideal tool for dealing with dynamic systems such as flames and engines.

Where can our readers go to find out more?

My colleague Alexandrine, a fellow Field Application Scientist and I are always eager to help people understand the basics of infrared imaging. You can contact us at contact@telops.com

About Marc-André Gagnon

Dr. Marc-André Gagnon is a field application scientist at Telops, a leading provider of high-performance broadband infrared, multispectral and hyperspectral imaging systems. He received his bachelor’s degree in chemistry from Université de Sherbrooke (Canada) in 2002 and his doctorate in chemistry, with an emphasis on spectroscopy, from Université de Montréal (Canada) in 2009. Before joining Telops in 2011, he has previously worked as a R&D chemist for various environmental, pharmaceutical and hydrometallurgy companies. Dr. Gagnon contributes to the progress and development of new applications in the field of infrared remote sensing through publications and conferences on a regular basis.

Telops Inc.

Address

100-2600 St-Jean-Baptiste Avenue
Quebec
Quebec, G2E 6J5
Canada

Phone: 1 (418) 864 7808

Email: contact@telops.com

Visit Website

Telops specializes in the design and production of sophisticated opto-electronic systems for the defense, aerospace and telecommunications industries. A reliable source of accelerated innovation inoptronics, the experienced engineering team thrives on high expectations and great challenges. Technical experts understand your business and their diverse backgrounds represent a powerful source of innovation.

Telops also excels at project management while remaining flexible since the team understands that changes can be inevitable. Whether you are looking for equipment, expertise or outsourcing, we will turn your high expectations into success.

Primary Activity

Opto-Electronic Systems