MULTIPLIR—Portable Long Wave Infra-red Camera for Gas Detection

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Combining a long wave infra-red bolometer, germanium microlens array and an interference filter matrix we create a compact portable multispectral system suitable for direct quantitative gas detection. Many regulated gases have absorption line in the long wave infra-red, e.g., NH_3, methane, SF_6, N_2O, and Freon. Applications include helping firefighters locate dangerous gas leakages such as ammonia, gas leakage monitoring in industry and specifically those dealing with compressed gases, such as fuel gas control on Liquefied Natural Gas carrier ships or Low-Density PolyEthylene production with hyper compressors.

Detection in the thermal infrared wavelength region has applications in environmental testing, agriculture, life science and medical markets. The rapid market expansion can be attributed to the recent advances in Long Wave Infra-Red (LWIR) technologies, in particular the apparition of cost-effective LWIR bolometers cameras and the invention of IR glass which allows inexpensive LWIR optics for high volume applications.

Many gases and materials have direct spectral signatures in the LWIR, for example greenhouse gases or ammonium sulfate. By attributing and quantifying these absorptions or reflections lines we identify and quantify these elements.

In this project, CSEM combines thermal imaging, filters and signal processing techniques to visualize and identify materials using their infra-red spectral signatures. This is useful to monitor gas leakage, gas emissions or to distinguish materials. One use case was is to help firefighters detect ammonia, which is highly toxic and common in modern building's cooling systems. In such cases it is important for the firefighters to locate the ammoniac leakage to be able to isolate and seal it quickly. Other industrial use cases are when gas leakage monitoring can avoid large air pollution, monitoring in cargo ships for loss during transport, decrease greenhouse gas contributions or minimize explosion risks in industrial sites.

CSEM is developing a multispectral optical system in the LWIR, composed of up to 35 spectral wavelengths. A bolometer with 1024x768 pixels is used as the detector. Each wavelength forms its own spectral image in a narrow spectral band given by passing through a dedicated filter (Ref to patents: WO2018115320 & WO2018113939). This results in 35 imagelets with a resolution of about 150x150 pixels.

As alternative to commercial interference filters, CSEM is developing Fabry-Perot filters based on porous metallic mirrors that will lead to cheaper filters when produced in large quantities with microfabrication technologies and processes (patent pending).

The optical system was reproduced using optical simulation software (ZEMAX). An image simulation and a typical quality parameter (Modulation transfer function MTF) are presented on Figure 1. A picture of the 35 imagelets is presented on Figure 2.

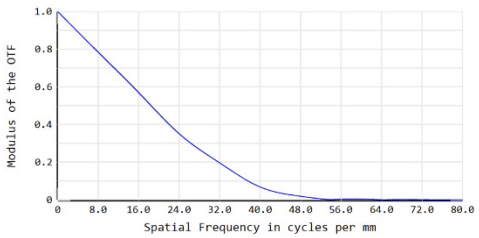

Figure 1: Image simulation and MTF quality parameter.

Using the absorption spectrum of the gases of interest and the filters transmission spectrum, image processing software is currently being developed to locate and measure specific gases and materials.

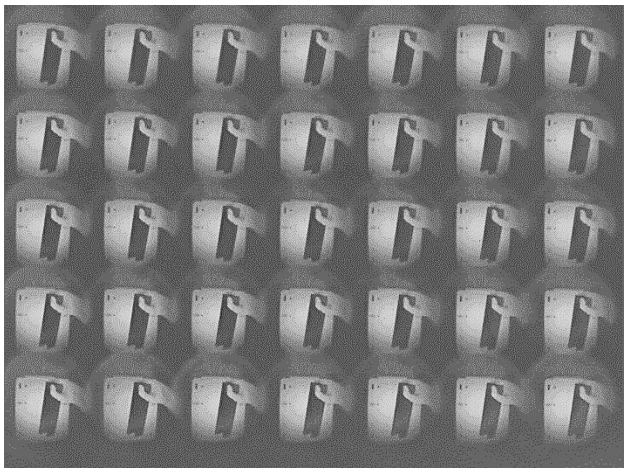

Figure 2: Example of an image with 35 imagelets.

The system has been tested with different gases (N_2O, SF_6, NH_3) using a gas cell with IR transparent window. The cell was filled with a target gas at different pressure. Imagelets at different wavelength were recorded. As expected, the absorption of the gas at the specific wavelength can be directly visualize on images (Figure 3 left). Software identifies the gas and estimates its absorption (Figure 3 right).

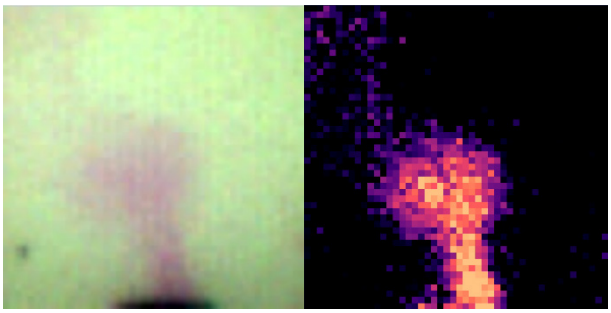

Figure 3: Visualization of NH^3 vapors coming out from a bottle: left composite image (left), concentration map (right).

Using the latest technology of thermal imaging and filters, it was possible to demonstrate the feasibility of visualizing a gas with a specific absorption in the Long Wave Infra-Red. Detection in the range of dozens ppm.m for gas like SF6 can be reached. The system is portable and can be adapted to different gas panel by changing the microarray of filters.

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