APPLICATION NOTE

Airborne Detection of Methane Leaks using Hyperspectral Imaging

Abstract

The worldwide natural gas transmission and distribution system is composed of millions of kilometers of pipelines and by thousands of transmission and compressor stations, valves and distribution centers. With an ever-increasing regulatory pressure and increased cost of raw material, Oil & Gas, pipelines companies and distributors are worried about gas leaks occurring in their aging infrastructures. The choice of reliable and cost efficient gas leak detection technologies is an important challenge for those companies. Various technologies and products are currently used to detect these leaks, minimizing the associated hazards and risks to the environment and for the population.

Integrated into a fully automated gimbal onboard a helicopter, the Telops Hyper-Cam, an infrared hyperspectral imager, has been used to perform an airborne detection of a methane gas leak. This paper describes how the remote detection of a methane gas leak was successfully achieved with the Telops airborne hyperspectral imaging system.

Introduction

Natural gas leak detection in the transmission and distribution system is a responsibility that Oil & Gas and pipeline companies must assume. While these leaks represent important revenue losses, they also pose serious threats to the environment and to the public security. This is why surveillance and monitoring of these infrastructures require the use of rapid, selective and sensitive detection technologies and tools. Due to the flammable nature of natural gas, remote sensing is the ideal and safest way to detect gas leaks, making airborne detection the preferred and the most cost efficient approach as large distances can be rapidly inspected in a short period of time. Indeed, standard detection methods are mostly efficient when short distances between the monitoring device and the gas leak are involved. Thus, the suitable method for airborne leak surveying is performed only by traveling close to leak plumes.
Remote sensing using Fourier transform infrared spectroscopy (FTIR) is a non-invasive technique for the detection and identification of gases such as methane (CH_4), the main component of natural gas.

The Telops Hyper-Cam is a remote sensor based on FTIR spectroscopy presenting unique spatial, spectral and temporal resolution capabilities. The Telops Hyper-Cam sensor was integrated into a gimbal as illustrated in Figure 1. The usefulness of airborne hyperspectral imaging for the detection of methane leaks is demonstrated in this paper.

Figure 1: Telops Hyper-Cam mounted into a Gimbal on a helicopter

Experimental information

Airborne Hyper-Cam System

The Telops Hyper-Cam is a compact hyperspectral imaging instrument using Fourier Transform Infrared (FTIR) spectroscopy. It provides a unique combination of spatial, spectral and temporal resolution for a complete characterization of the substances being monitored. Its high performance and efficiency as a standoff chemical agent detector has been proven through numerous field campaigns. The Hyper-Cam Long-Wave features a Focal Plane Array (FPA) detector containing 320×256 pixels over a basic 6.4°×5.1° field of view. The spectral resolution is user-selectable between 0.25 and 150 cm^{-1} over the 8.0 to 11.8 µm spectral range. The Hyper-Cam offers a high sensitivity for each pixel of the scene under observation. The Hyper-Cam was designed from the ground up so the control and the data acquisition are specifically optimized. The sensor is capable of generating calibrated hyperspectral images (Fourier transformed and radiometrically calibrated) in real-time at the highest data rate available. For the airborne survey, the Telops Hyper-Cam was integrated into a fully automated PV Labs Look-Down gimbal compensating for perturbations by pitch and roll shifts as well as vibrations (Figure 2).

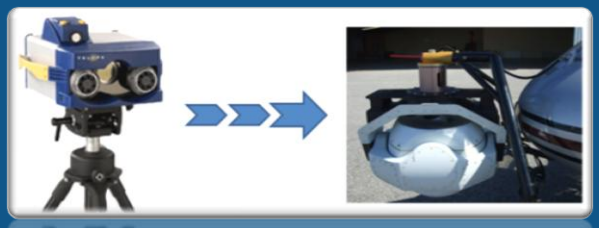

Figure 2: The Telops Hyper-Cam integrated into a PV Labs Look Down gimbal

Hyperspectral images were recorded at an altitude of 450 meters (1500 feet) above the leak site. The helicopter was stationary and heading toward a wind of 10 km/h during the acquisitions. At this height, one pixel represents an area of 15 × 15 cm. A methane gas leak of 20 L/min was monitored at a spectral resolution of 6 cm^{-1} leading to a recording time of 0.8 second per image.

Results & Discussion

In-Flight Hyper-Cam Performances

In-flight performance tests were carried out with the Hyper-Cam mounted in the gimbal and the results were found to be similar to factory measurements in similar conditions. Small translational shifts, on the order of 1 to 2 pixels per acquisition, were measured for each recording. Therefore, vibrations and movements induced by the helicopter were well compensated and good images could be recorded during the test flight.

Airborne Leak Detection

Figure 3 shows the visible image recorded during the flight over the leak area. Successive hyperspectral images were then recorded at this location.

A clutter match filter (CMF) was applied to the hyperspectral images in order to selectively detect methane from its background environment. As shown in Figure 4, methane gas can be clearly identified from the rest of the scene at different times using the methane spectral features located in the 1250 to 1350 cm^{-1} spectral region of the infrared spectra. Moreover, the leak source can be easily ascertained in each image proving the potential of airborne hyperspectral imaging for leak detection purposes.

Figure 3: Visible image of the leak area as recorded during the flight at an altitude of 450 meters (1500 feet)

Conclusion

Remote gas leak detection of methane was successfully achieved using the Telops Hyper-Cam system mounted in a gimbal. By using this airborne system, gas leak detection can be carried out in an efficient and safe way over large areas and long distances. Hyperspectral imaging offers an advantageous and cost-effective approach for airborne identification of gas leaks in natural gas transmission and distribution system infrastructures.

Figure 4: Consecutive detection images of a methane (purple) leak as seen from the Telops airborne hyperspectral imaging system at an altitude of 450 meters (1500 feet)

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