Abstract

Raman spectroscopy has emerged as a promising technique in this context due to its molecular fingerprinting capability, which enables highly specific chemical identification. However, conventional Raman spectroscopy is limited by its point-detection nature, significantly hindering its effectiveness over large areas—especially in standoff scenarios.

Traditional Raman imaging, however, requires long acquisition times due to its point-by-point spatial scanning approach. This limitation can be overcome by implementing a Raman imaging system based on a single-pixel camera (SPC) framework integrated with compressive sensing (CS) principles. An SPC consists of a single photodetector combined with a spatial light modulator (SLM), which applies a series of coded masks onto the scene. The photodetector then measures the total intensity for each mask.

This research focuses on the development of SPC technology using compressive sensing. It investigates how the transmittance of coded masks and the number of CS measurements affect image reconstruction quality. The study further explores the use of the SPC modality in spectral imaging, evaluating spectral image quality against ground truth image. It demonstrates that high-resolution spectral imaging systems can be developed using the SPC approach and assesses the performance of various CS-based reconstruction algorithms.

A Raman spectral imaging system based on SPC modality was developed and applied in practical scenarios, showcasing significant improvements in acquisition speed, standoff detection range, and classification of multiple explosives based on reconstructed image using Raman light. The research presents a cost-effective, scalable, and high-resolution Raman spectral imaging platform based on compressive sensing.