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Hyperspectral cascade laser-image based quantitative trace detection: Some practical aspects

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The possibility of mid-IR laser based hyperspectral imaging for trace detection has been shown mostly in the laboratory by several groups over the last 6 years. Commercial availability of Quantum and Interband Cascade Lasers (QCL/ICL) and recent advancement in sensitive and cost effective LWIR cameras have been the main enablers of this technology. Although operational proof-of-principle have been shown successfully in optothermal (or photothermal) and diffuse reflection techniques, there exists some technology barriers before any of these methods can result in practical devices for real world situations in security, chemical, health care and medical diagnosis sectors. As a way of convenient device characterization for comparing different techniques, optimization of 3S parameters representing Sensitivity, Specificity and Speed of detection was proposed besides the obvious considerations of power-size-weight-price and wireless data transfer capability. Quantification of the 3S parameters in trace recognition of a particular target would be SNR (signal-to-noise ratio) for sensitivity, PFA (Probability of False Alarms) for Specificity and Hyper spectrally analyzed FPS (frames per second) for Speed. Minimum desirable numbers typically would be SNR=10, PFA=0.05 and FPS=10. While most groups have proposed the use of a single widely tunable QCL, the use of a spatially multiplexed set of algorithmically chosen single wavelength laser beams (typically a total of 5 QCLs and/or ICLs) due to significantly higher CW power, no band width limitation, no moving parts, saving valuable time loss in tuning and/or image data analysis that is spectroscopically less relevant has been proposed by the author. Coherence of laser beams poses a significant challenge for quantification of trace materials of very low surface densities. Random and uncontrollable interference patterns challenge quantification and increases LOD (limit of detection) by an order of magnitude. Randomizing temporal coherence of fixed wavelength laser beams will result frequency fluctuations affecting specificity of detection. Randomizing spatial coherence however will reduce speckle pattern significantly without affecting the frequency of the beam. In this presentation, the author will review the state of the art of this technology, recent efforts and what lies ahead.

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