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Time-resolved Multispectral Imaging of Combustion Reaction

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Abstract

Thermal infrared imaging is a field of science that evolves rapidly. Scientists have used for years the simplest tool: thermal broadband cameras. This allows to perform target characterization in both the longwave (LWIR) and midwave (MWIR) infrared spectral range. Infrared thermal imaging is used for a wide range of applications, especially in the combustion domain. For example, it can be used to follow combustion reactions, in order to characterize the injection and the ignition in a combustion chamber or even to observe gases produced by a flare stack. Most chemicals like carbon dioxide (CO_2) selectively absorb/emit infrared radiation at discrete energies, i.e. over a very narrow spectral range. Temperatures derived from broadband imaging are erroneous when facing situations involving these gases. It is well known that spectral emissivity has to be taken into account in order to get reliable temperature values while this information is not available when using broadband imaging. In this work, combustion analysis of a candle was carried out using Telops MS-IR MW camera which allows multispectral imaging at a high frame rate. A motorized filter wheel allowing synchronized acquisitions on eight (8) different channels at a high frame rate is used to provide time-resolved multispectral imaging. Among the filters, seven distinct spectral filters and one neutral density filter, i.e. which corresponds to broadband imaging, were used for the experiments. The combustion recorded produced water and carbon dioxide, the latter being clearly observed in filters corresponding to its infrared signature. It was then possible to estimate the temperature of the gas plume by modeling its spectral profile. Comparison with temperatures obtained using conventional broadband imaging illustrates the benefits of time-resolved multispectral imaging for the characterization of combustion processes.

Keywords: thermal infrared imaging, combustion, gases detection, broadband, multispectral.