SPATIAL AND TEMPERATURE MEASUREMENTS ON HIGH-TEMPERATURE OBJECTS BY CAMERAS (VISIBLE, NIR & IR)

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The Clement Ader Institute of Albi (ICAA) and the von Karman Institute follow since numerous years works about IR radiometry with the aim to do quantitative thermography (true temperature measurement without contact). These works allowed to explore potentiality several spectral bands: 8-12µm, 3-5µm and recently the 0.75-1.7µm band (near IR) with the help of CCD camera (Si) or VisGaAs camera. Studies done in this specific domain have underlined some perturbations emphasized at high-temperature (T>800°C). This work has to deal in details with the treatment of these perturbations which play a role in the measurement of different parameters. The first of these parameters is the emissivity, this treatment is made in another thesis. The second parameter affects particularly the hot spot location and the spatial distortion. This perturbation comes from convective effect present around every hot objects.

The purpose of this thesis is to analyze this effect and to correct it. Indeed, when a hot object is in a colder surrounding media, a temperature gradient is shaped around the object and thus a refractive index gradient too. This phenomena brings inevitably distortions of the spatial information received by the camera (fig. 1). The goal of this work will be to estimate and correct error made on temperature and/or distortion measurement by CCD or VisGaAs camera on hot object.

We chose to focus our work on the convective plume created by a hot horizontal disk. This study will be done with an experimental and a numerical approach. For the numerical approach, a ray-tracing code has been developed in order to obtain numerically the displacement due to the light deviation occurring in the perturbation. The input data of the code is the refractive index of the hot air present around the object. This refractive index, depending on the wavelength, can be found directly from the temperature thanks to the Gladstone-Dale law. The temperature is given by a CFD software such as FLUENT. Experimentally, we will use the Background Oriented Schlieren (BOS) method in order to retrieve the displacement (fig. 2). We can see that the displacement can reach 4 pixels in the plume (corresponding to 1mm in this case). This perturbation has been studied for several spectral bands (visible, near infrared, infrared). Some solutions of correction are in progress, like using the inverse Abel Transform in order to retrieve from the 2D displacement, a 3D (axisymmetric) refractive index field that we will implement in the ray-tracing code and in consequence predict the displacement for any kind of wavelength or distance (distance between the camera and the object).

Figure 1: Natural mirage effect due to a hot air layer right above the road

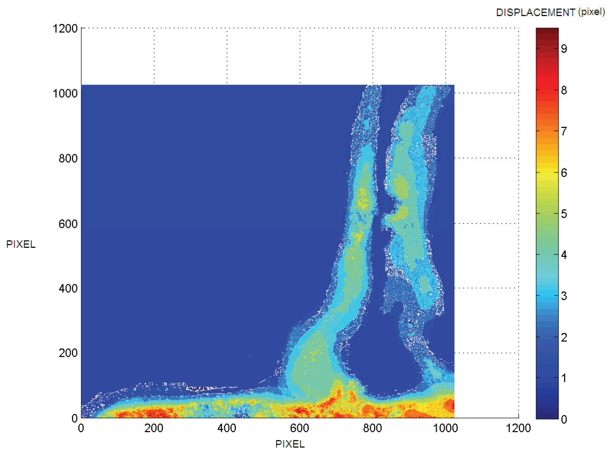

Figure 2: Instantaneous displacement image obtained in the visible band with the BOS method above a hot disk