Chapter 8

New Advances in Multidimensional Processing for Thermal Image Quality Enhancement

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ABSTRACT

This chapter presents three recent methodologies about multidimensional processing for signal to noise ratio (SNR) and thermal contrast enhancement on sequences of thermographic images, acquired from active pulsed thermography experiments over composite slabs, mainly, carbon fiber reinforced plastic (CFRP). The first technique corresponds to noise pre-processing by means of iterative 3D filtering to take advantage of the high space-time correlation in thermal sequences; the other two techniques correspond to thermal contrast enhancement processing: one of them using an atypical median filtering scheme, and the other based on heat propagation discrete models. Beginning with their heuristic and mathematical foundations, and following with the algorithmic procedures development, advantages and limitations will be shown through suitable indexes for evaluation, and some comparisons with other similar techniques.

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INTRODUCTION

Although thermography is not an area with recent application in engineering, the advances in informatics and computing systems, which have increased the performance of digital image processing algorithms, have done thermography to be one of the more promising techniques for Non-Destructive Testing (NDT) of materials because of non-contact and non-intrusion qualities (Bagavathiappan, Lahiri, Saravanan, Philip, & Jayakumar, 2013); because of these, thermography is gaining relevance in predictive and preventive maintenance activities. One of the more interesting and extensive NDT application for thermography focuses on the evaluation of composite materials, like *carbon fiber reinforced plastic* (CFRP), in automotive and aeronautical industries. This type of materials exhibits a better mechanical resistance/weight ratio than other very important materials, such as aluminum and steel (Snell Jr. & Spring, 2007), which is why NASA consider composites as the materials of choice for achieving lower weights and costs of aerospace vehicles (Tenney, Davis, Byron, & Johnston, 2009). However, excessive impacts or repetitive mechanical stress applied to them may create several types of failures: the most common being delamination between layers (Pohl, 1998), which may grow until breaking the material. The huge important role of a reliable NDT strategy for composites is demonstrated in the use of CFRP slabs, for example, as the main structural material for flight control surfaces, and fuselages of recent military and commercial planes, resulting in savings up to 20% of fuel consumption and decreasing the same quantity in CO_2 emissions (International Air Transport Association, 2009; Segui, 2014).

There are many challenges involved in application of thermography as an industrial NDT technique, but one of the most common and fundamental is an adequate *thermal contrast* of images for detection success: the more thermal contrast between defective regions and their healthy surroundings, the more probability of accurate detection of those defects. Subsequent characterization tasks depend on performance of the selected estimation methods, but only they will be run on the previous detected flaws. In that sense, it can be observed two fundamental trends about thermographic image processing for thermal contrast enhancement and internal flaws detection in materials:

- Processing focused on enhancing and finding the differential temperature between defective and healthy regions; in such a way that the expected resulting images consist of a certain intensity level of reference for sound substrate of the inspected material, and appreciable smaller or greater intensity levels (depending on thermal properties) for sought defects. An important feature of this group of techniques is that the information they give correspond to the temporal evolution of contrast temperature, either absolute, or relative, for