ASSESSMENT OF 3D IMAGE PROCESSING USING FMCW THZ IMAGERY

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ABSTRACT

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In recent years, the field of terahertz (THz) has come into the limelight of many industrial oriented practical applications. Techniques using sub-THz frequencies penetrate most non-metal materials and provide the ability for three-dimensional (3-D) imagery and in-depth information [1]. Several of the image processing techniques used for the THz imaging can be adopted from other well-established fields such as Synthetic Aperture (SA) imagery and X-ray tomography [2]. Given the high amount of information available in the THz images, appropriate signal and image processing are of uttermost importance. Therefore, new automatic or semi-automatic image processing techniques for analysis of THz imagery are strongly needed. The present study proposes a fully integrated, semi-automatic and near real-time mode-operated image processing methodology developed exclusively for THz images. Among a list of possible uses, quality control of aeronautics composite multi-layered materials and structures (e.g. laminates, fiberglass, Rohacell etc.) using Non-Destructive Testing is the main focus of this work.

The THz signal generation and detection have been performed using a Frequency-Modulated Continuous-Wave sensor, moving at a constant speed following a two-dimensional grid. Three different operating modes are used in parallel in one set-up: center frequencies around 100 GHz, 300 GHz and 850 GHz. Operating modes can be selected to best fit applications or materials. A first raw 3-D image is formed in this way defined by two types of resolution. The first one is referred to as the depth resolution, the second type of resolution is a 2-D azimuth resolution which is typically limited by the beam width. Resolution results of classic THz imagers show values that are more or less twice the size of the wavelength (a resolution of 3 mm is obtained with a 0.2 THz CW system [3]).

Image processing is applied on the reconstructed 3-D images to extract useful information. The contribution of this paper is focused on presenting fully integrated methodology from image pre-processing, processing, analysis and post-processing stages. In the proposed algorithm, first normalization filters [4] are used to correct corrupted or non-uniform background; followed by enhancement and de-blurring procedures. Then areas of interest extracted by applying a chain of processing tools: morphology operators, textural tools and edge detectors. The detected areas are subjected to image analysis for more particular investigation managed by Bayesian approach implemented to Markov random fields method [5]. Finally, the post-processing stage examines and evaluates the spatial accuracy of the extracted information by comparing image localization and dimensionality.

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