Optimization process of an automatic segmentation of a TEM tomography reconstructed volume based on genetic algorithms

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Quantitative microscopy characterization of samples requires the segmentation of images (in 2D) or stacks of images (in 3D). The quality and contrast in the images is frequently poor, making it difficult to define the limits of an object even for an expert, and, in addition, these manual segmentations are subjective. Several automatic segmentation algorithms have been proposed to overcome these problems [1]. However, most of the segmentation algorithms depend on the choice of appropriate values for some parameters. Often, these parameters are affected by the whole stack of images, and finding the optimum values is a complicated task. In some cases, to perform a good segmentation the user has to decide between quite similar values without knowing the result. This decision is even more complex when the size of the stack of images is very large, making the probing of every possible value of each parameter impossible. Moreover, the evaluation of different segmentations of the same image/stack calculated under different parameters is a subjective task. In this work, a methodology to optimize an automatic selection of values for significant parameters that feed segmentation algorithms is proposed, thus reducing the computational cost of the entire process.

Evolutionary optimization techniques have been applied in several engineering applications to solve similar problems [2, 3]. In this case, these techniques have been used to determine the optimum parameters values for a Region Growing [4] segmentation algorithm, reducing calculation time and improving the segmentation. The parameters that must be adjusted in this algorithm are the position of the seed inside of the whole stack of images and the threshold value of gray for a set of pixels to be considered as the same object. This evolutionary optimization is based on genetic algorithms techniques. It is mainly focus in the mutation and crossover between individuals of different generations, where only the individuals that get better segmentations can be part of the next generation, getting new generations that improves results generation by generation. The selection of individuals of this evolutionary methodology is based on a fitness function which provides the value of a mutual information parameter (MI) [5]. The segmentation with the highest value of MI is the one with the highest accuracy and, in consequence, defines the individual for following generations.

A stack of images of a CB(N330)-reinforced EPDM rubber in a tomography reconstruction calculated from images acquired in a Transmission Electron Microscopy operated in bright field mode (BF-TEM, tilted images acquired form -60° to 60° every 1° in a FEI Tecnai G2 20 TWIN microscope at 200kV, with a pixel size of 0.91 nm) has been segmented, and the outcome has been evaluated.

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