Coupling X-ray Physics and Engineering Mechanics, for Enhanced Analysis of Computer Tomographic Images

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Since its invention in the 1960s, Computed Tomography has become one of the most powerful and versatile non-destructive imaging tools, with applications ranging from biomedicine to concrete technology. For about two decades, it is also common to use CT images as the basis for Finite Element modeling of the scanned objects. Thereby, the main focus has been classically laid upon the accurate representation of geometrical details, while particularly for solids made up of natural non-homogeneous materials, the question of material property assignment has remained an open challenge over the years.

Since 2008 [1], our group, in cooperation with colleagues from Germany, Italy, Russia, Poland, Belgium, and Iceland [1-5], has been deeply involved in overcoming this challenge, by more deeply studying the X-ray physics underlying Computed Tomography: we developed increasingly mature methods to retrieve, from the grey value-defined voxel characteristics given in CT images, the actually underlying physical property, called X-ray attenuation coefficient. The latter contains information on the chemical composition of the material making up the considered voxel, and combining this information with known chemical characteristics of the material class making up the scanned object, gives access to important microstructural information inside the voxel, such as microporosity, or contents of known chemical substances. The latter then enter, as input values, experimentally validated micromechanical formulations representing the material inside the voxel, so as to reliably determine the voxel's mechanical properties. Corresponding CT-to-mechanics conversion schemes will be presented in appropriate detail, with applications ranging from various ceramics [2,3,6] and polymer-ceramic composites [4] used in tissue engineering, to organs made up of the natural material bone [1,5].

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