

# Image-based multiscale modeling of bone elasticity: how to make the most out of uncertainty?

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Accurate and reliable modeling of bone elasticity at the organ scale requires to take into account the specific microstructure of bone. X-ray based methods, such as micro-computed tomography ( $\mu$ CT) or synchrotron radiation  $\mu$ CT (SR- $\mu$ CT) can provide useful and accurate information on bone architecture and composition *in vitro*. Focusing on cortical bone, the most relevant microstructural information concerns the Haversian Porosity (HP, characteristic length scale of a few to several tens of micrometers) and the mineralization of the solid bone matrix (measured by the Tissue Mineral Density, TMD, characteristic length scale of a few to several micrometers). This information can be used to set up detailed Finite Element (FE) or homogenization models of bone which allow studying the heterogeneous distribution of its elastic properties. Unfortunately, these approaches cannot be applied easily in *in vivo*. Indeed, spatial resolution of clinical devices (several tens of micrometers) prevents resolving details of bone microstructure accurately and may produce blurry, uncertain data. Thus, uncertainty affecting the experimental input data may question the reliability of the results predicted by the models. Since input data are uncertain, deterministic approaches are limited and new modeling paradigms are required. Probabilistic approaches [1] and fuzzy and interval analysis offer new and powerful ways to face these challenges. In this talk, we will present an overview of the issues related to uncertainty in image-based modeling of bone elasticity and discuss the benefits and drawbacks of some approaches which may be used to tackle them in a multiscale setting.

**Keywords(optional):** Bone elasticity, Haversian Porosity, Tissue mineral density, Imaging, Uncertainty, Stochastic Modeling, Multiscale, Homogenization, Finite Element Method.

## References(optional)

- [1] V. Sansalone, D. Gagliardi, C. Desceliers, V. Bousson, J.D. Laredo, F. Peyrin, G. Haïat, and S. Naili, Stochastic multiscale modelling of cortical bone elasticity based on high-resolution imaging, Biomech. Model and Mechanobiol., July 2015 On line.