1. Simulations for endovascular surgery: from medical images to clinical reality through computational and experimental biomechanics

Lecturer: Assistant Professor Dr. Michele Conti
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Endovascular treatments of arterial diseases such as atherosclerotic stenosis, aneurysms and dissections have revolutionized the vascular surgery in the last decades. Such a therapeutic progression is constantly sustained by technological innovation of (bio)materials, medical imaging, device design, and accurate patient selection. Within this scenario, vascular biomechanics plays a key role supporting both basic knowledge and applicative developments. The seminar will discuss the use of patient specific simulations for planning endovascular treatment of the aortic diseases. The use of experimental methodologies (ex-vivo, in-vitro, 3D printing) to validate and integrate the numerical simulations will be presented as well. Finally, the development of dedicated numerical approaches to investigate post-operative haemodynamics using in vivo medical images will be discussed.

2. Thermo-Mechanical simulation of Hydrogel Droplets in 3D Bioprinting using the FEM

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3D bioprinting is an emerging tissue engineering method that applies additive manufacturing technology to generate three-dimensional tissue constructs. In 3D bioprinter, the gelation process (polymerization) of hydrogel droplets represents the transition from the viscous liquid to the viscoelastic solid once it passes the gel point. This process highly affects the printing procedure and the final printed structure. The optimization of the 3D bioprinting process by appropriately controlling the time- and temperature-dependent gelation process of hydrogel droplets is a major challenge. In particular, for computer-aided analyses, an accurate material model is highly needed. This lecture focuses on the constitutive modeling and the thermo-mechanical simulation of the mechanical behavior of hydrogel droplets during gelation. Accordingly, experiments to predict the shear modulus and the activation energy for the chemical formulation of the hydrogel are firstly conducted. Afterwards, the appropriate constitutive model and the corresponding parameters are derived. Finally, the polymerization of hydrogel droplets having different shapes is addressed by numerical simulations. The developed model represents an efficient approach for understanding the influences of the temperature on the gelation (polymerization) process of hydrogel droplets, and consequently, the optimization of the controlling parameters can be accomplished.