ACMS Applied Math Seminar

Carlos Sing Long

Pontificia Universidad Catolica de Chile

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154 Hurley Hall

3:30 PM – 4:30 PM

The Effect Of Vessel Geometry In Wall Shear Stress Uncertainty Quantification In The Cardiovascular System

The vascular system delivers nutrients and oxygen to the body through blood vessels whose walls are subjected to a constant hemodynamic stress due to blood flow. This wall shear stress (WSS) has proven to be a biomarker providing information about the thickness, ulceration and rupture of atherosclerotic plaques. In practice, the WSS is not measured directly, but computed instead from blood flow measurements obtained with phase-contrast 4D flow Magnetic Resonance Imaging (MRI). This computation depends explicitly on the gradient of the flow velocity and on the geometry of the vessel. Consequently, the statistics of the noise on flow velocity measurements are modified according to the geometry of the vessel wall.

In this talk, we present how the vessel geometry determines how the uncertainty in flow velocity measurements propagates to WSS values. Using an additive noise model based on Gaussian processes, we show that the statistics of the noise in the computed WSS values lead to spatial correlations. In addition to this theoretical model, we study numerically a noise model arising from phase-contrast 4D flow MRI. We show the results of numerical experiments on synthetic geometries, and on human anatomic models. Our numerical results confirm our theoretical findings and suggest that in practice the noise in the computed WSS values is spatially correlated.