CRUNCH Seminars at Brown, Division of Applied Mathematics

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Paper Review: Bridging Finite Element and Machine Learning Modeling: Stress Prediction of Arterial Walls in Atherosclerosis by Ali Madani et al.

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Finite element and machine learning modeling are two predictive paradigms that have rarely been bridged. In this study, we develop a parametric model to generate arterial geometries and accumulate a database of 12,172 2D finite element simulations modeling the hyperelastic behavior and resulting stress distribution. The arterial wall composition mimics vessels in atherosclerosis–a complex cardiovascular disease and one of the leading causes of death globally. We formulate the training data to predict the maximum von Mises stress, which could indicate risk of plaque rupture. Trained deep learning models are able to accurately predict the max von Mises stress within 9.86% error on a held-out test set. The deep neural networks outperform alternative prediction models and performance scales with amount of training data. Lastly, we examine the importance of contributing features on stress value and location prediction to gain intuitions on the underlying process. Moreover, deep neural networks can capture the functional mapping described by the finite element method, which has far-reaching implications for real-time and multiscale prediction tasks in biomechanics.
paper link: https://biomechanical.asmedigitalcollection.asme.org/article.aspx?articleid=2729617