CRUNCH Seminars at Brown, Division of Applied Mathematics

Friday – February 2, 2018

Non-intrusive reduced order modeling of nonlinear problems using neural networks

Anna Lischke

We develop a non-intrusive reduced basis (RB) method for parametrized steady-state partial differential equations (PDEs). The method extracts a reduced basis from a collection of high-fidelity solutions via a proper orthogonal decomposition (POD) and employs artificial neural networks (ANNs), particularly multi-layer perceptrons (MLPs), to accurately approximate the coefficients of the reduced model. The search for the optimal number of neurons and the minimum amount of training samples to avoid overfitting is carried out in the offline phase through an automatic routine, relying upon a joint use of the Latin hypercube sampling (LHS) and the Levenberg–Marquardt (LM) training algorithm. This guarantees a complete offline-online decoupling, leading to an efficient RB method – referred to as POD-NN – suitable also for general nonlinear problems with a non-affine parametric dependence. Numerical studies are presented for the nonlinear Poisson equation and for driven cavity viscous flows, modeled through the steady incompressible Navier–Stokes equations. Both physical and geometrical parametrizations are considered. Several results confirm the accuracy of the POD-NN method and show the substantial speed-up enabled at the online stage as compared to a traditional RB strategy.