CRUNCH Seminars at Brown, Division of Applied Mathematics

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Data-Driven Stabilization Schemes for Singularly Perturbed Partial Differential Equations

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In this presentation, the speaker will introduce novel approaches that harness the power of Artificial Neural Networks (ANN) in conjunction with traditional numerical techniques to tackle the computational challenges posed by Singularly Perturbed Differential Equations (SPDEs). SPDEs often exhibit undesirable oscillations in the standard numerical solutions, mainly due to the presence of boundary and interior layers. Stabilization techniques are commonly employed to mitigate these oscillations; however, the accuracy of these techniques heavily relies on a problem-dependent stabilization parameter, posing difficulties in achieving optimal performance. To address this challenge, the author has developed several data-driven techniques that utilize ANN to predict the optimal stabilization parameter. The first method, named SPDE-Net, employs ANN to accurately predict the stabilization parameter for the streamline upwind/Petrov-Galerkin (SUPG) stabilization technique, specifically tailored for solving one-dimensional SPDEs. The second method, AI-stab FEM, introduces an innovative optimization scheme that utilizes an unsupervised ANN to minimize the residual, along with the crosswind derivative term, facilitating the solution of two-dimensional SPDEs. Finally, the third method, SPDE-ConvNet, leverages a convolutional neural network to predict the local (cell-wise) stabilization parameter. During the talk, the speaker will compare and analyze the performance of these data-driven stabilization schemes, shedding light on their efficacy and potential for future extensions.