

Title: Neural Network Surrogate Models for Flow Control and Image Feature Extraction

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Abstract: Recent developments on machine learning have recently been paving the way to new research avenues. In this talk, a framework will be proposed whereby numerical simulation data is leveraged to extract relevant information from flowfield visualizations. The present methodology applies computer vision techniques to predict the unsteady pressure distribution of an airfoil under different dynamic stall conditions. We show that neural networks are capable of identifying relevant flow features present in the images and associate them to the airfoil response. Results demonstrate that the model is effective in interpolating and extrapolating between flow regimes and for different airfoil motions, being a promising alternative for building robust surrogate models of complex unsteady flows. We also apply the backpropagation of neural network models to control nonlinear dynamical systems using different approaches. By leveraging open-loop data, we show the feasibility of building surrogate models with control inputs that are able to learn important features such as types of equilibria, limit cycles and chaos. Two novel approaches are presented and compared to gradient-based model predictive control (MPC): the neural network control (NNC), where an additional neural network is trained as a control law in a recurrent fashion using the nonlinear neural network models (NNMs), and linear control design, enabled through linearization of the NNMs. The proposed methodologies are tested on the compressible Navier-Stokes equations, where the stabilization of a cylinder vortex shedding is sought by taking measurements of the lift force with delay coordinates.