Abstract

by

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Accurate control of wind-tunnel test conditions can be dramatically enhanced using feedforward control architectures which allow operating conditions to be maintained at a desired setpoint through the use of mathematical models as the primary source of prediction. However, as the desired accuracy of the feedforward prediction increases, the model complexity also increases, so that an ever increasing computational load is incurred. This drawback can be avoided by employing a neural network that is trained offline using the output of a high fidelity wind-tunnel mathematical model, so that the neural network can rapidly reproduce the predictions of the model with a greatly reduced computational overhead.

A novel neural network database generation method, developed through the use of fractional factorial arrays, was employed such that a neural network can accurately predict wind-tunnel parameters across a wide range of operating conditions whilst trained upon a highly efficient database. The subsequent network was incorporated into a Neural Network Model Predictive Control (NNMPC) framework to allow an optimised output schedule capable of providing accurate control of the wind-
tunnel operating parameters. Facilitation of an optimised path through the solution space is achieved through the use of a chaos optimisation algorithm such that a more globally optimum solution is likely to be found with less computational expense than the gradient descent method. The parameters associated with the NNMPC such as the control horizon are determined through the use of a Taguchi methodology enabling the minimum number of experiments to be carried out to determine the optimal combination.

The resultant NNMPC scheme was employed upon the Hessert Low Speed Wind Tunnel at the University of Notre Dame to control the test-section temperature such that it follows a pre-determined reference trajectory during changes in the test-section velocity. Experimental testing revealed that the derived NNMPC controller provided an excellent level of control over the test-section temperature in adherence to a reference trajectory even when faced with unforeseen disturbances such as rapid changes in the operating environment.