SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS (D2)
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NEURAL NETWORK BASED FLUSH AIR DATA SYSTEM (FADS) FOR REUSABLE LAUNCH VEHICLES

Abstract

Flush air data systems (FADS) are gaining importance for use in measurement of air data parameters like angle of attack, sideslip angle, Mach number and dynamic pressure for reentry and reusable vehicles, advanced aircrafts, interplanetary space probes etc. These air data parameters are critical for successful mission management of the vehicle during the flight phases dominated by complex aero thermal effects.

Flush Air Data System makes use of a matrix of flush pressure orifices located on the nose region (or stagnation region) of the vehicle to estimate air data parameters. The surface pressures are sensed using highly accurate absolute pressure transducers. The multivariable relationship between the pressure measurement and the output air data parameters is complex and highly nonlinear. Different methods are proposed in literature for the estimation of air data parameters using surface pressure measurements. Some of the earlier semi-empirical model based approaches used to process FADS pressure data have experienced numerical instabilities resulting in momentary degradation in system performance.

In this paper a neural network based FADS algorithm is developed for a reusable launch vehicle technology demonstrator. FADS is proposed to be used for the flight regime from Mach number 2.5 to 0. Neural networks, which require large quantities of training aerodynamic data set offer a simple, flexible and accurate solution for such complex applications. Neural network systems allow for the correlation of complex nonlinear systems without requiring explicit knowledge of the functional relationship that exists between the input and output variables of the system. Further, algorithms with neural network techniques are inherently stable for the calibration of nonlinear data involving more number of independent parameters.

The pressure port configuration used in this paper consists of nine pressure ports located on the nosecone of the vehicle. The pressure ports are arranged in a crucifix fashion with five ports located in the vertical meridian and four in the horizontal meridian. The pressure ports are connected to the pressure transducer using pneumatic tubing designed to satisfy frequency and thermal response requirements. The developed algorithm is validated using calibration data generated from wind tunnel tests. Back propagation technique is used to train the neural network to achieve the desired level of accuracy. The present study shows that with properly trained networks, the neural network can be used effectively for real-time prediction of air data states during the critical flight phases.