Modern flight control laws are designed utilizing modeled plant aerodynamics, and as such the closed-loop system is sensitive to the actual aerodynamics and flight environment. Control laws such as dynamic inversion rely on an onboard aerodynamic model of the flight controller that is not always accurate because of simplifications in the modeling process or unmodeled dynamics. Typically, the most accurate estimation of the aerodynamics is determined with an expensive wind tunnel test (WTT) supplemented with aerodynamic finite element modeling. The WTT takes a considerable amount of the research and development budget, yet it may not provide an aerodynamic model suitable for flight control. This issue can be overcome by implementing a linear robust control law augmented with an online adaptive control law. The linear robust control law can be designed by any established methods, but in this work we will present a new parameter space method that guarantees a desired gain and phase margin. The new method is developed to obtain a desired performance and stability in the presence of the aerodynamic uncertainty. Unlike the conventional s-domain parameter space method that utilizes the pole-placement technique analytically, the new method designs the controller in the frequency domain numerically using the stability margin specification. The linear robust control is enhanced by an adaptive control system that is designed by online Feed-Forward Neural Network (FFNN). The FFNN adaptive control compensates for the aerodynamic uncertainty and imperfect modeling of aircraft dynamics, and it gradually replaces the linear controller as the network gains converge to a value that minimizes the linear control law. Although the FFNN adaptively adjusts the controller gains, an additional stability augmentation system is designed by Sigma-Pi Neural Network (SPNN) for compensating for the nonlinearity of the aircraft dynamics. The SPNN predicts the control input at a specific flight condition by memorizing the previous flight empirically. The SPNN adapts both the engine speed and elevator commands in the aircraft speed/altitude control. Training the SPNN is performed using a recursive least square estimator, and the control design is demonstrated on a six-degree-of-freedom (6DOF) digital simulation.

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The public is welcome to attend.