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AGILE RECEDING-HORIZON OPTIMAL CONTROL LAW USING NEURAL MODELS OF STABILITY AND CONTROL DERIVATIVES AND ON-LINE PARAMETER IDENTIFICATION†

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SUMMARY

This paper describes a successful approach taken to address the problem of control law design for agile, high-angle-of-attack flight. Barron Associates, Inc. developed a full-envelope controller for the VISTA/F-16 MATV aircraft using an off-line nonlinear, time-varying, six degree-of-freedom (6DOF) digital simulation provided by Lockheed Martin Tactical Aircraft Systems (LMTAS). The controller was based on a receding-horizon optimal (RHO) control law design methodology that (1) allows for rapid and cost-effective design of a full-envelope multi-axes control law, (2) predicts and tracks embedded flying-qualities models, (3) compensates for parameters that change rapidly with time, and (4) explicitly accounts for known continuous differential nonlinearities such as those from inertial cross coupling. An automated synthesis procedure was used to learn automatically the structure and coefficients of Polynomial Neural Network (PNN) models to provide the RHO control law with efficient and accurate models of the aircraft stability and control derivatives at every operating point. The derivatives used for network training were computed numerically from time histories of aircraft states and effector displacements observed during simulated 6DOF maneuvers. LMTAS evaluations performed over the AOA envelope from – 5 deg. to over + 70 deg. concluded that the neural network flight control system (NNFCS) "was quite impressive... [demonstrating] sound control power in agility, and robust equivalent damping, frequency, and time-delay in flying qualities." Additionally, LMTAS concluded

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