Real-Time Minimization of Tracking Error for Aircraft Systems

Direct adaptive control looks at errors and decides if and when corrections are needed.

Ames Research Center, Moffett Field, California

In many cases when an aircraft/spacecraft vehicle encounters a failure (such as a jammed control or loss of a part), there are still enough redundant actuation mechanisms to safely maneuver the vehicle. However, most pilots/autonomous systems are unable to adapt to the altered configuration and learn to control the damaged aircraft in the very short time available for safe operation. Fortunately, the flight computer may have the necessary information as well as bandwidth available to learn the new dynamics and determine mechanisms to control the vehicle quickly. The flight computer needs an intelligent controller that flies the vehicle with the baseline controller during normal conditions, and adapts the design when the vehicle suffers damage. Using information about the vehicle from all the available sensors, the system determines whether the vehicle is damaged. Direct adaptive control (DAC) looks directly at the errors, and updates the control law accordingly. This technology looks not just at the tracking error, but rather its characteristics over time to determine whether the controller needs to be adapted or left alone. This is typically fast and meets the timing considerations for aircraft/spacecraft system implementation.

This technology presents a novel, stable, discrete-time adaptive law for flight control in a DAC framework. Where errors are not present, the original control design has been tuned for optimal performance. Adaptive control works towards achieving nominal performance whenever the design has modeling uncertainties/errors or when the vehicle suffers substantial flight configuration change. The baseline controller uses dynamic inversion with proportional-integral augmentation. On-line adaptation of this control law is achieved by providing a parameterized augmentation signal to a dynamic inversion block. The parameters of this augmentation signal are updated to achieve the nominal desired error dynamics.

If the system senses that at least one aircraft component is experiencing an excursion and the return of this component value toward its reference value is not proceeding according to the expected controller characteristics, then the neural network (NN) modeling of aircraft operation may be changed.

This work was done by John T. Kaneshige, Kalmanje S. Krishnakumar, and Nilesh V. Kulkarni of Ames Research Center, and John Burken of Dryden Flight Research Center. ***For more information, download the Technical Support Package (free white paper) at www.techbriefs.com/tsp under the Physical Sciences category.***

Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at 1-855-NASA-BIZ (1-855-6272-249) or sumedha.garud@nasa.gov. Refer to ARC-16235-1