Visitor Research Report

Visitor Name: **Ms. Megumi Matsutani**
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Area of Research: **Adaptive Control Technology for Safe High-Performance Aircraft**

Period of Visit: **June 15, 2008 through August 22, 2008**

Goal:

The challenge of achieving safe flight comes into sharp focus in the face of adverse conditions caused by faults, damage, or upsets. An appropriate technology that has the potential for enabling a safe flight under these adverse conditions is adaptive control. One of the main features of an adaptive control architecture is its ability to react to changing characteristics of the underlying aircraft dynamics.

The field of adaptive control is a mature theoretical discipline that has evolved over the past thirty years, embodying methodologies for controlling uncertain dynamic systems with parametric uncertainties [1], [2], [3]. Through the efforts of various researchers over this period, systematic methods for the control of linear and nonlinear dynamic systems with parametric and dynamic uncertainties, stability and robustness properties of these systems in the presence of disturbances, time-varying parameters, unmodeled dynamics, time-delays, and various nonlinearities, have been outlined in several journal and conference papers over the past three decades. What is needed therefore is a systematic deployment and evaluation of these methods for the problem of ensuring safe flight in an aircraft under various adverse conditions.

Strategy:

In this research, we consider the control of the C-5 transport aircraft, which is similar to the Generic Transport Model (GTM) [4]. We delineate the underlying nonlinear dynamic model and introduce various upsets, damages, and failures by representing these various adverse conditions in the form of uncertainties. We consider two different flight conditions that focus on the longitudinal and lateral dynamics separately. An adaptive controller based on the linearized model of the C-5 is designed, in conjunction with a baseline LQ-controller with integral action, and anti-windup components to accommodate magnitude saturation, similar to that proposed in [5], [6].

The resilience of the adaptive control architecture to uncertainty is evaluated for safety using the control verification methodology proposed in [7]. This methodology enables the determination of ranges of uncertainty for which a prescribed set of closed-loop requirements are satisfied.

Accomplishments:
The research presents an adaptive control architecture for the safe flight of a transport aircraft under adverse operating conditions and uncertainties. This architecture combines a nominal controller based on an LQR with integral action, and an adaptive controller that accommodates for actuator saturation and disturbances. The resilience of both controllers to uncertainty is studied using a control verification methodology, where flight upsets, CG movements, and actuator failures are considered. The results of this study show that the adaptive controller enlarges the region of satisfactory performance by a sizable margin.

Future Work:
As a future work, we are planning to conduct a flight test to validate the designed controller.

Pending Publications:
Matsutani, M., Crespo, L. G., Annaswamy A. M.; An Adaptive Control Technology for Safety of a GTM-like Aircraft Model, American Control Conference 2009, St. Louis, Missouri, USA.

Seminar Presented:
An hour talk was given in Langley Research Center on August 15th, 2008.