Adaptive Model Predictive Control of the Unmanned Rotorcraft using Recursive Least Squares Parameter Estimation

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Abstract

The main purpose of this paper is to evaluate the performance of an automatic flight control system for an unmanned helicopter, utilizing Model Predictive Control (MPC) enhanced with Recursive Least Squares (RLS) model parameter estimation. The control system integrates a Stability Augmentation System (SAS) in the inner loop and an MPC-based system in the outer loop, iteratively solving a constrained optimization problem through quadratic programming. By employing RLS for model parameter estimation, the proposed system adapts to changing environmental conditions and accounts for nonlinearities in rotorcraft dynamics. Simulation tests are conducted using an unmanned helicopter mathematical model built in the Flightlab environment, fully integrated with the Matlab/Simulink platform. This paper presents a general methodology for synthesizing an MPC-based controller for unmanned rotorcraft. Additionally, the research highlights the impact of model disturbances within the MPC-based control loop on helicopter dynamics and discusses the potential advantages of using RLS parameter estimation algorithms in predictive control systems.

Currently, simulation tests are comparing the performance of the MPC-based control system with and without RLS parameter estimation during a flight level change maneuver while hovering. The results provide insights into the limitations of the proposed algorithms and suggest potential upgrades for the automatic flight control system. In the final paper, a detailed description of the control system and the utilized algorithms will be presented. Tests will cover a comparison of helicopter responses when using an MPC-based automatic control system with and without RLS model parameter estimation for the transition between hover and forward flight at 30 knots per second.

Keywords: Model Predictive Control; Quadratic Programming; Recursive Least Squares; Flightlab; Helicopter Dynamics

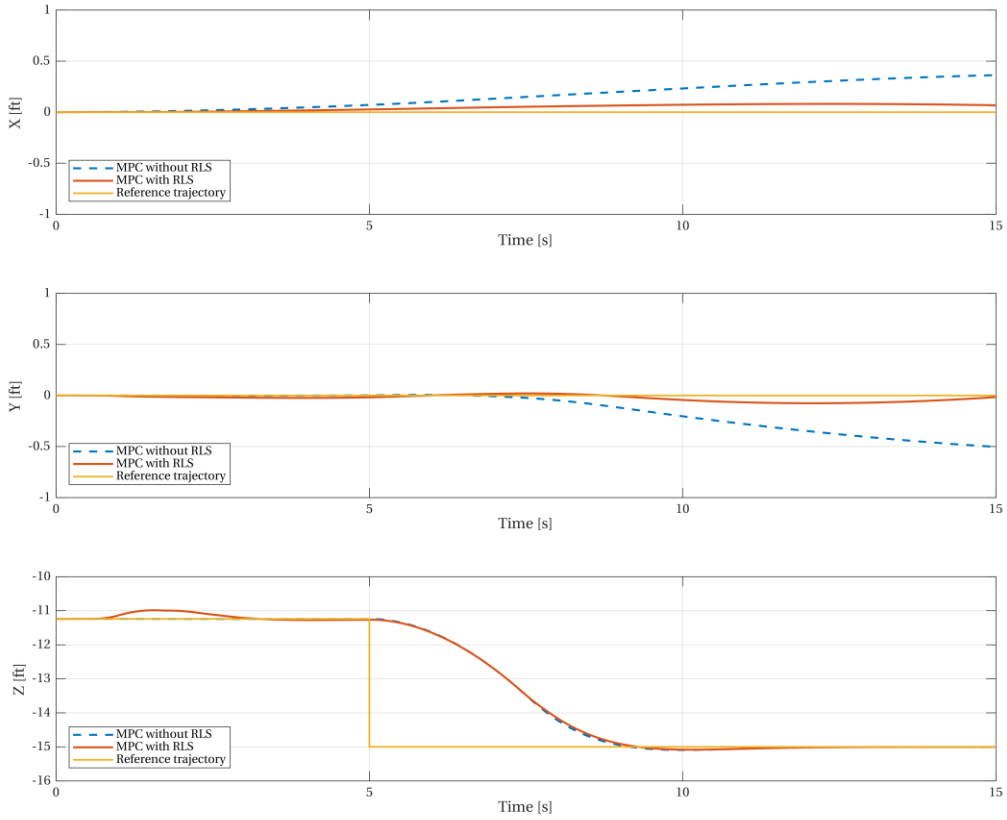

Figure 1: Simulation results of flight level change using MPC with and without RLS model parameter estimation