Impact of Actuators Slack on the Helicopter Control During Landing on a Moving Vessel Deck

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ABSTRACT

The paper presents selected goals achieved in the HELIMARIS project (”Modification of an optionally piloted helicopter for maritime mission performance”) led by PZL Swidnik in cooperation with Warsaw University of Technology. The project is devoted to development of additional features allowing maritime operations of a light, single engine helicopter with introducing high level of automatization.

A helicopter landing on a vessel deck is considered as composed of three stages: approach to a moving vessel, hover relative to a landing deck and final landing phase with touchdown. The objective of this research was to check influence of the actuators slacks on the performance of developed control system devoted to perform the task. Here, the automatic control algorithm based on Linear Quadratic Regulator (LQR) methodology is combined with the algorithm predicting the future vessel movement. The prediction algorithm is based on autoregressive method with parameters calculated using Burg’s method. Calculated control commands are executed by four electromechanical actuators. This paper is a further development of work presented in [1] and [2].

In this research a helicopter model is built in FLIGHTLAB environment reflecting a single rotor helicopter powered by one turboshaft engine with a three-bladed articulated main rotor and see-saw tail rotor. The airframe model includes fuselage, empennage, sensors and a landing gear. All elements of the helicopter, except the undercarriage, are modelled as rigid. The main and tail rotors are modelled using blade element theory including flapping dynamics. The aerodynamic model is a nonlinear unsteady one with stall delay, and Peters-He 6 state induced velocity model with model of an empirical ground effect. The interactions between rotors and fuselage are also taken into account. The aerodynamic loads of the fuselage and empennage are modelled using empirical look-up tables. The engine model is a turboshaft engine model with models of its dynamics and control systems. The helicopter model validation was done using data from manufacturer for both steady flight and dynamic response cases.

Here, different values of slacks are applied to the four actuators to check the performance of the developed control system in case of approach and landing of the helicopter on the vessel deck using prescribed procedure at selected sea state. Helicopter responses during approach and landing on the moving vessel at sea state 3 (in Douglas sea scale), with 0.1mm actuator slacks applied are presented in Fig. 1. Helicopter responses are marked black and the responses of the vessel – red. Responses of the helicopter cover position (X, Y, Z in the inertial coordinate system), attitude (PHI, THETA, PSI in the gravitational coordinate system), linear velocities (Vx, Vy, Vz in the body coordinate system), angular velocities (P, Q, R in the body coordinate system) and values of control variables.

In the final paper, the detailed description of control system, helicopter model, actuators model and approach and landing procedure will be presented. Tests will cover helicopter responses for different actuators slacks during approach and landing on the vessel deck at selected sea state. Impact of actuator slacks values will be analyzed from mission performance point of view.

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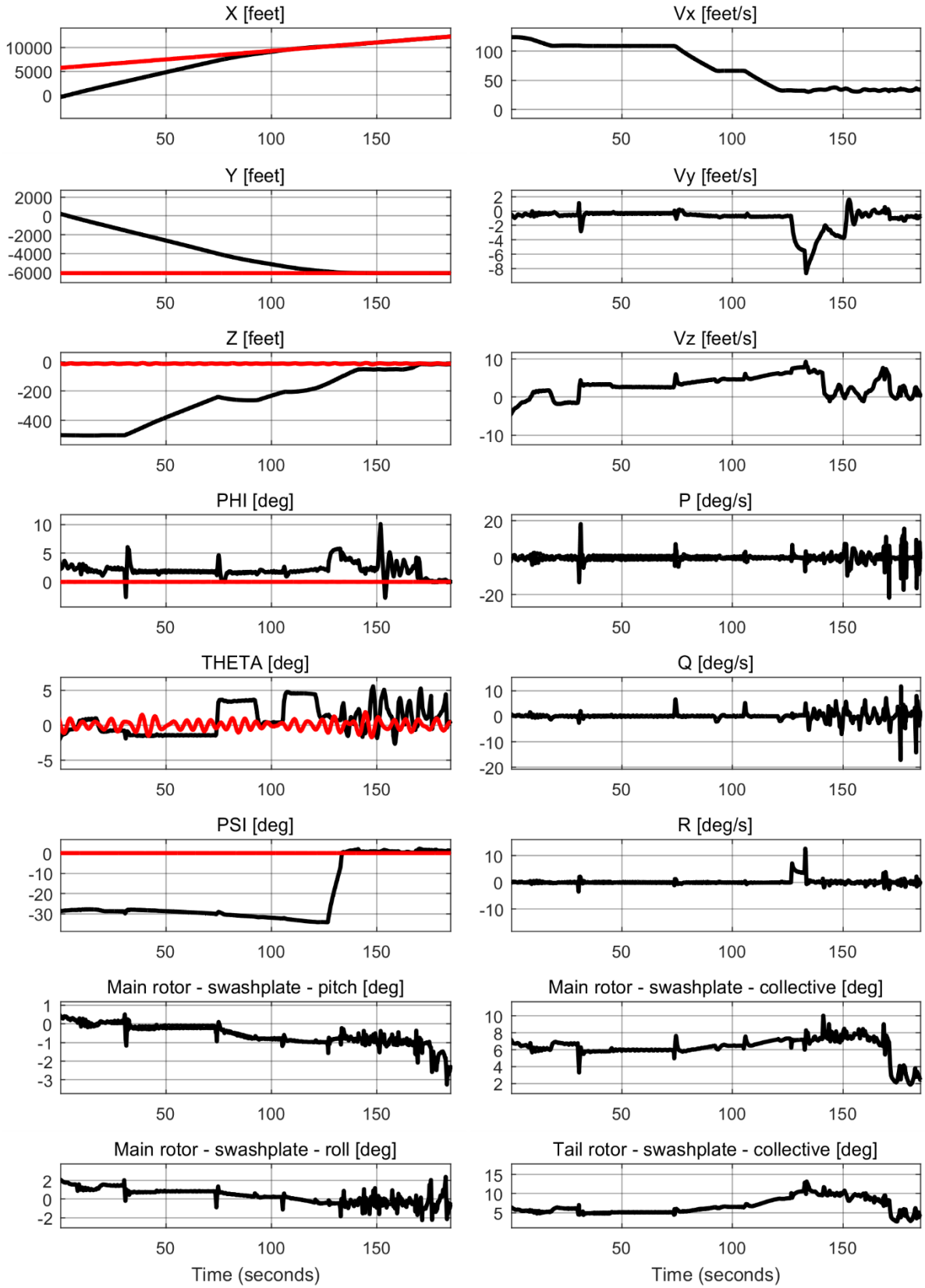

Fig. 1 Approach to the moving vessel – 0.1mm actuators slacks applied

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