Integrated Automatic Control of the ARCHER Compound Helicopter

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Abstract:

The paper presents the development and results of studies on an automatic flight control system for a compound helicopter equipped with an additional pusher propeller. Based on the ARCHER modular helicopter platform developed at the Warsaw University of Technology, a numerical model of the compound helicopter was created in Flightlab. Subsequently, the integrated control algorithm, including a linear quadratic regulator to control the classical part of the helicopter and a proportional fuzzy controller to control the pitch and angular velocity of the additional pusher propeller was implemented in Matlab/Simulink. The manoeuvrability of the helicopter with the additional pusher propeller and the efficiency of the automatic flight control system were evaluated using the slalom manoeuvre described in the Aeronautical Design Standard 33 (ADS-33). Due to the small scale of the unmanned helicopter, appropriate corrections were made to the selected manoeuvre trajectory parameters based on the Froude scaling method. The study compares the results for the model equipped with the additional pusher propeller with the classical helicopter model at different manoeuvring speeds. Example results of the simulations, during which a slalom manoeuvre is performed with a reference forward velocity in the body coordinate system equal to $\mathrm{Vx_{ref}} = 30\,\frac{\mathrm{ft}}{\mathrm{s}}$, are shown in figures 1 and 2, corresponding to configurations without and with the additional pusher propeller. In the plots, the black curves correspond to the helicopter's actual state and control variables, and the red lines represent the values of the selected reference variables. The helicopter responses in the form of time histories of state and control variables include position coordinates (X, Y, Z), Euler angles (Phi, Theta, Psi), linear velocities in the body coordinate system (Vx, Vy, Vz), angular velocities (P, Q, R), control variables typical for the classical helicopter configuration (XC, XB, XA and XP) and pusher propeller variable parameters such as pitch angle and angular velocity. The general conclusions of the study include that the compound helicopter has several advantages over the classical configuration, such as better maintenance of the preset forward speed and better coverage of the reference slalom trajectory at low speed flights. The studies suggest that the proposed control system improves the performance of the selected compound helicopter configuration.

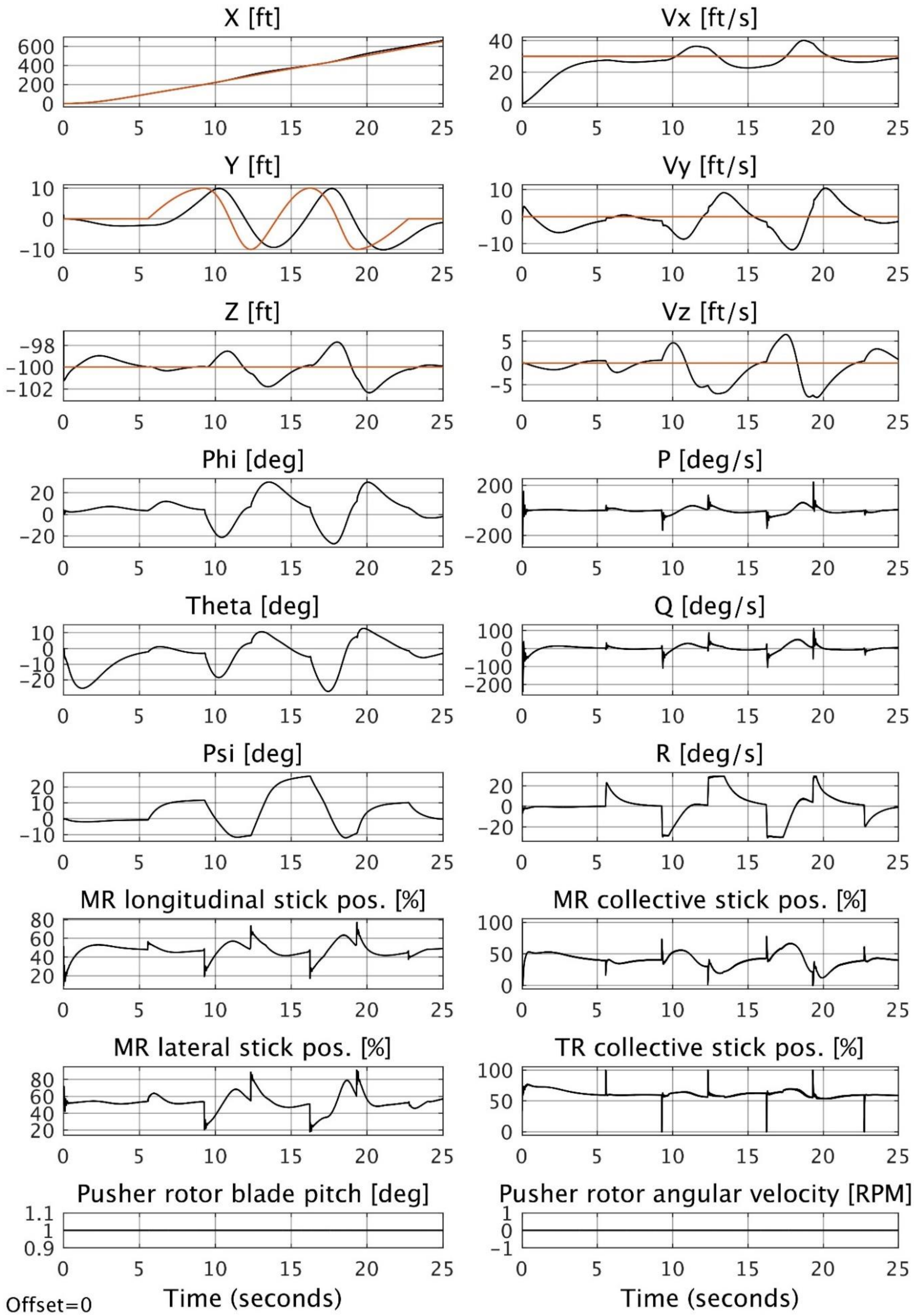

Figure 1: State and control variables for helicopter in classical configuration, $\mathrm{Vx_{ref}} = 30$ ft/s

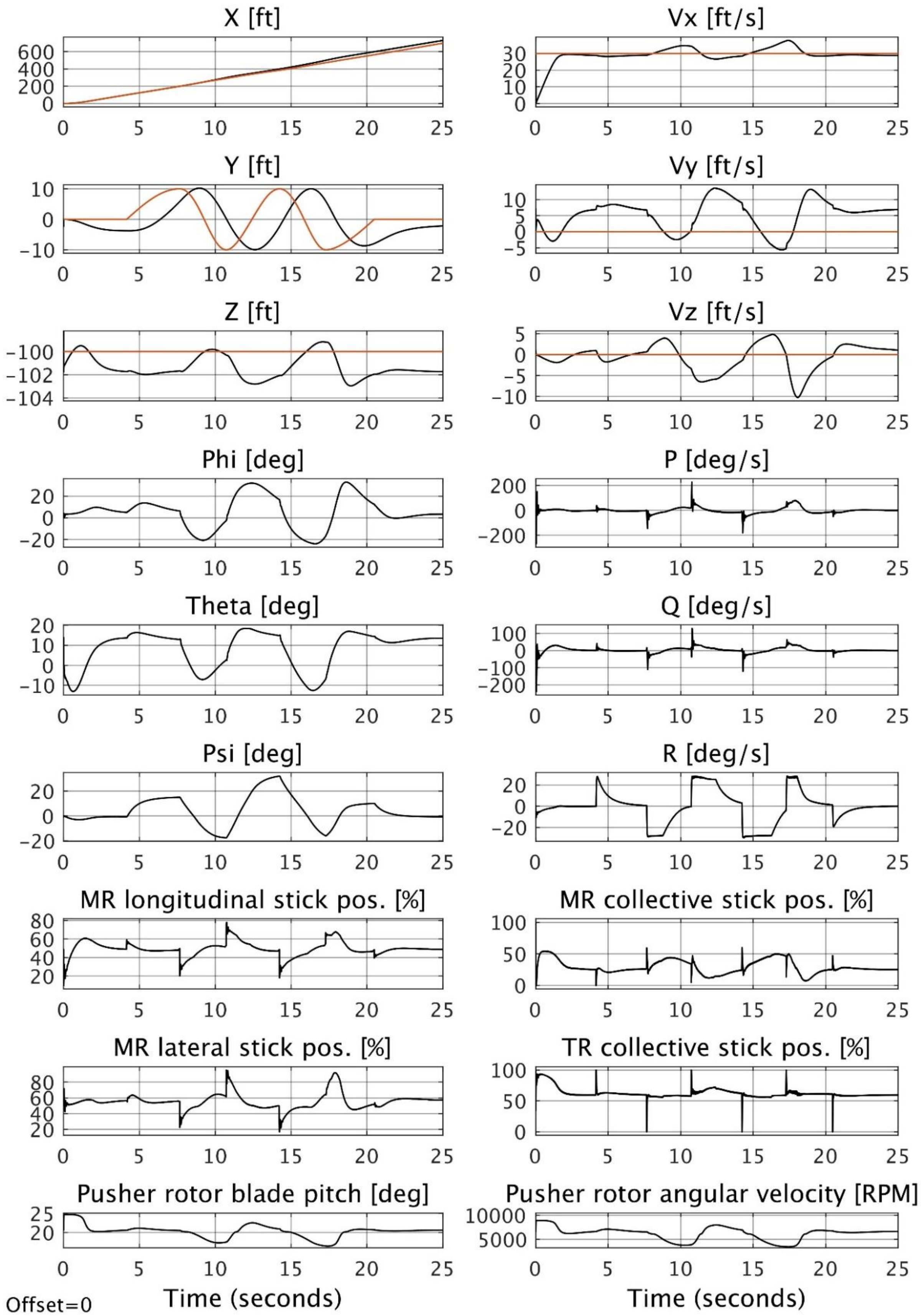

Figure 2: State and control variables for helicopter in compound configuration, $Vx_{ref} = 30$ ft/s