Automatic Landing System for Civil Unmanned Aerial System

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Keywords: *Ground Effect, Simulation, Automatic Landing*

In spite of a number of potentially valuable civil UAS applications The International Regulations prohibit UAS from operating in the National Air Space. Maybe the primary reasons are safety concerns. In fact their ability to respond to emergent situations involving the loss of contact between the aircraft and the ground station poses a serious problem. Therefore, to an efficient safe insertion of UAS in the Civil Air Transport System one important element is their ability to perform automatic landing afterwards the failure.

Moreover, the mathematical model of ground effect is usually neither included in the model of the aircraft during takeoff and landing nor in the design requirements of the control system Usually two different mathematical models of the aircraft are used during landing: the first Out the Ground Effect (OGE) and the second In Ground Effect (IGE).

The objective of this paper is to design a longitudinal automatic landing system taking ground effect into account. The designed control system will be tested and implemented on board by using the Preceptor N3 Ultrapup aircraft. In fact, such aircraft is used as technological demonstrator of new control navigation and guidance algorithms in the context of “Research Project of National Interest” (PRIN 2008) by Universities of Bologna, Palermo, Ferrara and the Second University of Naples.

First of all, a general mathematical model of the studied aircraft is built to obtain non – linear analytical equations for aerodynamic coefficients both Out of Ground Effect and In Ground Effect conditions. According to previous researches, aerodynamic characteristics of the aircraft , have been modelled by means of hyperbolic equations in the whole flight envelope. So it is possible to use a single model during the whole landing phase taking into account the actual ground effect.

To overcome the difficulties due to the use of nonlinear models of the aircraft in ground effect for designing the controller, the control system has been designed using the following approach:

- The Landing flight path has been divided into two segments: the descending path for aircraft altitudes $h > b$ (OGE) and the flare for $h <= b$ (IGE);
- The flare manoeuvre starts for $h = b$;
- An acceptable number of linear models has been obtained by means of linearization of the original nonlinear model in various flight conditions;
- A modified gain scheduling approach has been employed for the synthesis of the controller. It is made by six PID and by a supervisor. This one, by using the actual flight altitude, schedules the set of gains to be inserted online, depending on the real flight condition.

Several tests have been carried out by means of simulation, in Matlab Simulink environment. The obtained results show a good accuracy of the control system for trajectory tracking in ground proximity.

Further developments of the present research will be the extension of the designed control system to the take-off phase.

Afterwards the aircraft model will be improved by evaluating both lateral stability derivatives variations In Ground Effect and the bank angle derivatives (ϕ derivatives). The present methodology will be employed to design a Lateral Automatic Landing System.

The obtained results could be used later on, with the purpose to realize a fully autonomous UAS.