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Title

Virtual pilot: a review of the human pilot's mathematical modeling techniques

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Abstract
Virtual prototypes and mathematical models are a powerful assessment instrument during several phases of the flying vehicle life-cycle, from the preliminary design to certification [1]. For instance, certain certification flight test activities, particularly those involving hazardous maneuvers, can be classified as high-risk in terms of flight safety, therefore the possibility to involve flight simulations in the certification process is currently widely evaluated [2].
In [3] is reported a proposed methodology to validate and certify Point-in-Space (PinS) helicopter routes using simulation: the GNSS signal level on the designated route and the presence of obstacles on the path can be checked by a small UAV, while the pilot's workload and the helicopter performance constraints can be assessed by means of simulation. Indeed, the helicopter is usually required not to exceed an expected range of attitude and rates, imposed by constraints on the turning radius, flight path angle and so on: the respect of these requirements can be verified by setting-up a closed-loop simulation model where both the dynamics of the pilot and of the rotorcraft are modeled.
The purpose of this paper is a review of mathematical modeling of the human pilot, intended as an active control element (as opposed to the passive biodynamic model) that can be used to perform closed-loop simulations. The human operator will be treated as the controller that closes the aircraft dynamics loop.
This review is necessary in order to categorize human pilot's models in terms of complexity, task, pilot's characteristics and other possible features. The investigation will start from the classic crossover model [4] applied to single-loop compensatory systems, and will be extended arriving to precision models that contain the neuromuscular dynamics, the visual system dynamics, the remnant (operator-induced error) dynamics. Multi-loop models will then be discussed, and the difference between tracking tasks and compensatory tasks will be treated.

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