Ensuring the Safety of UAV Flights by Means of Intellectualization of Control Systems

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EXECUTIVE SUMMARY

In this chapter, the authors present analysis of reasons for deficient safety of unmanned aerial vehicles (UAV) and further ground an approach to improve the safety by intellectualizing operation of the control system. Intellectualization results from the rational control owing to machine vision means used. A conception of building algorithms for visual evaluating position of the UAV that is equipped with a computer vision system is suggested. Algorithms are illustrated by related investigation of an adapted UAV. Both hardware and software means for realizing the visual estimation algorithms are presented.

BACKGROUND

International aviation salons manifest convincingly the trends present in aerospace technology. One of the most sustained of them is annual essential growth of UAVs. Another material trend is expansion of application areas and capability of drones.

Drones expansion is the result of their evident advantage comparing to piloted vehicles. The main benefit is unmanned aircraft functioning that brings to considerable simplification of the aircraft construction and reduction of avionics capacity, hence, the life cycle cost. In contrast, the functionality of the vehicle may rise through the possibility of management intellectualization.

Drones usage in various human activities is not wide enough, although there are a lot of spheres to potentially apply: cargo delivery, human habitat monitoring, forest fires monitoring, ensuring national security, mapping, traffic control, rational land-use, disaster assistance, help in case of man-made accidents, etc (Sładkowski, A. (Ed.). (2013).

To provide a demanded drones usage level in mentioned spheres of activity, it is required a higher safety of using pilotless aviation complexes (UAC) including the unmanned aerial vehicles (UAV).

The main reasons for the UAS deficient safety (Gulevich, SP, Veselov, Yu. G., Pryadkin, SP, & Tyrnov, SD (2012)) are the following:

1. Engine fault resulting in the uncontrolled fall of the fly vehicle.
2. Avionics failure that causes the flight mission failure, uncontrolled landing, objects collision, partial or complete UAV destruction.
3. Flight control room failure that results in UAV communication loss, hence, uncontrolled flight mission execution and the inability to receive monitoring information on the mission execution quality.
4. Exceeding the functionality related limits e.g. overstepping the design limits due to strong atmospheric turbulence, increased uncertainty of flight conditions, etc.
5. Breaking of the airframe and its structural elements (ailerons, rudder, wing partition) under degraded flight conditions that causes a UAV controllability deterioration and possible accident.
6. Mistakes occurrence while planning the flight mission, associated with the trajectory, distance to goal, duration of the flight, engine power resources.
7. Imperfect UAC maintenance leading to not specified emergency situation during the flight.

Thus, deficient UAV usage safety is explained by numerous contingency situations (sudden and unpredicted occasions) during the life cycle. Abnormal situations are the events, which are indefinite, first, regarding the time of appearance, and second because of the unknown peculiarity (specs) of the impact causing the abnormal situation. It is possible to automate the analysis of contingency events using theoretical approaches. It is possible to automate the contingency analysis procedure using for that different theoretical approaches. Techniques differ by the hypotheses base in use containing the mathematical models hypotheses adopted for the abnormal events, also by methods used to solve diagnosis inverse problems, as well as instrumentation means involved, and with expected implementation outcomes evaluation.

To study the UAC, which is a complex dynamic system assumed to present a lot of uncertain events to happen, one can apply the approach associated with using the principle of diagnosis and associated instruments of analysis allowing the detection of abnormalities. The approach utilizes dedicared means for identifying the causes of events with indeterminate characteristics occurrence (Isermann, R. (2006), Hajiyev, C., & Caliskan, F. (2013)). From a variety of known methods to diagnosing dynamic systems, the signal-parametric approach seems to be the most appropriate for the peculiar UACs (Kulik, A.S. (1991, September)). The approach is grounded on the hypothesis of uncertainty for fault's emerge time, its place, class, and specific physical reason. To eliminate the uncertainty, the principle of successive uncertainties evaluation, which is actually a set of interrelated and purposeful steps, is applied (actual diagnostic support) to allow the diagnosis of an abnormal situation promptly and with a given depth.

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