Chapter 14

Methods for the Synthesis of Optimal Control of Deterministic Compound Dynamical Systems With Branch

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ABSTRACT

This chapter states the result of the development of optimal control methods for deterministic discontinuous systems of optimal control problems for deterministic compound dynamical systems (CDS) with branching paths. The necessary conditions for optimality of the CDS branching paths are formulated in the form convenient for subsequent development of algorithms for the operational synthesis of these paths. The optimality conditions developed by the authors allow both preliminary and in real time (on-line) optimization of the CDS branching paths. The need for an operational synthesis of the CDS branching trajectory is caused by the inaccuracy of prior knowledge of information about the factors affecting CDS movement which are critical for the implementation of the CDS end-use. The developed conditions are universal for solving problems with any finite number of branches of a branching trajectory and are focused on the use of artificially intelligent systems which allow analyzing the structure of optimal control of CDS components as they move along the path branches.

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㤝BACKGROUND

Currently, the successes in creating precision mechanical objects, wireless telecommunication systems and high-performance compact on-board computers allow designing up-to-date complex technical systems that solve a single technical task without a mechanical connection and having data exchange between the separate components of these objects.

The section describes the unmanned aerial vehicle (UAV) groups that form a mobile sensor network (“flying sensor networks” or “information robots”), as well as reusable aerospace systems of airborne launch type as an alternative to the up-to-date complex technical systems. Theoretically, these control objects can be classified as compound dynamic systems (CDS), i.e., systems consisting of a set of objects (subsystems) with a controlled interaction between them during motion.

The CDS paths in the scientific publications (Lysenko, Tachinina, 2014a) are called branching, on the grounds that they consist of sections of common motion of the CDS subsystems and sections of their individual movement to a target along individual path branches. The CDS functioning efficiency depends on the operational (real-time) optimal choice of spatial coordinates and time moments when the CDS structural transformations occur, as well as on the operational optimal synthesis of control in the intelligent computer by the CDS components as they move along the path branches during the periods of time between the structural transformations.

Therefore, the problem of operational optimization of the CDS branching paths is considered in the scientific community as topical from academic and practical standpoints (Lysenko, Tachinina, 2014b; Lysenko, Tachinina & Chumachenko, 2015). For example, commercial launches into space of a payload by the aerospace systems of airborne launch type, require reliable guarantee of launch under some previously unpredictable change of weather conditions in the launch area. So, the problem of operational correction (optimization) of the branching trajectory of the aerospace system motion, consisting of the aircraft carrier (AC) and orbital stage (OS) paths at the phase of their joint motion in so-called “bundle”, common optimization of the AC and OS paths in the process of partition and initial separation with subsequent ascent to the given points of near-earth space, is topical.

The algorithms of the operative correction of the aerospace system trajectory should be programmed in the artificial intelligent system (AIS) of the AC onboard launch system, this makes it possible to correct on-line the branching path in the launch area and this correction will be taken into account when deciding to maneuver.

We emphasize that the task of operational optimization of the branching path of the aerospace system is also of current importance in emergency situations when necessary to safely and quickly separate the OS from the AC.

The precise operational information about victims in the emergency zone under conditions of heavy destruction of infrastructure (fires, earthquakes, tsunamis, tornadoes, etc.) can be obtained by using the sensors placed in the UAV (mobile sensors) that form the “flying sensor network”.

The problem of operational optimization of “group behavior” (optimization of the branching path) of mobile sensors in an aggressive environment arising under emergency situation is important.

The algorithm of operational optimization is programmed in the on-board intelligent computer of a telecommunication platform that controls the movement of mobile sensors.

The success of the search and rescue operation is determined primarily by the consistency of “group behavior” of the elements of “flying sensor network” (Kirichek, Paramonov, & Vareldzhyan, 2015; Moiseev, 2017), which should provide latest and precise (timely and reliable) information about victims.
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