DOI: http://doi.org/10.25728/pu.2020.1.1

TWO METHODS OF SYNTHESIS OF STATE AND DISTURBANCES OBSERVERS FOR AN UNMANNED AERIAL VEHICLE

Ju.G. Kokunko[#], D.V. Krasnov, A.V. Utkin

V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russia

[#]✉ juliakokunko@gmail.com

Abstract. As part of the synthesis of a tracking system for an unmanned aerial vehicle (UAV) under the influence of external uncontrolled disturbances and incomplete measurements of the state vector, the procedures have been developed for the synthesis of state observers and low-order disturbances of a new type, which do not require the building of dynamic models of external influences. The observation subsystem includes two state observers. The first observer gives estimates of velocities based on measurements of the UAV's center of mass coordinates. By using measurements of tracking errors, the second observer gives estimates of mixed variables (state functions, external influences and their derivatives), on which feedback is formed directly. It is noted that implementation of the algorithms developed, which do not require reconfiguration when external influences change, will increase the functionality of the UAV control system and its reliability in case of failure of measuring devices. The effectiveness of the proposed approach to the synthesis of the tracking system is confirmed by the results of numerical modeling. The results of modeling are presented (comparative analysis of closed systems with static feedback (assuming that all internal and external variables are measured) and with dynamic feedback using two approaches to solving the problem of evaluation under the influence of external disturbances: observers with large coefficients and with piecewise linear, limited corrective actions). It is shown that, despite the simpler setup, in systems with linear feedback it is advisable to use observers of the second type, and observers with large coefficients will be in demand in systems with obviously limited control.

Keywords: unmanned aerial vehicle, tracking, block approach, state and disturbances observer, high gains, piecewise linear functions.

DOI: http://doi.org/10.25728/pu.2020.1.2

APPLICABILITY LIMITS OF MODEL-BASED PREDICTIVE CONTROL ALGORITHMS UNDER UNCERTAIN CONTROL OBJECT DYNAMICS

A.A. Chereshko[#], M.M. Shunderyuk

Honeywell Inc., Moscow, Russia

[#]✉ Alexey.Chereshko@Honeywell.com

Abstract. It is noted that advanced process control (APC) comprises a wide variety of mathematical methods and software algorithmic tools, application of which allows to increase the production profitability through more effective compensation of external impact on the process, automatic selection and maintenance of an optimal mode. It is also noted that model predictive control (MPC) of the multi-loop objects has been the mainstream of APC over the past 30 years. The robustness is examined of MPC algorithms with regard to model accuracy. The term «robustness» is understood as the ability of attaining the control aim under conditions of uncertainty. Control applicability criterion is formulated allowing to conclude about the correctness of the control algorithm. The model in the study is specified in a form of a transfer function of a linear object with time delay. Boundary conditions are determined for transfer function parameters, the violation of which leads to the control object destabilization or to the sluggish control. The results are given of the numerical calculation of 3D-domains of the model parameters, within which the control applicability criterion is met. The validity range of the results obtained is given.

Keywords: advanced process control (APC), model predictive control (MPC), robustness of advanced control algorithm, predictive model, transfer function of linear object, stability of control object, control applicability criterion, domain of robustness.

DOI: http://doi.org/10.25728/pu.2020.1.3

OPTIMALITY OF THE INCENTIVE COMPATIBLE MECHANISMS IN NETWORK ORGANIZATIONAL STRUCTURES

A.K. Enaleev

V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russia

✉ anverena@mail.ru

Abstract. The paper considers the problems of optimal control mechanisms design for an interconnected agents system provided incomplete awareness conditions of the governing body (center) about the parameters of agents. A directed graph that does not contain contours presents the connections of the agents in this system. Agents have their own goals and transmit information about their parameters to the center. They can intentionally distort data if distortion is beneficial to them. The center controls the behavior of agents. The behavior of agents is to inform the center about their parameters and the choice of their states. The ability of subsequent agents to select their states depends on the state selected by a preceding agent. The given directed graph determines the precedence structure of agents. The center's management consists of choosing a mechanism that includes planning procedures in the form of functions that depend on the information received from the agents and the incentive system. The incentive system consists of the functions of fines for deviating the state of the agent from the plan and the functions of encouraging agents for choosing the state. Optimal mechanisms are designed in accordance with which agents are not interested in manipulating the information communicated to the center and the implementation of plans. Conditions of incentive compatibility are determined that ensure this behavior of agents without decreasing the optimal value of the objective function of the center. The results of the study can be useful in managing the implementation of complex projects or assembly plants.

Keywords: hierarchy, network structure, mechanism design, optimization, coordination, equilibrium, sustainability, non-manipulation.

DOI: http://doi.org/10.25728/pu.2020.1.4

INCENTIVE-COMPATIBLE CONTROL IN DYNAMIC MULTI-AGENT SYSTEMS. Part 1. Contracts in dynamic system with one principal and multiple agents

M.V. Belov

IBS company, Moscow, Russia

✉ mbelov59@mail.ru

Abstract: The formulation and solution are considered of the problems of coordinated control of multi-element dynamic active systems (AS) with restrictions on the joint activity of their elements in the form of technological networks. An AS is studied consisting of one principal and many agents subordinate to it. It has been proved that for any admissible trajectory of results, a coordinated compensatory incentive system can be constructed that implements (as an equilibrium in dominant strategies) the trajectory of the agents leading to the desired trajectory of results; decomposes the control task by agents and by time periods; provides guaranteed (for all possible far-sighted agents) minimum costs of the governing body of the

principal for the implementation of this trajectory of results. It is shown that in such incentive systems, the values of payments depend only on the corresponding values of the cost functions, which, in turn, indirectly take into account the technological functions, network structure and AS structure as a whole. The problem of optimal planning is posed and an algorithm for solving it is indicated.

Keywords: incentive problem, dynamic system with one principal and multiple agents, contract theory.

DOI: http://doi.org/10.25728/pu.2020.1.5

ANALYSIS OF DECISIONS UNDER UNCERTAINTY WITH NON-NUMERIC ASSESSMENT OF PREFERENCES AND PROBABILITIES

V.V. Podinovski

National Research University «Higher School of Economics», Moscow, Russia

✉ podinovski@mail.ru

Abstract. It is shown that practical decision-making problems often involve taking into account preferences not fully identified, as well as uncertain factors. Known approaches to the analysis of such problems are based on introducing of quantitative probabilities and using of utility function. However, this requires obtaining rather complex and therefore unreliable and not always available information. In this paper, such methods are proposed for analyzing decisions under uncertainty, for the implementation of which utility functions and quantitative probabilities are not required. They are based on the ideas and results of the theory of the importance of criteria in multi-criteria problems of decision-making under certainty. Partial preference and indifference relations generated by qualitative probability on a set of strategies are used. Computational methods for constructing such relations are considered. Calculation examples are given.

Keywords: decision-making under uncertainty, incomplete information about preferences and uncertain factors, preference relations, qualitative probability.

DOI: http://doi.org/10.25728/pu.2020.1.6

EXPANSION OF THE «ATTACK – DEFENSE» MODEL

V.V. Shumov

International Informatization Academy, Moscow, Russia

✉ v.v.shumov@yandex.ru

Abstract. A probabilistic model of combat based on the principles of warfare and the definition of combat is considered. The parameter of combat superiority takes into account the moral and technological characteristics. Its estimation by the maximum likelihood method is proposed. The «attack-defense» model is formulated, taking into account the two-tier formation of troops (implementation of the next and subsequent tasks). The solution of three problems connected with search is found: 1) distribution of means between the points of defense; 2) quantity (share) of the means allocated in the second echelon (reserve); 3) the rate of movement of units in battle and their losses. The first problem is solved using the Y.B. Germeyer's generalized principle of equalization. Within the second problem reducing the game to an antagonistic matrix type allowed us to find optimal solutions for the distribution of forces of the parties between the echelons. It is shown that the decision of the game has a meaningful interpretation from the military science point of view (positional and mobile defense). To solve the third problem, military statistics data were used. The applicability of the presented models during command-staff and experimental exercises is shown on concrete examples.

Keywords: model of battle, Gross' model, Germeyer's model, echelonment of troops, assessment of parameters.

DOI: http://doi.org/10.25728/pu.2020.1.7

CONTROL OF EFFECTIVE IMPLEMENTATION OF TECHNOLOGICAL PROCESSES FOR MECHANICAL PROCESSING OF PARTS IN MECHANICAL ENGINEERING

V.B. Melekhin[1,2,#], V.M. Khachumov[3,4]

[1]Daghestan State Technical University, Makhachkala, Russia
[2]Daghestan State University of National Economy, Makhachkala, Russia
[3]Federal Research Center «Computer Science and Control» of Russian Academy of Sciences, Moscow, Russia,
[4]Program Systems Institute of Russian Academy of Sciences,Pereslavl-Zalessky, Russia

[#]✉ pashka1602@rambler.ru

Abstract. The main problems concerning effective implementation of technological processes in mechanical engineering under uncertainty are considered and solved. An integral criterion for efficiency estimation of the present state of technological processes is proposed, which allows reducing the solution of the multiobjective problem of choosing effective control actions to a single-objective optimization problem with both maximized and minimized efficiency indicators available. A method based on the use of fuzzy logic for processing expert data is presented, which makes it possible to form a multivariate analytical dependency between the efficiency indicators of the implemented technological process and the state parameters in the form of a linguistic function graph that ensures its required flow under changing operating conditions. A selection method is developed on an alternative basis of the most effective control actions in case of problem situations during the implementation of a complex technological process as a result of the influence of various disturbing environmental factors. In the selection method proposed, decision-making is based on a composition of correspondences that make it possible to relate disturbing factors of an unstable environment with control actions that ensure the efficient flow of a complex technological process. In general, control tools for deviation and disturbance compensation were obtained, which ensure the effective implementation of complex technological processes of machining parts in mechanical engineering in unstable environmental conditions.

Keywords: technological process, efficiency indicators, disturbing factors, control parameters, effective control.

DOI: http://doi.org/10.25728/pu.2020.1.8

MOVING OBJECT EVASION FROM SINGLE DETECTOR AT GIVEN SPEED

A.A. Galyaev[#], P.V. Lysenko, V.P. Yakhno

V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russia

[#]✉ galaev@ipu.ru

Abstract. Within the problem of evasion from detection by a single sensor on a plane at a constant speed the problem is considered of planning the optimal route of a moving object in order to minimize the integral level of the useful signal coming to the observer. It is shown that the various mechanisms of detection of a moving object can be reduced to a general mathematical formalization, namely to the study of the detection problem for different types of signal and a small signal/noise ratio. The study of the two-point variational problem with an integral constraint reduces to solving three types of systems of algebraic-integral equations, which include elliptic integrals of Legendre of the first and second kind, and the system type is determined

by different initial conditions and values of the integral constraints. For each of the systems described in the paper, a numerical procedure for its solution is implemented.

Keywords: search for a moving object, route planning, optimal law of evasion from detection.