PRINCIPLE OF AUTHENTIC EQUIVALENCE IN PROBLEMS OF ADAPTIVE CONTROLS IN THE CONDITIONS OF APRIORISTIC UNCERTAINTY

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In article systems with control which function in the conditions of aprioristic uncertainty with unknown parameters are considered. On objects of control revolting influences with unknown functions of distribution of probability the mathematical description which it is set by means of inequalities operate. Therefore automatic control system engineering by these objects it is necessary to carry out on the basis of the theory of adaptive systems. Problems of adaptive control solve now on the basis of a principle of authentic equivalence.

Keywords: Dual control, aprioristic uncertainty, object of control, adaptive control systems, operating influence, principle of authentic equivalence.

Introduction

Main principles of optimal control in the conditions of aprioristic uncertainty of revolting influences and the processes occurring in object of control, has formulated A.A. Feldbaum also named them dual control. In systems of dual control at formation of optimal operating influence at the present time it is necessary to know all information about past and future values of variables of a condition of object of control and revolting influences.

Principle of authentic equivalence in problems of adaptive control

In the majority of practical problems this information is inaccessible to the designer, but it can be restored to some extent from the analysis of observable target signals of object of control in managerial process. At an enough effective completion of missing data the control system gets optimal properties, or close to the optimal. Such control system should solve following problem:

- To define functions of density of distribution of probability of entrance influences and target variables of object of control;

- To define efficiency indicators (cost function) criteria of an optimality of estimation of variables of a condition and control;

- To calculate optimal estimations of current values of variables of a condition of object of control;

- To define optimum trajectories of transition of variables of a condition of object of control from an initial condition in the set final condition;

- To define algorithm of formation of operating influences, optimal by the chosen criterion of control;

The problem of dual control with functional adaptation is too difficult for practical realization as there is no the exact mathematical scheme, allowing to consider in algorithm of formation of operating influence of all future values of revolting influences and all future values of variables of a condition of nonlinear objects of control. Dual control can be realized only in neutral systems. Only in these cases optimal values of operating influences at the present situation do not depend on the future values of variables of a condition and the future values of revolting influences. Therefore, in neutral control systems the theorem of division of problems of optimum estimation of variables of a condition and formation of optimal operating influences is fair. The existing theory of adaptive control is based on a principle of authentic equivalence according to which at formation of optimal operating influences in

control systems instead of unknown variables of a condition and parameters, it is possible to use their estimations found in managerial process as a result of the analysis of measured values of target signals of object of control.

Coordinates of optimal trajectories of transition of operated variables in a demanded condition should be set in an explicit form or indirectly – by means of criterion of control efficiency. The control system realising a principle of authentic equivalence, contains object of control, system of measuring devices, the shaper of operating influences and the observer of variables of the condition, included in a feedback chain (Drawing 1).

In control problems the principle of authentic equivalence is carried out by nonlinear objects, if the mathematical description of optimal trajectories of transition of variables of a condition of object of control in the set final condition is known to within parameters, and revolting influences are additive white gausses noise. However in real systems, as a rule, these conditions are not carried out. So, for example, communication systems and radio navigation systems use non-stationary communication channels with unknown parametres and (or) condition variables in which noise with unknown functions of distribution of probability operation.
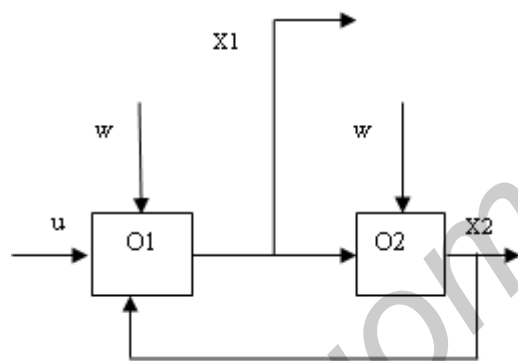

Drawing 2 – Example of multidimensional object of control

Thus, time of correlation of noise comparably in due course correlations of the report of information. The optimal trajectory of transfer of object of control from an initial condition in a demanded final condition, as a rule, is not known. Restrictions on set of admissible trajectories of transfer of object of control from an initial condition in the demanded final condition, set by means of inequalities are usually known only. The object of control often consists of two subsystems O1 and O2 (Drawing 2), thus operating influences arrive on inputs only subsystems O1, and other part of variables of a condition of object of control is accessible to measurements. Therefore, in adaptive control systems use the approached methods based on regularization of initial statement of a problem, for example, by means of a method regulation A.N.Tikhonov. At correct application the method regulation guarantees reception of the approached decision regulation problems with accuracy, sufficient for application in engineering practice. In the theory of adaptive control there were two approaches to the description aprioristic uncertainty mathematical model of a control system: stochastic and determined (minimax).

Adaptive control in the conditions of aprioristic uncertainty

In connection with development of astronautics and other spheres of a science the new mathematical apparatus of the description of control systems in space of conditions with which help system movement describe system of the ordinary differential equations of the first order has been created. These equations contain functions with which help set processes of change in time of revolting and operating influences. Thus, processes of change in time of revolting influences approximated, aligned with white gausses noise. In the same time the fundamental idea of an optimality of synthesis of a control system has arisen and - the operating influence formed by system of optimum control was successfully developed, should optimise some indicator of quality of control taking into account the restrictions created by mathematical model of a control system. The problem of synthesis of control systems is considered as a problem of optimisation of criterion of quality of control, including all requirements to a control system. It gives the chance to use variation methods, a maximum principle, dynamic programming and the theory of stochastic processes for formation of operating influence.
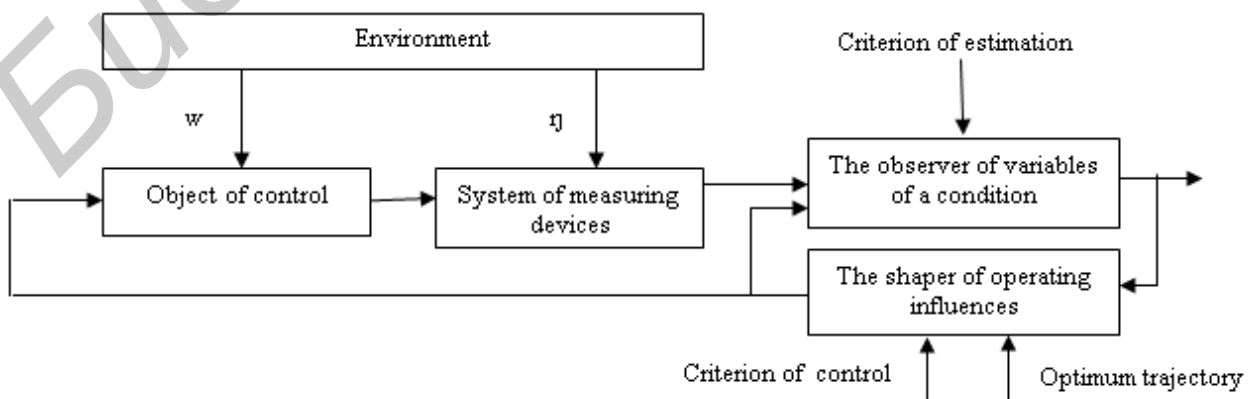
Drawing 1- The system of adaptive control realizing a principle of authentic equivalence

3. The analysis of observers of variables of a condition of object of management

The correct choice of mathematical model of object of control is the solving condition guaranteeing success in the decision of a problem of the adaptive controls.

This choice should be based as on understanding of the procedure of identification of model, and on the substantial and formalized information on identified object. Quality of the received model can be estimated, in particular, by criterion of an average quadratic errors in which the set of design variables includes model structure. In stochastic problems of control usually use model of dynamics of object of control in space of conditions. The method of variables of a condition is based on concept a system condition, mathematical definition of which is given Zadeh L.A.. A condition of object of control at the moment of time describe set of the phase variables connected by it for entrance signals known functional dependences and characterising behaviour of object of control in the future provided that entrance signals and an object condition at time starting point are known. If in separate elements of object of control there are unknown processes, these processes describe that by means of numbers of Fure, polynoms, B - splines, vejvlet-numbers and others base functions with the unknown parametres which are subject to identification in control process.

Revolting influences consider colour gausses as noise with known likelihood characteristics. It is supposed that these revolting influences can be received on an exit of linear dynamic system on which inputs submit aligned white gauss noise. Unknown parametres of the bleaching filter are subject to identification in control process. It is supposed that initial estimations of parametres are random variables with known likelihood characteristics. Variable conditions of the bleaching filter and unknown parametres include in structure of the expanded vector of variables of a condition of object of control. The processes occurring in object of control and the bleaching filter, describe in space of conditions the matrix differential equation.

4. Synthesis of the shaper of operating influences at the stochastic the description uncertainty

In the theory of optimum estimation it is known that updating process filter Kalman intensity and a population mean is a vector white gauss noise with a matrix. It follows from this that evolution of a condition of object of control is described by the stochastic equation. In problems of stochastic management consider that operating influences belong to the set of the limited functions. Thus the management purpose usually formalize in the form of the chosen criterion of quality of management. Most often use average value of square-law function or average value of function of the generalized work. Thus, a problem of synthesis of the shaper of operating influences adaptive control system consists in function minimization.

This problem рещают by means of a stochastic variant of a principle of a maximum or by means of a stochastic variant of a principle of dynamic programming. In linear control systems with square-law function by means of a principle of a maximum and dynamic programming it was possible to receive algorithm of formation of optimum operating influences. This way of synthesis of linear control systems has received enough wide circulation also it is known as a method of analytical designing of optimum regulators of Kalman-Letov. However it was gradually found out that the theory of stochastic control adequately describes rather narrow circle of practical problems. In other situations there is a considerable quantity of the factors interfering application of this theory of control. So, in nonlinear problems of control with function of the generalized work the principle of a maximum and dynamic programming lead to the nonlinear regional problems which decision in real time (as it is required in automatic control systems) it is impossible to find.

In real problems of control there is the inevitable uncertainty connected with presence of non-stationary parameters of model of object of control and non-stationary revolting influences with unknown likelihood characteristics which cannot be defined precisely in control process. Besides, optimum operating influence form in the form of in advance set function of time (programmed control). It is obvious that such strategy of control is the extremely undesirable. It is more natural to form control by means of feedback, as function of target signals of system at time present situation.

5. The analysis of adaptive systems of automatic control

The made analysis shows that many systems with control, function in the conditions of aprioristic uncertainty. In these systems there are nonlinear processes to unknown parameters. On objects controls operate revolting influences with unknown functions probability distributions, thus time of correlation of revolting influences is often commensurable in due course correlations of variables of a condition. The mathematical description of revolting influences, sets of the admissible operating influences and set of admissible trajectories of transfer of object of control in a demanded condition are usually set by means of inequalities. Therefore automatic control system engineering by these objects is necessary for carrying out on the basis of the theory of adaptive systems.

Problems of adaptive control solve now on the basis of a principle of authentic equivalence according to which the problem of adaptive control includes a problem of synthesis of the observer of variables of a condition of object of control, a problem of definition of an optimum trajectory of transition of object of control in a demanded condition and a problem of

synthesis of a regulator operating influences. Synthesis of adaptive control systems carry out by means of the theory stochastic control, regulators of the set structure with optimised parametres and the minimax approach. However at use of these approaches there are the following problems complicating their realisation in adaptive systems of automatic control of nonlinear objects:

1) In the nonlinear systems functioning in the conditions of the aprioristic uncertainty, it is impossible to apply the division theorem at the problem decision optimum estimation of variables of a condition.

2) The Decision of an arising nonlinear problem of optimum control it can be not unique. In this case additional research is necessary, allowing to find out, what should be chosen from available decisions for optimum control.

3) The Decision of a problem of optimum control can appear not smooth enough for practical realisation.

4) Even if the decision of a problem of optimum control has the smooth the decision, the control found from this decision, can not belong to set of admissible controls.

5) The Decision of problems of adaptive control by means of stochastic variants of a principle of a maximum and dynamic programming leads to formation of optimum operating influence under the programmed control law. If the indignations operating in a control system, are distinct from colour white gauss noise such control systems possess a static error of control as operating influences form to proportionally current values of a vector of variables of a condition.

6) Optimum control by means of calculus of variations and maximum principle form by the decision of point-to-point regional problems, generally the nonlinear. However now there are no algorithms of the decision of nonlinear point-to-point regional problems in real time, as it is required in automatic control systems.

7) At approximation of real indignations by colour noise dimension of system of the equations for variables of a fortune of model of object of control that leads to increase in the computing is essentially increased complexities of the decision of a problem of estimation of variables of a condition.

8) For application of methods of the stochastic control based on generation up and the decision of the equation the Fokker-Plank-Kolmogorov, is required to know laws of distribution of all entrance and target signals of object of control.

9) If control systems contain nonlinear elements on which non-stationary revolting influences with unknown likelihood characteristics stochastic methods cannot be applied to synthesis of adaptive systems of automatic control operate.

Conclusion

The method of analytical designing of adaptive systems of automatic control by nonlinear objects in the conditions of aprioristic uncertainty when revolting influences are the signals limited on absolute size is considered, and the mathematical description of trajectories of transition of operated variables in a final condition is set by inequalities. As a result the theory of optimal stochastic control which in aggregate with digital computers represents a powerful method of the decision of problems of control has been created. This approach was widely adopted due to its mathematical elegance and possibility to use computers for realization of algorithms of control.

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ПРИНЦИП ДОСТОВЕРНОЙ ЭКВИВАЛЕНТНОСТИ В ЗАДАЧАХ АДАПТИВНОГО УПРАВЛЕНИЯ В УСЛОВИЯХ АПРИОРНОЙ НЕОПРЕДЕЛЕННОСТИ

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В статье рассматриваются системы с управлением, которые функционируют в условиях априорной неопределенности с неизвестными параметрами. На объекты управления действуют возмущающие воздействия с неизвестными функциями распределения вероятности математическое описание, которое задается с помощью неравенств. Поэтому разработку систем автоматического управления этими объектами необходимо осуществлять на основе теории адантивных систем. Задачи адаптивного управления в настоящее время рещают на базе принципа достоверной эквивалентности.