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PROBLEMS OF MODEL CONTROL OPTIMIZATION DESCRIBING HOMOGENEOUS FLUCTUATIONS

Problems of model control optimization describing homogeneous fluctuations are considered on this paper. A method of optimization that differs from classic one is offered. The model is considered as a problem of bilinear system's optimal control with small parameter ε.

Introduction 1. Enzyme kinetics is essentially research enzyme response rate and conditions effecting them. Basic research models of enzyme kinetics era better described in paper (1). In this paper one of the major class of enzyme kinetics models' class is considered that describes the enzyme – substance reaction. Let's remind some well-known definitions for full presentation. Enzyme is an organic compound, usually protein, that hastens or causes substance change by catalytic action for which it is specific. Enzyme as a catalyst is highly effective – they work in concentrated product even under common pressure and temperature. The enzyme reacts very selectively only with definite compounds called substances. The enzymes can be either promotor or preventer. One of the simplest and at the same time the main enzyme reactions widely

spreaded in practice is the reaction, where substance moves irreversibly to material by one enzyme.

The most spreaded is the theory of Michaelis-Manten [1] where the basis is a supposition, that free enzyme and substance firstly form enzyme – substance complex during reversible reaction, that decays irreversibly in its turn forming free enzyme and substance again. This reaction can be in the following way:

$$S + E \xrightarrow{\rightarrow}_{\leftarrow} SE \rightarrow P + E,$$
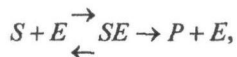
where S - substance E - enzyme, SE - enzyme – substance complex, P-material. And the model of this reaction is:

$$\frac{dx}{dt} = -x + (x + k - \lambda)y,$$

$$\varepsilon \frac{dy}{dt} = x - (x+k)y,$$

$$x(t_0) = x_{10}, \ y(t_0) = y_{10}, \ t \in [t_0, T]$$

2. Condition of controlled object can be described by common differential equation:

$$\frac{dx}{dt} = f(x,t) + p(x,t) + g(x,t)u(x,t),$$

$$x(t_0) = x_0, \ t \in [t_0, T]. \tag{1}$$

where $x = (x_1...x_n)$ n -, $f(x,t) = (f_1(x,t)...f_n(x,t))$ measuring vector of phase coordinates, $p(x,t) = (p_1(x,t)...p_n(x,t))$, $g(x,t) = (g_1(x,t)...g_n(x,t))$ - n- measuring vector-functions. $u(x,t)$ -piecewise-constant scalar function satisfying a limitation

$$| u(x,t) | \leq M, M = const > 0. \tag{2}$$

For the model (1) control quality is estimated by function of function by Boltz.

Let scalar function $v(x,t)$ - be the first integral of the system

$$\frac{dx}{dt} = f(x,t), t \in [t_0, T] \tag{3}$$

and let's define the function of function of Boltz by the following way:

$$J(u) = v[x(t),T] + \int_{t_0}^{T} | \sum_{i=1}^{n} \frac{\partial v(x,t)}{\partial x_i} p_i(x,t) | dt +$$

$$+ \int_{t_0}^{T} M | \sum_{i=1}^{n} \frac{\partial v(x,t)}{\partial x_i} g_i(x,t) | dt. \tag{4}$$

Theorem [2]. Let the function $v(x,t)$, that is the first integral for non-controlled system (3) is given for the system (1). Then functions like

$$u^0(x,t) = -Msign(\sum_{i=1}^{n} \frac{\partial v(x,t)}{\partial x_i} g_i(x,t)) \quad give \quad bare$$

minimum to function of function by Boltz (4) и

$$J(u^0) = \min_{|u|<M} J(u) = v[x(t_0),t_0].$$

General part.

Let's apply this theoreme for given model. Structure of the system is bilinear and with two controlling functions, that means:

$$\frac{dx}{dt} = -x + (x+k-\lambda)y + a_{11}u_1,$$

$$\varepsilon \frac{dy}{dt} = x - (x+k)y + a_{22}u_2,$$

with initial conditions $x(t_0) = x_{10}$, $y(t_0) = y_{10}$, $t \in [t_0, T]$, and with limitation for controlling

$| u_1(x,t) | \leq M_1, M = const > 0 | u_2(x,t) | \leq M_2, M = const > 0$.

Using first integral of non-controlling part of the system, let's write down the function of function by Boltz

$$J(u) = v(x,t) + \int_{0}^{T} | M_1 a_{11} + \varepsilon M_2 a_{22} | d\tau \rightarrow \min.$$

$v(x,t)$ -the first integral of non controlling part of considered system and look as :

$$v(x,t) = x + \varepsilon y - \int_{0}^{t} (2k+\lambda)y(\omega)d\omega.$$

At that, values of optimal controlling functions are the following:

$$u_1^0 = M_1 a_{11}, \ u_2^0 = M_2 a_{22}.$$

And minimum value of function of function is:

$$J(u^0) = x_{10} + \varepsilon y_{10} - \int_{0}^{t} (2k+\lambda)y(\omega)d\omega.$$

Thus, a sum of optimal bilinear system's control with small parameter ε was considered on presence of first integrals of non-control system's part and with the help of choice of function of function by Boltz . An advantage of this optimizational approach is that the optimal control is in analytic view. The sum on optimization of bilinear systems with the small parameter ε. In common case, analytic system's solution describing models of enzyme kinetics is very difficult to find. But in this sum, on the condition that bilinear system has the firs interval, an analytic view of controlling functions is found for definite model.

LITERATURE

1.*Marry J.* Nonlinear differential equations in biology.Translation from English by Babsky V.G../ Editorial – Myshkys A.D.-M.:Myr, 1983.-393p.

2. *Baygelov K.Zh., Biyarov T.N., Zhumagulov B.T.* Optimization of biological systems with limitations on control. Almaty: preprint of Engineering academy RK,1993.№4.-P.23.

Резюме

Бұл жұмыста біртекті тербелістерді өрнектейтін үлгіні тиімді басқару мөселері қарастырылған. Белгілі әдістерден өзгеше әдіспен үлгіні тиімді басқару көрсетілген. Сонымен бірге, алынған үлгіні ε аз параметрлі сызықтық емес жүйенің тиімді басқару есебі деп шығарылған.

Резюме

Рассмотрены вопросы оптимизации управления модели, описывающие однородные колебания. Данная модель рассмотрена как задача оптимального управления билинейных систем с малым параметром ε.

Предложен подход оптимизации, отличающейся от классического.

Kazakh akademy of transport and communication named after M.Tynychpaev
Almaty