MASV method

and energy optimization of control parameters

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The paper is focused to problems with finite and infinite models, time optimization, energy optimization parameters in the MASV method, called Method Aggregate State Variables.

The MASV method, called Method Aggregate State Variables, and its applications consist of four steps:

- mathematical model,
- control algorithm,
- simulation control,
- application in industry.

Classical formulation of the MASV method does not solve the control in the finite time and construction algorithm uses the control in the infinite time. Time optimization cannot use this formulation. In the paper we show one way of optimization control parameters **T,D.**

MATEMATICAL METHOD OF CONTROL SYSTEM

The following mathematical model of the nominal nonlinear subsystem will be considered

$$\dot{\mathbf{x}} = \mathbf{f}(\mathbf{x}, t) + \mathbf{G}(\mathbf{x}, t)\mathbf{u}\,,\ \mathbf{x}(0) = \mathbf{x}_0\,, \qquad (1)$$

where

$\mathbf{x} = [x_1, x_2, \ldots, x_n]^T,\ \dim \mathbf{x} = n$ is the vector function of state variables,

$$\mathbf{u} = [u_1, u_2, \ldots, u_m]^T,\ \dim\ \mathbf{u} = m$$

is the vector function of control variables,

$$\mathbf{f} = [x_2, .., f_{r_1}, x_{r_1+2}, .., f_{r_2}, x_{r_2+2}, .., f_n]^T,$$

$$\dim \mathbf{f} = n$$

is a continuous vector function,

G, $\dim \mathbf{G} = (n, m)$ is the matrix of continuous functions $g_{i,j}(x)$,

n – number of state variables (the order of the nonlinear subsystem),

n_j – partial order, m - the number of the control variables.

The matrix **G** is of the following form

$$\mathbf{G} = \begin{bmatrix} 0 & 0 & \ldots & 0 \\ \ldots & \ldots & \ldots & \ldots \\ g_{r_1 1} & g_{r_1 2} & \ldots & g_{r_1 m} \\ 0 & 0 & \ldots & 0 \\ \ldots & \ldots & \ldots & \ldots \\ g_{r_2 1} & g_{r_2 2} & \ldots & g_{r_2 m} \\ 0 & 0 & \ldots & 0 \\ \ldots & \ldots & \ldots & \ldots \\ g_{n1} & g_{n2} & \ldots & g_{nm} \end{bmatrix}$$

$$r_0 = 0;\quad r_j = r_{j-1} + n_j,\ j = 1,2,\ldots,m,$$

$$n = r_m = \sum_{j=1}^{m} n_j$$

The condition of controllability of the nominal nonlinear subsystem (1) [Zítek & Víteček 1999]

$$\operatorname{rank} \mathbf{G}(\mathbf{x}, t) = m \qquad (3)$$

is assumed.

It is supposed that $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$ and strictly not distinguished between a subsystem (system) and a model in the entire the following text.

CONTROL ALGORITHMS DESIGN – MASV METHOD

The task of the optimal tracking control design is determination of the feedback control

$$\mathbf{u} = \mathbf{u}(\mathbf{x}, \mathbf{x}^w, t) \qquad (5)$$

for the controllable nominal standard nonlinear subsystem (1), which for a given state trajectory $\mathbf{x}^w(t)$ ensures its tracking by a real state trajectory $\mathbf{x}(t)$ so that value of the quadratic objective functional

$$J = \int_0^\infty \left(\mathbf{e}^T \mathbf{D}^T \mathbf{D}\mathbf{e} + \dot{\mathbf{e}}^T \mathbf{D}^T \mathbf{T}^2 \mathbf{D}\dot{\mathbf{e}}\right) dt \qquad (6)$$

$$\mathbf{e} = \mathbf{x}^w - \mathbf{x},\ \dim \mathbf{e} = n,$$

$$\lim_{t\to\infty} \mathbf{e}(t) = \lim_{t\to\infty} \dot{\mathbf{e}}(t) = 0 \qquad (7)$$

is minimal, where **e** is the error vector,

D - the constant nonnegative aggregation matrix [dim ***D*** = (m,n), rank (***DG***) = m],

T - the diagonal matrix of positive time constants T_j of the order m, i.e.

$$\mathbf{T} = \operatorname{diag}[T_1, T_2, \ldots, T_m] \qquad (8)$$

By the method of the aggregation of the state variables, it is possible to obtain the optimal feedback control [Zítek & Víteček 1999]