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Procedia Computer Science 120 (2017) 554–560

Procedia Computer Science

www.elsevier.com/locate/procedia

9th International Conference on Theory and Application of Soft Computing, Computing with Words and Perception, ICSCCW 2017, 24-25 August 2017, Budapest, Hungary

Synthesis of intelligent control system with coordinate and parametric feedback

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Abstract

In the persent work, it has been proposed the synthesis method of a fuzzy adaptive control system with variable structure for uncertain and nonstationary dynamic objects. Since the proposed fuzzy control system constructed regarding to bynar-coordinate and parametrically feedback, according to parametric non-stationarity, the system has adaptivity property and according to state variable it has high performance characteristics.

Peer-review under responsibility of the scientific committee of the 9th International Conference on Theory and application of Soft Computing, Computing with Words and Perception.

Keywords: electric actuator (drive); coordinate and parametric feedback; dynamic object; uncertainty slippery regime.

1. Introduction

Dynamic objects in the processes, devices, apparatus and equipment applied in technology and various manufacturing processes, are characterized by uncertainty and non-stationary properties (Aliyev , 2002;2004;2005; Emelyanov ,1984; 1983;1984) Nowadays, non-stationary control objects have been disseminated in mechatronics, robotics, radio technology, power engineering, chemistry, oil-refining, machine-building and in other field of industry (Aliyev (2004); Aliyev (2005); Emelyanov (1984); Emelyanov (1983); Emelyanov (1984); Jafarov (2009); None (2016)). Variation of the parameters of control object impacts the quality of control or in other words, the quality of transition process occurred in a system (Aliyev (2002); Aliyev (2004); Aliyev (2005)). In this regard, in

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1877-0509
Peer-review under responsibility of the scientific committee of the 9th International Conference on Theory and application of Soft Computing, Computing with Words and Perception.
10.1016/j.procs.2017.11.278

synthesis of control system with to some extent optimal performance characteristics is important and actual. Perfect systems, able taking into consideration variation of parameters of an object, should have adaptation property. Controller of an adaptive system consists of main and adaptive devices (Aliyev (2002); Aliyev (2005)). The main control device together with the object compose common automatic control system. Note that, via taking uncertainty into account, the methods and tools of setting and synthesizing adaptive control systems were not worked out sufficiently. In the present work, in order to efficiently control the uncertain dynamic objects, it has been proposed the methods and tools to design fuzzy intelligent system with binary property.

2. Statement of the problem and solution method. Let's look at the actuator, that is a key element of manipulator and mobile robot as dynamic object characterized by uncertainty and non stationarity (Aliyev (2004)). The mathematical model of actuator of manipulator as control object could be written as follows:

$$J_m \ddot{q} + [\, b + \frac{K_t K_e}{R} \,]\dot{q} + \frac{LK_t}{R} q(t) = \frac{K_t v}{R} \tag{2.1}$$

Here $(J_m = 1.8 \times 10^{-6} kg.m^2)$; inertia (moment) of mechanical system $\ddot{q}[rad/san^2]$-rotate acceleration of plate of gear (robot) of actuator;-the speed of rotation angle of plate of rotator (rotor);- constant of rotation moment of plate;=0.03Nm/Amp; R-the resistance of anchor loop (R=5.7Ohm); L-inductivity of anchor loop (very little value); b-coefficent of rotational friction; v-voltage of anchor loop.is controller effect. Note that, parameters in 2.1 equation could change to some extent, in other words, they are non-stationar. Taking into account the uncertainty and nono-stationarity of parametrs of the object, equation of actuator (2.1) could be described as follows:

$$\tilde{a}_0(t)\ddot{q}(t) + \tilde{a}_1(t)\dot{q}(t) + \tilde{a}_2 q(t) = \tilde{k}_{ob} u(t) \tag{2.2}$$

As it coud be seen from (2.2), parameters of the object are non stationar and are characterized by uncertainty. Deviations of the coefficients from nominal value coud be accepted as interval coefficients

$\bar{a}_i(t) \in [a_i^L, a_i^R]$, i=0,1,2 , i.e. $\bar{a}_0 \in [\, 1{,}71\text{x}10^{-6}, 1.87\text{x}10^{-16}]$, $\bar{a}_1 \in [4\text{x}10^{-3}, 6\text{x}10^{-3}]$, $\bar{a}_2 \in [8\text{x}10^{-2}, 9\text{x}10^{-2}]$

$\bar{k}_{ob} \in [k_{ob}^L, k_{ob}^R] \in [0.13, 0.2]$

Note that, in some cases, friction coefficients and the inductance value could be considered as close to zero (Aliyev 2004). Then equation (2.2) could be written as follows:

$$\tilde{a}_0\ddot{q}(t) + \tilde{a}_1\dot{q}(t) = \tilde{k}_{ob} u$$

İn states space, (2.2) could be written by fuzzy differential eqautions as follows:

$$\begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = -\bar{a}_{21}(t)x_1 - \bar{a}_{22}(t)\,x_2 + \bar{b}_{ob}(t)u \end{cases} \tag{2.3}$$

$$\bar{a}_{21} = \frac{\bar{a}_2}{\bar{a}_0}, \quad \bar{a}_{22} = \frac{\bar{a}_1}{\bar{a}_0}, \quad \bar{b}_{ob} = \frac{\bar{k}_{ob}}{\bar{a}_0}$$

İn a special case, in computer simulation let's take variation of the parameters of mathematical model (2.3) as follows:

$$a_{21}(t) = a_{21}^N + \Delta_{21} \sin[0.2(t-t_0)] \;;\; 0^N + 0.001 \sin[0.2\,(t-t_0)] \tag{2.4}$$

$$a_{22}(t) = a_{22}^N + \Delta_{22}\sin[0.5(t-t_0)] \;;\; 2.2 + 0.78 \sin[0.5(t-t_0)]$$

$$b_{ob} = b_{ob}^N + \Delta_{ob} \sin[0.01(t-t_0)] \;;\; 0.7 + 0.05 \sin[0.01(t-t_0)]$$

As it could be seen from (2.4) parameters a_{ij} and b_{ob} are limited and change within certain limits. For uncertain non-stationar dynamic object with above given specific features, it is needed to set up such intelligent adaptive system that main control unit friction regime without large leaps could bring automatic control system (ACS) from starting point (x_{10}, x_{20}) to the end point $(x_{1s}, x_{2s} = 0)$ and $\lim_{t\to T} \varepsilon(t) = 0$.

Intelligent adaptiv ACS are set up by using of bynary property (Emelyanov 1984; 1983;1984) and fuzzy sets theory (Aliyev 2005; Jafarov 2009; None.2016). That is why, a generalized scheme of adaptive control system with uncertainty is propsed as follows -Figure 2.1.

Coordinate feedback operator -R_u is formed as follow rule relatively to simple deviations:

$$u(x,t) = k(t)x(t) \tag{2.5}$$

Here $k(t)$ is formed parametrically in coordinate feedback system as follows:

$$k(t) = k_0(t)\mu(t)\text{sign}x \tag{2.6}$$

$R_{\mu(t)}$ - operator is prametrically formed function in coordinate feedback system. Dependence of this operator