UDC 681.876.2

A.I. Guda, A.I. Mikhalyov

INFLUENCE OF INPUT AND MEASUREMENT NOISE TO LORENZ SYSTEM ADAPTIVE-SEARCHING IDENTIFICATION

Abstract. In this article the influence of input and measurement errors to the process of adaptive-searching identification is researched. Ranges of workability are investigated.

Keywords: Lorenz chaotic system, adaptive-searching identification, simulation.

Introduction

Identification of the chaotic dynamic system [1] is a valuable challenge in real-time identification system synthesis. Adaptive-searching identification methods proved own ability to deal with such systems. In case of chaotic systems, correct choose of identification criterion is required. Set of articles [2–5] was devoted to creation and justification of different criterions to many chaotic systems. Namely, in [2] was proposed a criterion for Lorenz system. But all simulations were limited to one level of measurement error. Moreover, influence of additional noise on system input was neglected. In real chaotic systems, small disturbance on input will lead to essential changes in output. So, the question of identification system workability is important and actual.

Model and identification system

Let's consider Lorenz system with additional disturbance:

$$\begin{cases} \dot{x} = \sigma\left(y - x\right) + w_x(t); \\ \dot{y} = x\left(r - z\right) - y; \\ \dot{z} = xy - bz. \end{cases}, \qquad (1)$$

where x, y, z –system state variables, σ, b, r – parameters, $w_x(t)$ – Gaussian noise on "x" channel with parameters σ_x and τ_{wx}. One of output signals, namely "x", is measured with measurement error $w_e(t)$ – Gaussian noise too, with parameters σ_e and τ_{we}.

We consider task as identification of “*r*” parameter, with determines dynamics of considered system. In [2] identification criterion was proposed as:

$$\frac{dQ}{dt}=\frac{1}{\tau_q}\left(x^2(t)-Q(t)\right). \tag{2}$$

where τ_q – filter time constant. Generators variable frequency defined as:

$$F(Q)=\exp\left(-\frac{(Q_o-Q_m)^2}{q_\gamma^2}\right) \tag{3}$$

$$\omega=\omega_o\left(1+Fk_\omega\right) \tag{4}$$

Identification process simulation

Simulation of if dynamic system (1) adaptive-searching identification was conducted by the means of developed computer simulation program “qmo2x” [2–5]. The view of the system simulation is shown in fig. 1.

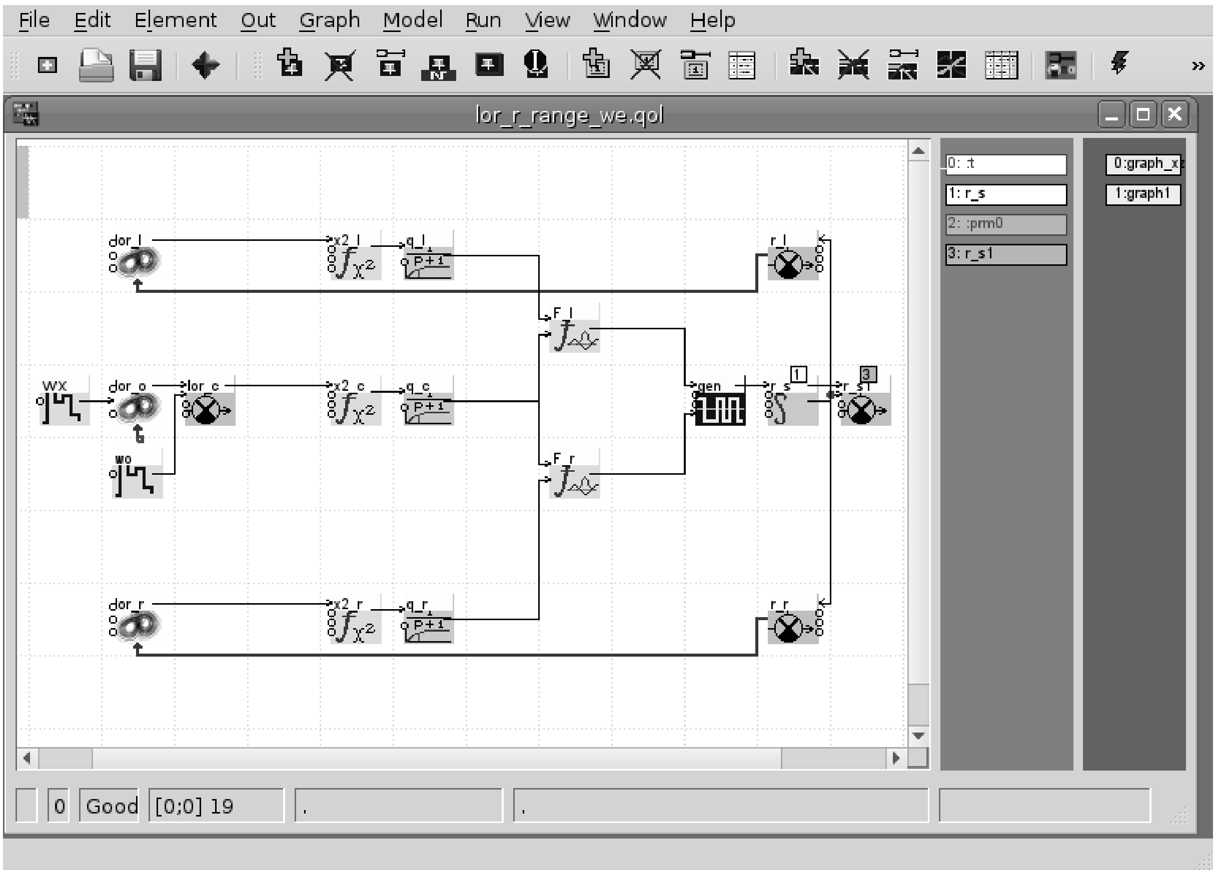

Figure 1 – Identification of system (1) in “qmo2x” program

There are 2 noise generators in this model: one (with label “wx”) for input, and one (“wo”) – for measurement error. The values of τ_x and τ_e was given as equal: $\tau_x = \tau_e = 0.05$, and values of σ_x and σ_e was variable. Parameters of identification system itself was chosen: $\tau_q = 50$, $q_\gamma = 20$, $\omega_0 = 0.1$, $k_\omega = 1$, $k_i = 0.3$, $A = 1$ [3].

In fig. 2 shown an example on identification process simulation with different values of σ_x. Value of parameter r in model was fixed at value $r_o = 40$. This figure demonstrates, that initial phase of identification seems similar, but in case of stringer input noise, searching process stops far from model’s value.

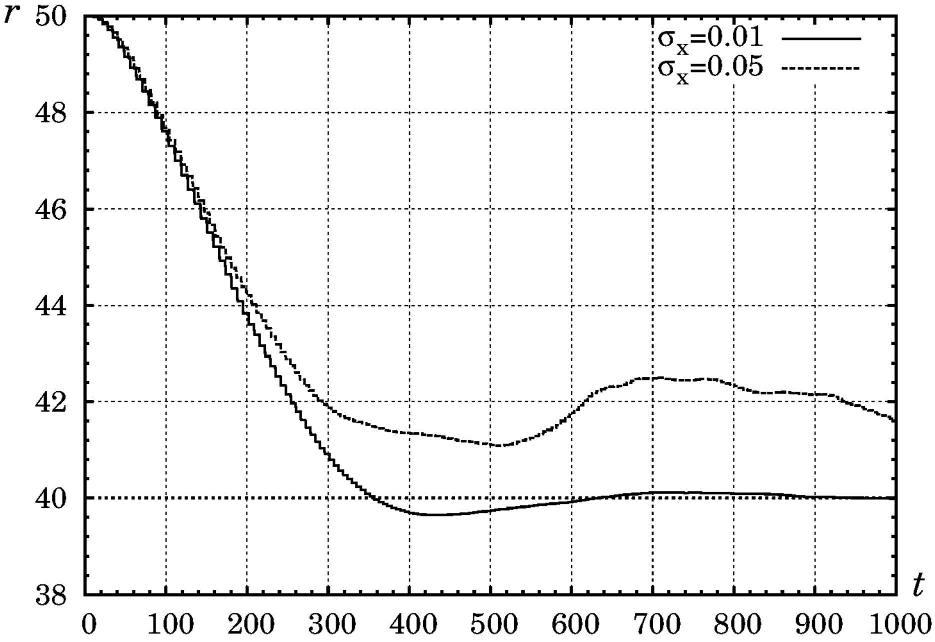

Figure 2 – Identification process simulation

To explore applicability of adaptive-searching identification system with different levels and sources of noise, a series of experiments was conducted. At first, a value of σ_x or σ_e was selected. Than, with fixed stating point $r_s = 40$ model value of parameter was iterated in quite wide range. Final values of coefficient “r” was stored and analyzed.

The results of first experiment series is shown in fig. 3. In this case the level of input noise was zero, and σ_e was iterated. On “y” axes the value of identification error $e_r = e_o - e_m$ is presented. We can see

 ISSN 1562-9945

"plateau", where identification process works. And at relatively large values of σ_e we receive an essential systematic identification error.

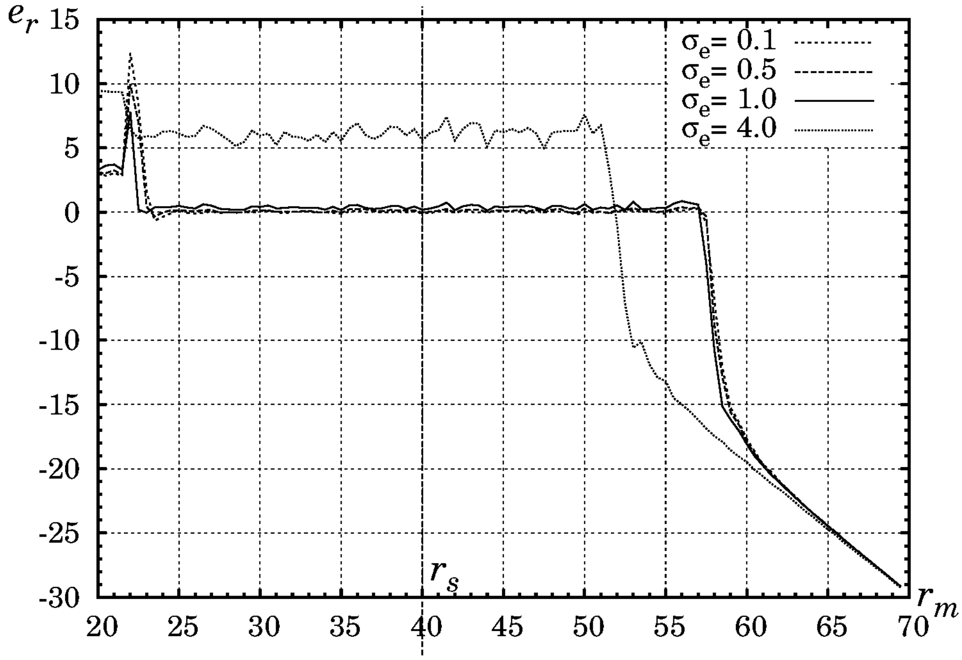

Figure 3 –Dependence $e_r(r_m, \sigma_e)$

Fig. 4 represents the similar results, but in case of $\sigma_e = 0$, and σ_x varies. We can see similar results with the same "plateau", but the values of σ_x is mush smaller, then σ_e in previous plot.

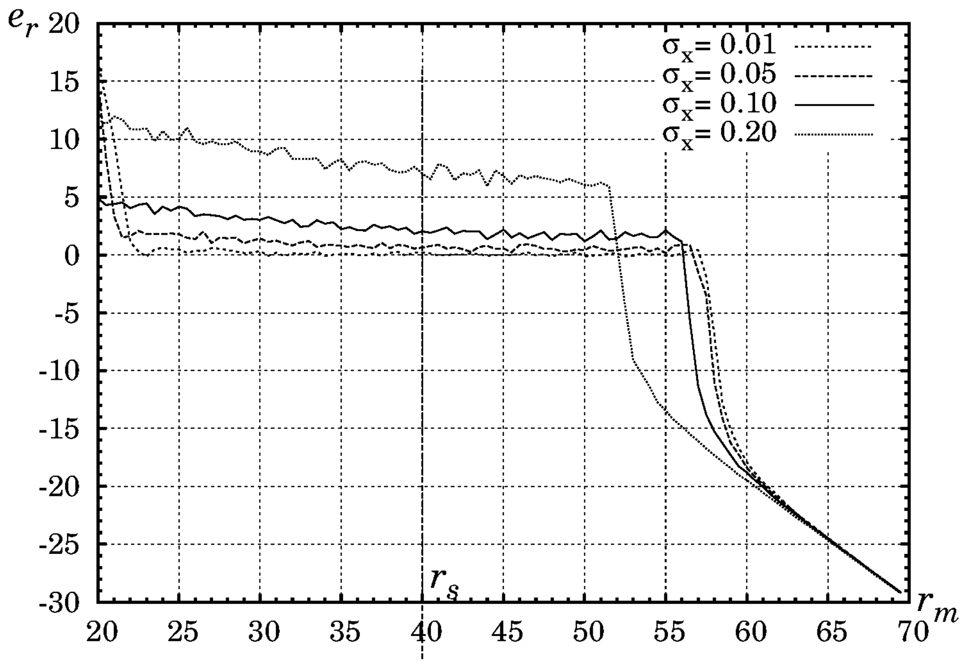

Figure 4 – Dependence $e_r(r_m, \sigma_e)$

This phenomena can be grounded by the fact, that strong filtering properties both criterion filter and generators can suppress even large measurement noise, but noise in Lorenz system itself change the system dynamic.

Conclusions

Results of identification process simulation allow us to make some conclusions:

- identification system able to acquire correct values of parameter *r* in wide range of noise power;
- system is much vulnerable to input noise, than measurement one;
- expanding of identification system adaptive prosperities is required.

REFERENCES

1. Moon F. Chaotic vibrations: An introduction for applied scientists and engineers. – M.: Mir, 1990. – 312 p (in russian).
2. A.I. Guda, A.I. Mikhalyov. Physical principles on adaptive-search identification criterion synthesis for Lorentz dynamic system // System technologies № 2(79). - Dnepropetrovsk, 2012. - p. 13—10 (in russian).
3. Adaptive-search system identification adjusting in application to chaotic objects / Guda A.I., Mikhalyov A.I. // Adaptive systems of automatic control. – 2013. – № 22(42). – P. 134–139. (in russian)
4. Mikhalyov A.I., Guda A.I. The choice of criterion for adaptive-search identification of a Van der Pol dynamic system // Adaptive systems of automatic control. – 2010. – № 16(36). – P. 154–160 (in russian).
5. Mikhalyov A.I., Guda A.I., Novikova K.Yu. Synthesis of criterion of nonlinear dynamic systems identification on physical principles // Adaptive systems of automatic control. – 2007. – № 11(31). – P. 136–142 (in russian).
6. Magnitskii N.A. Sidorov S.V. New methods if chaotic dynamic M.: Edutorial URSS, 2004 – 320 p (in russian).

 ISSN 1562-9945