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Letter to the Editor

Comment on "Parameter identification and synchronization of fractional-order chaotic systems" [Commun Nonlinear Sci Numer Simulat 2012;17:305–16]

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ABSTRACT

This paper comments on the recently published work related to parameter identification of fractional-order chaotic systems [1]. In this note, it is shown that according to the sensitivity issues of chaotic systems to their initial conditions, the criteria for the cost function to be acceptable are not satisfied.

1. Comment

Recently, an approach for parameter identification of chaotic systems was proposed in [1]. They have formulated parameter identification as a multi-dimensional optimization problem.

In "Problem statement" part of the original paper, parameter identification has been formulated as follows.

"Considering the following n-dimensional chaotic system:

$$D_*^{\alpha} Y(t) = f(Y(t), t, \theta) \tag{1}$$

where $Y(t) = (y_1(t), y_2(t), \ldots, y_n(t))^T \in R^n$ *denotes the state vector.* $\theta = (\theta_1, \theta_2, \ldots, \theta_n)^T$ *is a set of original parameters and* $\alpha = (\alpha_1, \alpha_2, \ldots, \alpha_n)^T$ $(0 < \alpha < 1)$.

$f(Y(t), t, \theta) = (f_1(Y(t), t, \theta),\ f_2(Y(t), t, \theta), \ldots, f_n(Y(t), t, \theta))$. *In this paper the fractional-order* α *is also treated as a parameter to be identified. Suppose that the structure of the system is known. Then, the estimated system can be written as:*

$$D_*^{\hat{\alpha}} \widehat{Y}(t) = f(\widehat{Y}(t), t, \hat{\theta}) \tag{2}$$

where $\widehat{Y} = (\hat{y}_1, \hat{y}_2, \ldots, \hat{y}_n)^T \in R^n$ *denotes the state vector of the estimated system, and* $\hat{\theta} = (\hat{\theta}_1, \hat{\theta}_2, \ldots, \hat{\theta}_n)^T$ *is a set of estimated parameters and* $\hat{\alpha} = (\hat{\alpha}_1, \hat{\alpha}_2, \ldots, \hat{\alpha}_n)^T$ *is the estimated fractional-order. To identify parameters, the following objective function is defined:*

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$$F = \sum_{k=1}^{N} \|Y_k - \hat{Y}_k\|^2 \tag{3}$$

where $k = 1, 2, \ldots, N$ is the sampling time point and N denotes the length of data used for parameter estimation. $\|\cdot\|$ is Euclidian norm. Y_k and $\hat{Y}_k$ denote the state vector of the original and estimated system at time k, respectively. The parameter identification can be achieved by searching suitable θ^* and α^* such that the objective function is minimized i.e.,

$$(\theta^*, \alpha^*) = minF, \quad (\theta, \alpha) \in \Omega \tag{4}$$

where Ω is searching space admitted for parameters and fractional-order."

In simple words, they suppose that less "error between real time series and model time series", indicates a better model. Obviously, it is not possible to know the exact value of initial conditions of real signals due to the measurement and observation error, noise, etc. (the error may be very small, but not zero) [2]. Consequently, since chaotic systems are sensitive to initial conditions and have random-like behavior, even if there is no mismatch between the system and its model, the cor-

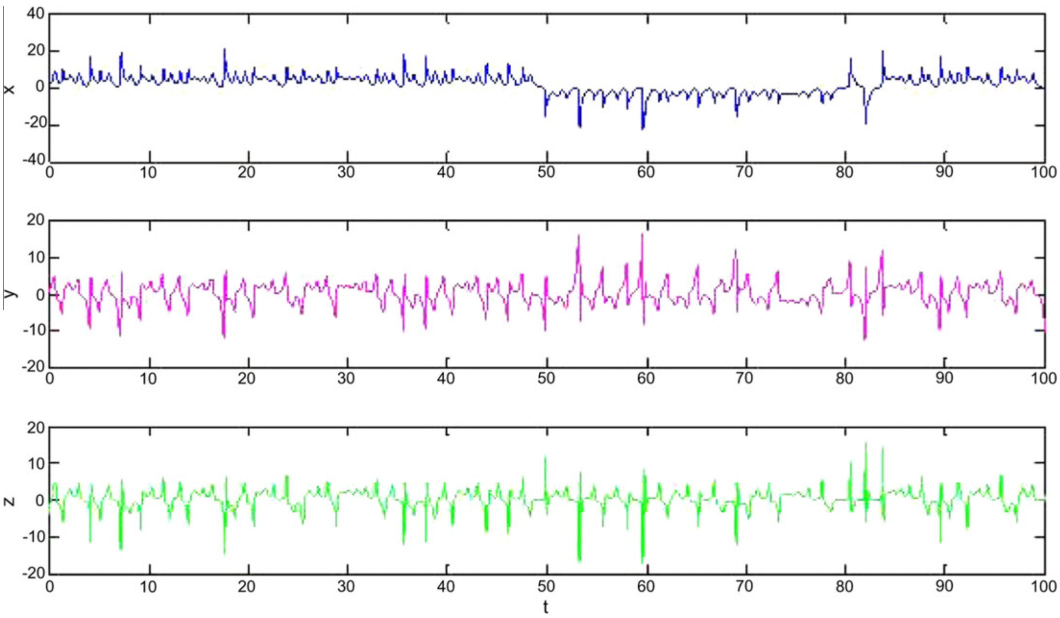

Fig. 1. Chaotic time series obtained from fractional-order system.

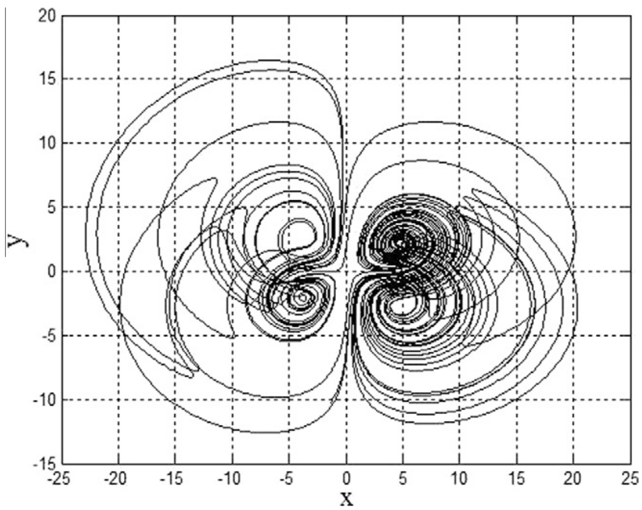

Fig. 2. Chaotic attractor of the system projected into x-y space.