World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:4, No:8, 2010

# Adaptive Sliding Mode Observer for a Class of Systems

D.Elleuch, T.Damak

***Abstract*—**In this paper, the performance of two adaptive observers applied to interconnected systems is studied. The nonlinearity of systems can be written in a fractional form. The first adaptive observer is an adaptive sliding mode observer for a Lipchitz nonlinear system and the second one is an adaptive sliding mode observer having a filtered error as a sliding surface. After comparing their performances throughout the inverted pendulum mounted on a car system, it was shown that the second one is more robust to estimate the state.

***Keywords*—**Adaptive observer, Lipchitz system, Interconnected fractional nonlinear system, sliding mode.



## I. INTRODUCTION

DIFFERENT forms of nonlinear systems with varying parameters are presented in literature. For this reason many adaptation laws are developed for each system to estimate the unknown parameters. To have appropriate adaptation laws, some techniques are used such as an adaptive controller ([6], [7], [16]) and an adaptive observer ([2], [5], [8], [9], [17]), where an augmentation of the vectors of state including the state and the unknown parameters is used [10]. An observer is called adaptive observer if it uses an adaptation law to estimate the unknown parameters [10].

In literature ([1], [2], [3], [4]), most of the adaptive observers are developed for a class of lipchitz nonlinear systems throughout a classical observer. But the adaptation laws proposed for a class of systems are not usually robust for all systems of the same class.

In this work, we have shown the modest performance of an adaptation law proposed for a lipchitz nonlinear system which can be written in a fractional form. Then, an adaptive sliding mode observer designed to a fractional nonlinear system is applied. These adaptation laws have been compared through the inverted pendulum mounting on a cart system in the case of constant parameters.

## II. ADAPTIVE SLIDING MODE OBSERVER FOR A CLASS OF LIPCHTIZ SYSTEM

In literature, the adaptive observers are more studied in the case of classical approaches. It is proved that the adaptation law depends on the class of nonlinear systems and on the technique applied to synthesize the observer.

A systematic approach to synthesize the adaptive observer is developed by [3] for Lipchitz nonlinear systems .Following that, an adaptive sliding mode observer for a system as in [3] will be studied. Consider the nonlinear systems.

$$\begin{cases} \dot{x} = Ax + \phi(x,u) + \theta^T f(x,u) \\ y = Cx \end{cases}$$

With: $x \in \Re^n$; $\phi \in \Re^n$; $f = diag(f_1, f_2 \cdots, f_n)$; $A$ is a constant matrix; $\theta \in \Re^n$ parameter vector; $y \in \Re^p$

The nonlinear functions $\phi$ and $f$ are two lipchitz matrices such as:

$$\| f(x,u) - f(\hat{x},u)\| \le \alpha_1 \|x - \hat{x}\|$$

$$\|\phi(x,u) - \phi(\hat{x},u)\| \le \alpha_2 \|x - \hat{x}\|$$

$\alpha_1, \alpha_2 \in \Re^n$.

Considering the following lyapunov function

$$V = \frac{1}{2} e^T e + \frac{1}{2} \rho \tilde{\theta}^T \tilde{\theta} \tag{1}$$

Where $\tilde{\theta} = \theta - \hat{\theta}$ and $e = x - \hat{x}$

This lyapunov function satisfies the condition of stability, the derivative of $V$ is negative, if:

- The architecture of the adaptive sliding mode observer is:

$$\begin{cases} \dot{\hat{x}} = A\hat{x} + \phi(\hat{x},u) + \hat{\theta}^T f(\hat{x},u) + L(y - C\hat{x}) - \\ \quad \lambda sign(y - C\hat{x}) \\ \dot{\hat{\theta}} = \dfrac{1}{\rho} f^T(\hat{x},u)(y - C\hat{x}) \end{cases} \tag{2}$$

- This adaptive observer is stable and converges to the desired state if:

$$k > \lambda \tag{3}$$

In [14], it is shown that the adaptive sliding mode observer can give a good performance for a Lipchitz nonlinear system when the parameters are constant or varied.

D.Elleuch is with Industrial Processes Control Unit Sfax University, ENIS, BP W, 3038, Sfax Tunisia e-mail :( dorsaf _ell@hotmail.fr).

T.Damak is with Industrial Processes Control Unit Sfax University, ENIS, BP W, 3038, Sfax Tunisia e-mail: (tarak.damak@enis.rnu.tn)}.

## III. Adaptive Sliding Mode Observer Having A Filtered Error As A Sliding Surface

Some nonlinear systems are written in the general structure (4) like the robot manipulator ([11], [12]) and the inverted pendulum mounting on a cart [13].

$$\dot{x} = F(x, \dot{x}, u) \tag{4}$$

This form can be transformed into the fractional form .If the parameter vector of the system is unknown, the joint estimation of the parameter and that of the state becomes more complicated because the parameter vector is designed in the numerator and in the denominator. The form of system (4) is written as a set of interconnected fractional systems having the following form:

$$S_j \begin{cases} \dot{x}_{1j} = x_{2j} \\ \dot{x}_{2j} = \dfrac{f_j(x,u)}{\beta(x,u)} \\ y = x_{1j} \end{cases} \tag{5}$$

Where $j = 1 \cdots m$

For each subsystem the output is $y = x_{1j}$ and the output of all the system is $y = \left[x_{11}\ x_{12}\ x_{22} \cdots x_{1m}\right]$ and the state vector is $x = \left[x_{11}\ x_{21}\ x_{12}\ x_{22} \cdots x_{2m}\right]$ .

The nonlinearity $f_j(x,u)$ and $\beta_j$ are expressed such as $f_j(x,u) = f_{0j}(x) + \theta^T W_{fj}(x,u)$ and $\beta(x,u) = \beta_0(x) + \theta^T W_\beta(x,u)$

With $x \in \Re^n$, $\theta \in \Re^p$, $f_j(x,u)$ and $\beta(x,u) \in C^1$, $W_{fj}(x,u)$ and $W_\beta(x,u) \in \Re^p$.

The function $W_{fj}(x,u)$ and $W_\beta(x,u)$ must satisfy the following assumption.

### A. Assumption:

- $W_{fj}(x,u) > W_\beta(x,u)$
- $W_{fj}(x,u) < \alpha$
- $W_{fj}(x,u)$ and $W_\beta(x,u)$ have the same sign

With $\alpha \in \Re^n$

### B. Definition: Weighting Control Lyapunov Function (WCLF)

For a state vector bounded. We define the following function:

$$V = \int_0^{e_{sj}} \sigma \beta_\alpha(x, \sigma + l_j)\, d\sigma \tag{6}$$

Where $\beta_\alpha(x, \sigma + l_j) = \alpha(x)\beta(x, \sigma + l_j)$

The function $V$ is a Weighting Control Lyapunov Function (WCLF) if:

- $\alpha(x)$ is a smooth function
- $V$ is positive for an error $e_{sj}$
- $V$ is radically unbounded with respect $e_{sj}$ i.e $V \to \infty$ when $e_{sj} \to \infty$
- $\dot{V} \le 0 \quad \forall\ e_{sj} \ne 0$

The function $\alpha(x)$ is a weighting function.

*Theorem:*

If the system (5) satisfies the assumption and if the function WCLF (6) verifies the condition as [6], the adaptive sliding mode observer for the form of the system (5) is defined as follows:

$$S_j \begin{cases} \dot{\hat{x}}_{1j} = \hat{x}_{2j} - s_{1j} \\ \dot{\hat{x}}_{2j} = \dfrac{\hat{\theta}^T W_{fj}(\hat{x},u)}{\hat{\theta}^T W_\beta(\hat{x},u)} - s_{2j} \\ \dot{\hat{\theta}} = \Gamma^{-1} e_{sj} \begin{bmatrix} \sup(W_{fj}(x_{1j}, e_{sj} + l_j) W_\beta^T(\hat{x}) - \\ W_\beta(x_{1j}, l_j) \sup(W_{fj}^T(\hat{x}) + \alpha \end{bmatrix} \hat{\theta} \end{cases} \tag{7}$$

The stability of the adaptive observer is guaranteed for all gains verifying this relation:

$$\sum_{i=1}^{2} k_{ij} \ge \sum_{i=1}^{2} \lambda_{ij} \quad \text{and} \quad |\tau| > 1$$

With $\Gamma^{-1} \in \Re^{nxn}$

$s_{ij}$ is the sliding surface which is written as

$$s_{ij} = -k_{ij} e_{sj} + \lambda_{ij} sign(e_{sj}),\ i = 1,2\ ;\ j = 1, \cdots\cdots, m$$

$e_{sj} = \dot{e}_{1j} + \tau e_{1j}$ : is the filtered error.

The error vector of each subsystem is

$$e_j = \left[x_{1j} - \hat{x}_{1j} \quad x_{2j} - \hat{x}_{2j}\right]^T$$

To design the observer, the expression (6) becomes:

$$V = \int_0^{e_{sj}} \sigma \beta_\alpha(x_{1j}, \sigma + l_j, \hat{x}_{2j})\, d\sigma \tag{8}$$

Where $\alpha(x)$ will be $\beta(\hat{x}_{2j})$,

$\beta_\alpha(x_{1j}, \sigma + l_j, \hat{x}_{2j}) = \beta(x_{1j}, \sigma + l_j)\beta(\hat{x}_{2j})$ and $l_j = \hat{x}_{2j} - [\tau\ \ 0] e_j$

The state vector of each subsystem becomes:

$$x_j = (x_{1j}, e_{sj} + l_j)$$

The lyapunov function (8) satisfies the same condition as (6).

These two architectures of adaptive observer are applied to an inverted pendulum mounted on a cart to test their performance.

## IV. Example

The studied adaptive observers are applied to the inverted pendulum mounting on a cart [15] having a Lipchitz nonlinearity which can be transformed into a fractional form. The equations of motion of the systems are:

$$\begin{cases}(M+m)\ddot{x}+F_x\dot{x}+ml(\ddot{\theta}\cos(\theta)-\dot{\theta}^2\sin(\theta))=u\\ j\ddot{\theta}+F_\theta\dot{\theta}-m\lg\sin(\theta)+ml\ddot{x}\cos(\theta)=0\end{cases}$$

With $x$ is the linear displacement and $\theta$ is the angular displacement; $m$ the pendulum mass; $M$ the car mass; $l$ the link length and $F_x$ and $F_\theta$ are the forces.

In the state space, the system is written as:

$$\begin{cases}\dot{x}_1=x_2\\ \dot{x}_2=\left[\theta_1F_xx_2+\theta_2(\dot{x}_4\cos(x_3)-x_4^2\sin(x_3))\right]\\ \dot{x}_3=x_4\\ \dot{x}_4=j^{-1}\left[\theta_3(g\sin(x_3)-\dot{x}_2\cos(x_3))+F_\theta x_4\right]\\ y=\begin{bmatrix}1&0&0&0\\0&1&0&0\\0&0&1&0\end{bmatrix}\end{cases}\quad(9)$$

Where $\theta=\begin{bmatrix}\theta_1=-\dfrac{1}{M+m}\\ \theta_2=-\dfrac{ml}{m+M}\\ \theta_3=ml\end{bmatrix}$, $A=\begin{bmatrix}0&1&0&0\\0&0&0&0\\0&0&0&1\\0&0&0&\dfrac{F_\theta}{j}\end{bmatrix}$,

$\phi(\hat{x},u)=0$,

$$f(x,u)=\begin{bmatrix}0&0&0\\ F_xx_2&\begin{bmatrix}\dot{x}_4\cos(x_3)-\\x_4^2\sin(x_3)\end{bmatrix}&0\\ 0&0&0\\ 0&0&\begin{bmatrix}g\sin(x_3)-\\ \dot{x}_2\cos(x_3)\end{bmatrix}\end{bmatrix}$$

Applying the adaptive observer (2) to this system, the following expressions are obtained:

- The sliding mode observer:

$$\begin{cases}\dot{\hat{x}}_1=\hat{x}_2+L_1(x_1-\hat{x}_1)-\lambda_1sign(x_1-\hat{x}_1)\\ \dot{\hat{x}}_2=\left[\hat{\theta}_1F_x\hat{x}_2+\hat{\theta}_2(\dot{\hat{x}}_4\cos(\hat{x}_3)-\hat{x}_4^2\sin(\hat{x}_3))\right]+\\ L_2(x_2-\hat{x}_2)-\lambda_2sign(x_2-\hat{x}_2)\\ \dot{\hat{x}}_3=\hat{x}_4+L_3(x_3-\hat{x}_3)-\lambda_3sign(x_3-\hat{x}_3)\\ \dot{\hat{x}}_4=j^{-1}\left[\hat{\theta}_3(g\sin(\hat{x}_3)-\dot{\hat{x}}_2\cos(\hat{x}_3))+F_\theta\hat{x}_4\right]+\\ L_4(x_i-\hat{x}_i)-\lambda_4sign(x_i-\hat{x}_i);\quad i=1,2\,or\,3\end{cases}\quad(10)$$

- The adaptation law:

$$\begin{cases}\dot{\hat{\theta}}_1=-\dfrac{1}{\rho_1}F_x\hat{x}_2e_2\\ \dot{\hat{\theta}}_2=-\dfrac{1}{\rho_2}(\dot{\hat{x}}_4\cos(\hat{x}_3)-\hat{x}_4^2\sin(\hat{x}_3))e_2\\ \dot{\hat{\theta}}_3=-\dfrac{1}{\rho_3}j^{-1}(g\sin(\hat{x}_3)-\dot{\hat{x}}_2\cos(\hat{x}_3))e_4\end{cases}\quad(11)$$

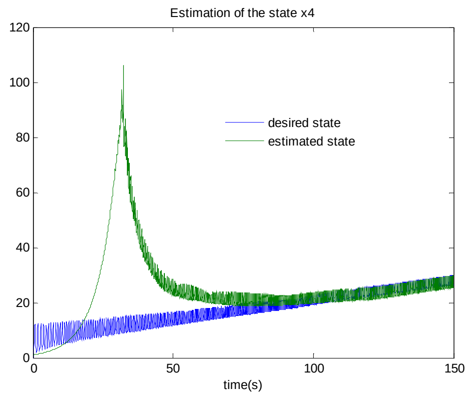
The nominal parameters used in simulations are:

$M=3.2Kg;\ m=0.535Kg;\ j=0.062Kgm^2;$
$l=0.365m;\ F_x=6.2Kg/s;\ F_\theta=0.009Kg/m^2$ *and*
$g=9.807m/s^2$

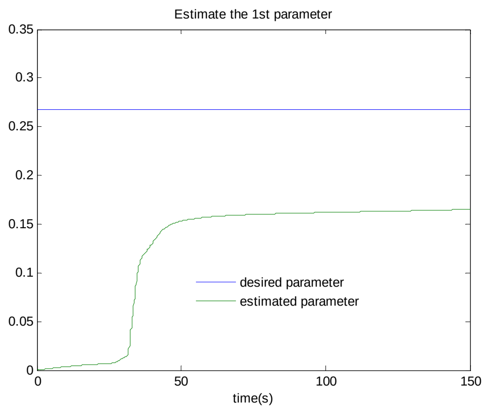
And the simulation conditions are:

$L_1=40;\ L_2=25;\ L_3=20;\ L_4=35;\ \lambda_1=\lambda_2=\lambda_3=10^{-3}$, $\lambda_4=-8;\ \hat{\theta}_1(0)=\hat{\theta}_2(0)=\hat{\theta}_3(0)=\hat{\theta}_4(0)=0;\ \hat{x}_1(0)=1;$ $\hat{x}_2(0)=3;\ \hat{x}_3(0)=10^{-3};\hat{x}_4(0)=1;x_1(0)=1;$ $x_2(0)=3;\ x_3(0)=10^{-3};x_4(0)=1;\dfrac{1}{\rho_1}=7*10^{-6};$ $\dfrac{1}{\rho_2}=2*10^{-6};\ \dfrac{1}{\rho_3}=2*10^{-6};$

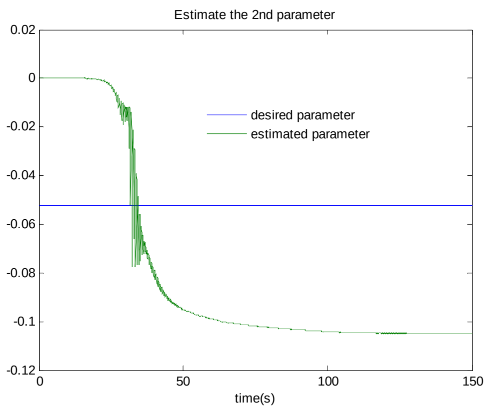
In figure (1), it is shown that the adaptive sliding mode observer designed for a Lipchtiz nonlinear system has a modest performance to estimate the angular speed and the parameters.



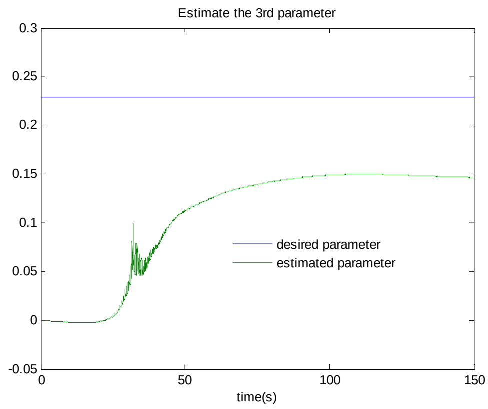

(a) Estimation of the state $x_4$




(b) Estimation of the parameter $\theta_1$




(c) Estimation the parameter $\theta_2$




(d) Estimation the parameter $\theta_3$

Fig.1: Estimation of the state and the parameters by an adaptive sliding mode observer

To apply the second adaptive observer the system should be put on fractional form.

After development and simplification, the equation of the system (9) becomes:

$$s_1\begin{cases}\dot{x}_{11} = x_{21} \\ \dot{x}_{21} = \dfrac{[-F_x x_{21} + j^{-1}(ml)^2 g\sin(x_{12})\cos(x_{12}) - (ml)(j^{-1}F_\theta x_{22}\cos(x_{12}) - x_{22}^2\sin(x_{12})]}{(m+M) - j^{-1}(ml)^2((\cos(x_{12}))^2)}\end{cases} \quad (12)$$

$$s_2\begin{cases}\dot{x}_{12} = x_{22} \\ \dot{x}_{21} = \dfrac{j^{-1}\begin{bmatrix}(M+m)F_\theta x_{22} - \\ (ml)^2 x_{22}^2\sin(x_{12})\cos(x_{12}) + \\ (ml)F_x x_{21}\cos(x_{12}) + (m+ \\ M)(ml)g\sin(x_{12}))\end{bmatrix}}{(m+M) - j^{-1}(ml)^2((\cos(x_{12}))^2)}\end{cases} \quad (13)$$

The output vector is $y = \begin{bmatrix}x_{11} & x_{12}\end{bmatrix}$ and the parameter vector is

$$\theta = \begin{bmatrix}-(ml)^2 & -(ml) & (m+M) & (m+M)(ml)\end{bmatrix}^T$$

With: $\theta_1 = -(ml)^2; \theta_2 = -(ml); \theta_3 = (m+M)$ and $\theta_4 = (m+M)(ml)$

Applying the architecture (9), it yields to the following systems:

The sliding mode observer having a filtered error is:

$$s_1\begin{cases}\dot{\hat{x}}_{11} = \hat{x}_{21} - s_{11} \\ \dot{\hat{x}}_{21} = \dfrac{[-F_x\hat{x}_{21} + j^{-1}(ml)^2 g\sin(\hat{x}_{12})\cos(\hat{x}_{12}) - (ml)(j^{-1}F_\theta\hat{x}_{22}\cos(\hat{x}_{12}) - \hat{x}_{22}^2\sin(\hat{x}_{12}))]}{(m+M) - j^{-1}(ml)^2((\cos(\hat{x}_{12}))^2)} - s_{21}\end{cases}$$

(20)

$$s_2\begin{cases}\dot{\hat{x}}_{12}=\hat{x}_{22}-s_{12}\\ \dot{\hat{x}}_{21}=\dfrac{j^{-1}\begin{bmatrix}(M+m)F_\theta\hat{x}_{22}-(ml)^2\hat{x}_{22}^2\sin(\hat{x}_{12})\cos(\hat{x}_{12})\\+(ml)F_x\hat{x}_{21}\cos(\hat{x}_{12})+\\(m+M)(ml)g\sin(\hat{x}_{12}))\end{bmatrix}}{(m+M)-j^{-1}(ml)^2((\cos(\hat{x}_{12}))^2)}-s_{22}\end{cases}$$

(21)

With:

$s_{11}=-k_{11}\,\mathrm{e}_{s1}+\lambda_{11}\mathrm{sat}(\mathrm{e}_{s1})$ ; $s_{21}=-k_{21}\,\mathrm{e}_{s1}+\lambda_{21}\mathrm{sat}(\mathrm{e}_{s1})$ ; $s_{12}=-k_{12}\,\mathrm{e}_{s2}+\lambda_{12}\mathrm{sat}(\mathrm{e}_{s2})$; $s_{22}=-k_{22}\,\mathrm{e}_{s2}+\lambda_{22}\mathrm{sat}(\mathrm{e}_{s2})$;

$e_{s1}=\dot{e}_{11}+\tau e_{11}$ ; $e_{s2}=\dot{e}_{12}+\tau e_{12}$ ;

$e_{11}=x_{11}-\hat{x}_{11}$ ; $e_{12}=x_{12}-\hat{x}_{12}$ ; *and* $x_{22}=e_{s2}+l_2$

The adaptation law is expressed to the subsystems $s_2$ because it contains all the parameters. Since we have

$$\sup\left(W_{f22}(x_{12,}e_{s2}+l_2)\right)=\begin{bmatrix}j^{-1}x_{22}^2\\-j^{-1}F_x x_{21}\\j^{-1}F_\theta\hat{x}_{22}\\j^{-1}g\end{bmatrix};$$

$$W_\beta(x)=\begin{bmatrix}j^{-1}(\cos(\hat{x}_{12}))^2\\0\\1\\0\end{bmatrix}$$

$$;\sup\left(W_{f22}(\hat{x}_{22})\right)=\begin{bmatrix}j^{-1}\hat{x}_{22}^2\\-j^{-1}F_x\hat{x}_{21}\\j^{-1}F_\theta\hat{x}_{22}\\j^{-1}g\end{bmatrix}$$

The adaptation law is the following:

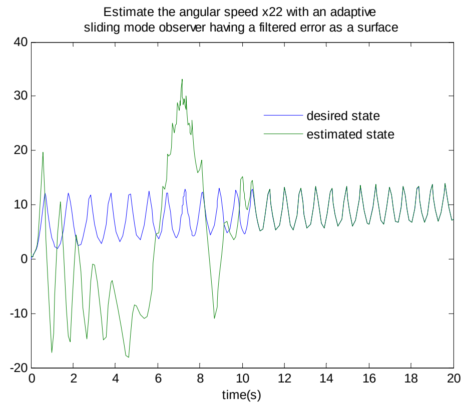
$$\begin{cases}\dot{\hat{\theta}}_1=\Gamma_1^{-1}e_{s2}\begin{bmatrix}j^{-2}(\cos(\hat{x}_{12}))^2((e_{s2}+l_2)^2-\hat{x}_{22}^2)\hat{\theta}_1-\\j^{-2}F_x\hat{x}_{21}\hat{\theta}_2+(-j^{-2}F_\theta\hat{x}_{22}(\cos(\hat{x}_{12}))^2\\+j^{-1}(e_{s2}+l_2)^2)\hat{\theta}_3-\\\hat{\theta}_4 j^{-2}g(\cos(\hat{x}_{12}))^2+21000\end{bmatrix}\\ \dot{\hat{\theta}}_2=\Gamma_2^{-1}e_{s2}\begin{bmatrix}-j^{-2}F_x\hat{x}_{21}(\cos(\hat{x}_{12}))^2\hat{\theta}_1+j^{-1}F_x\hat{x}_{21}\hat{\theta}_3\\-80\end{bmatrix}\\ \dot{\hat{\theta}}_3=\Gamma_3^{-1}e_{s2}\begin{bmatrix}(j^{-2}F_\theta(\cos(\hat{x}_{12}))^2(e_{s2}+l_2)-\\j^{-1}\hat{x}_{22}^2)\hat{\theta}_1+j^{-1}F_x\hat{x}_{21}\hat{\theta}_2+\\(-j^{-2}F_\theta\hat{x}_{22}(\cos(\hat{x}_{12}))^2+\\j^{-1}(F_\theta((e_{s2}+l_2)-\hat{x}_{22}))\hat{\theta}_3-\\\hat{\theta}_4 j^{-1}g+1000\end{bmatrix}\\ \dot{\hat{\theta}}_4=\Gamma_4^{-1}e_{s2}\left[j^{-2}g(\cos(\hat{x}_{12}))^2\hat{\theta}_1+j^{-1}g\hat{\theta}_3+1600\right]\end{cases}$$

(22)

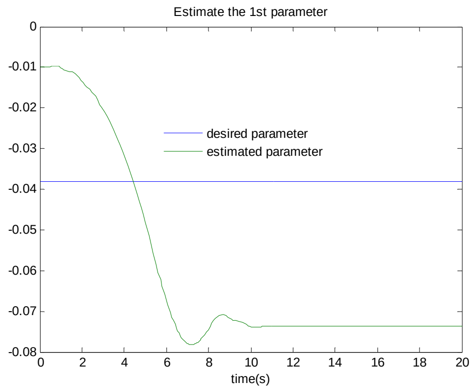
The simulation parameters are:

$\hat{\theta}_1(0)=-0.01$; $\hat{\theta}_2(0)=0$ ; $\hat{\theta}_3(0)=21$; $\hat{\theta}_4(0)=0.6$; $k_{11}=0.85$; $k_{21}=1$; $k_{12}=0.1$; $k_{22}=0.1$; $\lambda_{11}=\lambda_{12}=\lambda_{21}=10^{-5}$ $\lambda_{22}=-30$ ; $\Gamma_1^{-1}=-6*10^{-9}$ ; $\Gamma_2^{-1}=10^{-5}$ ; $\Gamma_3^{-1}=-10^{-5}$ ; $\Gamma_4^{-1}=10^{-6}$ ; $\tau=5.x_{11}(0)=2$; $x_{21}(0)=1$; $x_{12}(0)=10^{-5}$ ; $x_{22}(0)=0$; $\hat{x}_{11}(0)=2$; $\hat{x}_{21}(0)=3$; $\hat{x}_{12}(0)=10^{-4}$ ; $\hat{x}_{22}(0)=1$

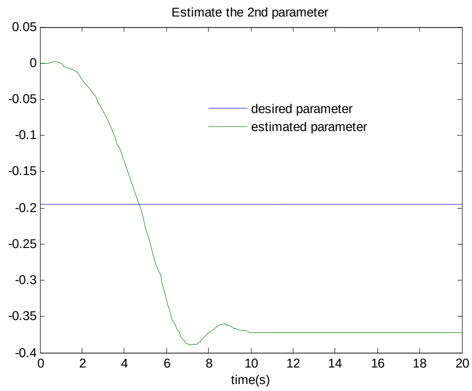
According to the simulation results, the adaptive sliding mode observer having a filtered error as a sliding surface shows the good performances in estimating the angular speed $x_{22}$ (Figure 2.a), whereas the parameters do not converge (Figure 2.b.c.d.e). This result is the same as in [7].



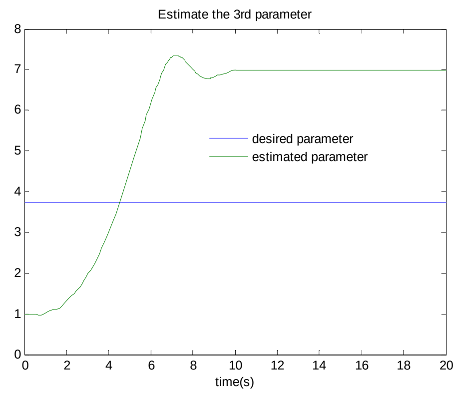

(a) Estimation of the state $x_{22}$



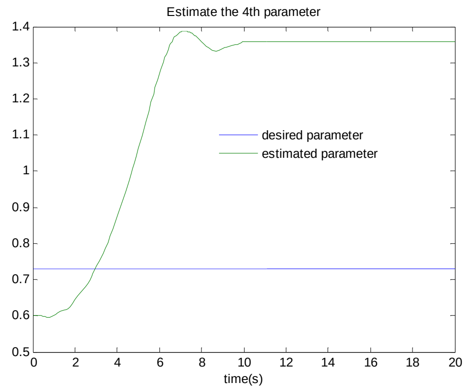

(b) Estimation of the parameter $\theta_1$




(c) Estimation the parameter $\theta_2$




(d) Estimation the parameter $\theta_3$




(e) Estimation of the parameter $\theta_4$

Fig. 2 Estimation of the state and the parameters by an adaptive observer having a filtered error as sliding surface and constant parameters

By comparing this result to the first one, we have shown that the adaptive sliding mode observer having a filtered error is more robust than the adaptive sliding mode observer designed to a lipchitz nonlinear systems to estimate the angular speed of the inverted pendulum. But both are not efficient to estimate all the parameters.

## V. Conclusion

In this work, the performances of the two adaptive sliding mode observers are studied through the example of inverted pendulum mounting on a cart. It was shown that the performance of the adaptive sliding mode observer attributed to a lipchitz nonlinear system is modest when the nonlinearity is written in a fractional nonlinear form. An adaptive sliding observer having a filtered error as a sliding surface is applied to a fractional nonlinear system; it gives better performance to estimate the states than the first one. But both architectures of the adaptive observer are not efficient to estimate all the parameters.

## References

[1] R. Rajamani "Adaptive observers for active automotive suspensions: theory and experiment" *IEEE transaction on control systems technology*. Vol 32, N°1 ,mars 1995
[2] F. Zhu "The design of full order and reduced-order adaptive observers for nonlinear systems" *IEEE international conference on control automation*, China, 30 May to june 1, 2007.
[3] Y. M. Cho , R.Rajamani "A systematic approach to adaptive synthesis for nonlinear systems" *IEEE* ,1995 ,pp 478-482.
[4] C.Cheng ``Design of adaptive observation schemes for lipschtiz nonlinear systems'' *JSME international journal*, series C, Vol 44, N° 3, 2001.
[5] H.Saadaoui, De leon, M.djemai, J.P Barbo "High order sliding mode and adaptive observers for a class of switched systems with unknown parameter: A comparative study"Proceeding of the 45th IEEE conference on decision and control, san diego ,CA , USA. December 13-15 2006.
[6] S.S.Ge , C.C.Hang, T-Zhang "A direct adaptive controller for dynamic systems with a class of nonlinear parametrizations" Automatica, vol 35,1999, pp 741-747.

[7] F.Y.Zeng , B.Dahhou "Adaptive control of nonlinear fermentation process via MRAC technique" Appl.math.modelling, vol 17 February, 1993,PP 58-69.
[8] R. Marino "Adaptive observers for single output nonlinear systems" IEEE transaction on automatic control, vol 35, N°9, September, 1990 v.
[9] N.M.Iyer, A. E. Forell "Design of stable adaptive nonlinear observer for an exothermic stirred Tank reactor" Computers Chem.Engng, Vol 20, N°9,1996, pp 1141-1147.
[10] G. Besançon "nonlinear observers and applications"Springer-verlag Berlin Heidelberg, 2007.
[11] Y-P Chen; J-L Chang "Sliding mode force control of manipulators" Proceedings of the national science council, Republic of China ,part A,physical science and engineering, vol 32, N°2 ,1999, pp 281-288.
[12] Paul C-P. Chao, Chien-Yu shen "Design and implementation of a sliding mode controller and high gain observer for output tracking of a three axis pickup" Sensors and actuators A 135, 2007, pp 713-730.
[13] K.Hakiki, B. Mazari, ,A. Liazid ,S. Djaber "Fault reconstruction using sliding mode observers" American journal of applied sciences, vol 3, N°1 ,2006, pp: 1669-1674.
[14] D.Elleuch, T.Damak "Adaptive sliding mode observer for Lipchitz nonlinear systems with varying parameters" 1 0th International conference on Sciences and Techniques of Automatic control \& computer engineering, Hammamet, Tunisia ,December 20-22,2009, pp1821-1833.
[15] K.hakiki, B.Mazariari, A.Liazid , S.Djaber "Fault reconstruction using sliding mode observer American journal of applied sciencez, vol 3,N°1, 2006, pp: 1669-1674.
[16] Ibrahim F. Jasim "Stable Robust Adaptive Controller and Observer Design for a Class of SISO Nonlinear Systems with Unknown Dead Zone" World Academy of Science, Engineering and Technology 59, 2009.
[17] Grouz Faten, Sbita Lassaâd "Speed Sensorless IFOC of PMSM Based On Adaptive Luenberger Observer" International Journal of Electrical and Electronics Engineering 2:1 2009.