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Design a Methodology to Model-Reference Control of First Order Delays System

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Abstract

Design a nonlinear controller for second order nonlinear uncertain dynamical systems is one of the most important challenging works. This research focuses on the design, and analysis of a model-reference sliding mode controller for first order delay system, in presence of uncertainties. In order to provide high performance nonlinear methodology, model-reference sliding mode controller is selected. Pure sliding mode controller can be used to control of partly known nonlinear dynamic parameters. Conversely, pure sliding mode controller is used in many applications; it has an important drawback namely; chattering phenomenon. To attenuation the chattering, new filter based high speed control technique is introduced. In this technique, two type derivative techniques are used to improve the rate of delay as well stability, robustness and chattering attenuation. This technique cased to improve the rate of delay compare with conventional PID controller and conventional sliding mode controller.

Keywords: *First order delays system, model-reference sliding mode controller, chattering phenomenon, chattering attenuation, filter-based sliding mode controller*

1. Introduction and Background

Controller is a device which can sense information from linear or nonlinear system to improve the systems performance [1]. The main targets to design control systems in this research are time response, stability, good disturbance rejection, and small tracking error [2]. Several industrial systems are controlled by linear methodologies (*e.g.,* Proportional-Derivative (PD) controller, Proportional- Integral (PI) controller or Proportional- Integral-Derivative (PID) controller), but when this systems works in various situations and have uncertainty in dynamic models this technique has limitations. The linear control technique has limitation in time response especially to reduce coupling effect. In practical application first order delay has uncertainty and nonlinear control technique is recommended. Sliding mode controller is an influential nonlinear controller to certain and uncertain systems which it is one of model-reference controller.

Sliding mode controller (SMC) is a powerful nonlinear controller which has been analyzed by many researchers especially in recent years. This theory was first proposed in the early 1950 by Emelyanov and several co-workers and has been extensively developed since then with the invention of high speed control devices [3]. The main reason to opt for this controller is its acceptable control performance in wide range and solves two most important challenging topics in control which names, stability and robustness [4-8]. Sliding mode control theory was first proposed in 1978 by Young to solve the set point problem by discontinuous method as follows:

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$$\boldsymbol{\tau}_{(\boldsymbol{q},\boldsymbol{t})} = \begin{cases} \boldsymbol{U}^{+}(\boldsymbol{q},\boldsymbol{t}) & \boldsymbol{if}\ \boldsymbol{S}_{\boldsymbol{i}} > 0 \\ \boldsymbol{U}^{-}(\boldsymbol{q},\boldsymbol{t}) & \boldsymbol{if}\ \boldsymbol{S}_{\boldsymbol{i}} < 0 \end{cases} \tag{1}$$

Sliding mode controller is divided into two main sub parts:

- Discontinues term
- Model-reference term

Discontinues term causes an acceptable tracking performance at the expense of very fast switching. Conversely in this theory good trajectory following is based on fast switching, fast switching is caused to have system instability and chattering phenomenon. Fine tuning the sliding surface slope is based on nonlinear equivalent part [9-12]. However, this controller is used in many applications but, pure sliding mode controller has an important challenge: chattering phenomenon [12-19]. Chattering phenomenon (Figure 1) can causes some problems such as saturation and heat the mechanical parts or drivers.

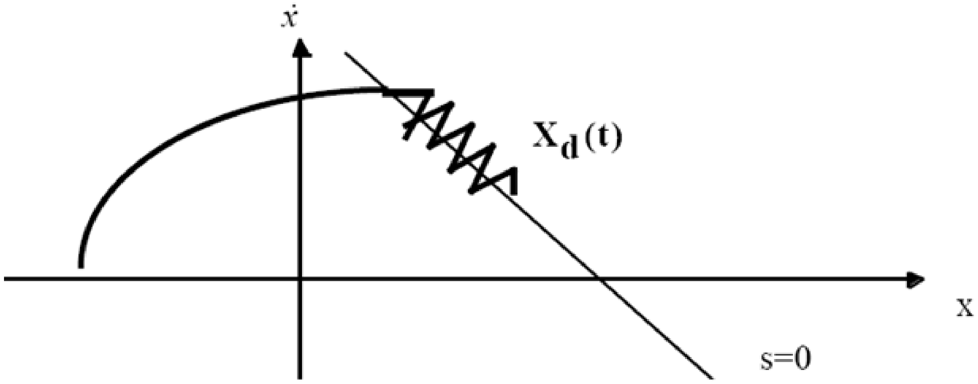

Figure 1. Chattering as a Result of Imperfect Control Switching

Regarding to literature to reduce the chattering boundary layer method have been introduced. In boundary layer saturation method, the basic idea is the discontinuous method replacement by saturation (linear) method with small neighborhood of the switching surface. This replacement caused to increase the error performance and time response against with the considerable chattering reduction.

This paper is organized as follows; second part focuses on the system modeling dynamic formulation and. Third part is focused on the methodology. Simulation result and discussion is illustrated in forth part. The last part focuses on the conclusion and compare between this method and the other ones.

2. Theory

Many industrial processes can be represented by a first order model; equation (2) shows the mathematical plant model (in *s-plane*). Discrete transfer function of this model has obtained using ZOH method, and the selected sampling period (T) is 0.1, equation (3) shows the discrete transfer functions, (in *z-plane*).

$$\boldsymbol{CS_1(s)} = \frac{\boldsymbol{1}}{\boldsymbol{S+1}} \tag{2}$$

and;

$$\boldsymbol{CS_1(z)} = \frac{\boldsymbol{0.09516}}{\boldsymbol{Z-0.9048}}, \boldsymbol{T = 0.1} \tag{3}$$

The time delay occurs when a sensor or an actuator are used with a physical separation. Equation (3) shows the mathematical plant model (in *s-plane*). Discrete transfer functions of this model has been obtained using ZOH method, and the selected sampling period (T) is 0.1, equation (5 and 6) show the discrete transfer functions, (in *z-plane*).

$$\boldsymbol{CS_2(s) = \frac{1}{S^2 \times (S+1)}} \tag{4}$$

$$\boldsymbol{CS_2(z) = Z^{-2} \times CS_1(z)} \tag{5}$$

$$\boldsymbol{CS_2(z) = Z^{-2} \times \frac{0.09516}{Z - 0.9048}, T = 0.1} \tag{6}$$

3. Methodology

Sliding mode controller (SMC) is robust conventional nonlinear controller in a partly uncertain dynamic system's parameters. This conventional nonlinear controller is used in several applications such as in robotics, process control, aerospace and power electronics. This controller can solve two most important challenging topics in control theory, stability and robustness. Consider a nonlinear single input dynamic system is defined by:

$$\boldsymbol{x^{(n)} = f(\vec{x}) + b(\vec{x})u} \tag{7}$$

Where u is the vector of control input, $\boldsymbol{x^{(n)}}$ is the $\boldsymbol{n^{th}}$ derivation of $\boldsymbol{x}$, $\boldsymbol{x = [x, \dot{x}, \ddot{x}, \dots, x^{(n-1)}]^T}$ is the state vector, $\boldsymbol{f(x)}$ is unknown or uncertainty, and $\boldsymbol{b(x)}$ is of known *sign* function. The main goal to design this controller is train to the desired state; $\boldsymbol{x_d = [x_d, \dot{x}_d, \ddot{x}_d, \dots, x_d{}^{(n-1)}]^T}$, and trucking error vector is defined by:

$$\boldsymbol{\tilde{x} = x - x_d = [\tilde{x}, \dots, \tilde{x}^{(n-1)}]^T} \tag{8}$$

A time-varying sliding surface $\boldsymbol{s(x,t)}$ in the state space $\boldsymbol{R^n}$ is given by:

$$\boldsymbol{s(x,t) = (\frac{d}{dt} + \lambda)^{n-1} \tilde{x} = 0} \tag{9}$$

where λ is the positive constant. To further penalize tracking error, integral part can be used in sliding surface part as follows:

$$\boldsymbol{s(x,t)} = (\frac{d}{dt} + \boldsymbol{\lambda})^{\boldsymbol{n-1}} \left(\int_0^t \boldsymbol{\tilde{x}\, dt}\right) = \boldsymbol{0} \tag{10}$$

The main target in this methodology is kept the sliding surface slope $\boldsymbol{s(x,t)}$ near to the zero. Therefore, one of the common strategies is to find input $\boldsymbol{U}$ outside of $\boldsymbol{s(x,t)}$.

$$\boldsymbol{\frac{1}{2}\frac{d}{dt} s^2(x,t) \le -\zeta |s(x,t)|} \tag{11}$$

where ζ is positive constant.

$$\text{If } \mathbf{S(0)>0} \rightarrow \boldsymbol{\frac{d}{dt} S(t) \le -\zeta} \tag{12}$$

To eliminate the derivative term, it is used an integral term from t=0 to t=$\boldsymbol{t_{reach}}$

$$\boldsymbol{\int_{t=0}^{t=t_{reach}} \frac{d}{dt} S(t) \le -\int_{t=0}^{t=t_{reach}} \eta \rightarrow S\,(t_{reach}) - S(0) \le -\zeta(t_{reach} - 0)} \tag{13}$$

Where t_{reach} is the time that trajectories reach to the sliding surface so, suppose S(t_{reach} = 0) defined as

$$\boldsymbol{0 - S(0) \le -\eta(t_{reach}) \rightarrow t_{reach} \le \frac{S(0)}{\zeta}} \tag{14}$$

and

$$\boldsymbol{if\ S(0)} < 0 \rightarrow 0 - S(\mathbf{0}) \le -\boldsymbol{\eta}(\boldsymbol{t_{reach}}) \rightarrow \boldsymbol{S(0)} \le -\boldsymbol{\zeta}(\boldsymbol{t_{reach}}) \rightarrow \boldsymbol{t_{reach}} \le \frac{|\boldsymbol{S(0)}|}{\boldsymbol{\eta}} \qquad (15)$$

Equation (15) guarantees time to reach the sliding surface is smaller than $\frac{|S(0)|}{\zeta}$ since the trajectories are outside of $S(t)$.

$$\boldsymbol{if\ S_{t_{reach}} = S(0) \rightarrow error(x - x_d) = 0} \qquad (16)$$

suppose S is defined as

$$\boldsymbol{s(x,t) = (\frac{d}{dt} + \lambda)}\quad \boldsymbol{\widetilde{x} = (\dot{x} - \dot{x}_d) + \lambda(x - x_d)} \qquad (17)$$

The derivation of S, namely, $\dot{S}$ can be calculated as the following;

$$\boldsymbol{\dot{S} = (\ddot{x} - \ddot{x}_d) + \lambda(\dot{x} - \dot{x}_d)} \qquad (18)$$

suppose the second order system is defined as;

$$\boldsymbol{\ddot{x} = f + u\ \rightarrow \dot{S} = f + U - \ddot{x}_d + \lambda(\dot{x} - \dot{x}_d)} \qquad (19)$$

Where $\boldsymbol{f}$ is the dynamic uncertain, and also since $S = 0\ and\ \dot{S} = 0$, to have the best approximation ,$\boldsymbol{\widehat{U}}$ is defined as

$$\boldsymbol{\widehat{U} = -\hat{f} + \ddot{x}_d - \lambda(\dot{x} - \dot{x}_d)} \qquad (20)$$

A simple solution to get the sliding condition when the dynamic parameters have uncertainty is the switching control law:

$$\boldsymbol{U_{dis} = \widehat{U} - K(\vec{x},t) \cdot \mathrm{sgn}(s)} \qquad (21)$$

where the switching function $\mathbf{sgn(S)}$ is defined as:

$$\boldsymbol{sgn(s)} = \begin{cases} \mathbf{1} & \boldsymbol{s} > 0 \\ \mathbf{-1} & \boldsymbol{s} < 0 \\ \mathbf{0} & \boldsymbol{s = 0} \end{cases} \qquad (22)$$

and the $\boldsymbol{K(\vec{x},t)}$ is the positive constant.

$$\boldsymbol{\frac{1}{2}\frac{d}{dt}s^2(x,t) = \dot{S} \cdot S = \left[f - \hat{f} - K\mathrm{sgn}(s)\right] \cdot S = \left(f - \hat{f}\right) \cdot S - K|S|} \qquad (23)$$

The sliding surface calculates as:

$$\boldsymbol{s(x,t) = (\frac{d}{dt} + \lambda)^2 \left(\int_0^t \widetilde{x}\, dt\right) = (\dot{x} - \dot{x}_d) + 2\lambda(\dot{x} - \dot{x}_d) - \lambda^2(x - x_d)} \qquad (24)$$

in this method the approximation of $\boldsymbol{U}$ is computed as

$$\boldsymbol{\widehat{U} = -\hat{f} + \ddot{x}_d - 2\lambda(\dot{x} - \dot{x}_d) + \lambda^2(x - x_d)} \qquad (25)$$

The sliding mode control law for first order delay system is:

$$\boldsymbol{U = U_{Model-Reference} + U_{dis}} \qquad (26)$$

$$\boldsymbol{U_{eq} = \left[\frac{1}{S^2 \times (S+1)} + \dot{S}\right]} \qquad (27)$$

$$\boldsymbol{U_{dis} = K \cdot \mathrm{sgn}(S)} \qquad (28)$$

In sliding mode controller select the desired sliding surface and $\boldsymbol{sign}$ function play a vital role to system performance and if the dynamic formulation is derived to sliding surface then the linearization and decoupling through the use of feedback, can be realized. In this state, the derivative of sliding surface can help to decoupled and linearized closed-loop system dynamics. Linearization and decoupling by sliding mode controller can be obtained in spite of the quality of the system dynamic model, in contrast to the other conventional nonlinear control technique that requires the exact dynamic model of a system. As a result, uncertainties are estimated by discontinuous feedback control but it can cause to chattering. To reduce the chattering in presence of switching functions; high speed filter controller is added to discontinuous part of sliding mode controller. High speed filter is type of stable controller as well as conventional sliding mode controller. In proposed methodology PD, PI or PID linear controller is used in parallel with discontinuous part to reduce the role of sliding surface slope as a main coefficient. The formulation of new chattering free sliding mode controller is;

$$\boldsymbol{U = U_{eq} + U_{dis-new}} \tag{29}$$

In (29) $\boldsymbol{U_{eq}}$ is equivalent term of sliding mode controller and this term is related to the nonlinear dynamic formulation of first order delay system (equation 27). The new switching discontinuous part is introduced by $\boldsymbol{U_{dis-new}}$ a6nd this item is the important factor to resistance and robust in this controller. In PD sliding surface, the change of sliding surface calculated as;

$$\boldsymbol{S_{PD} = \lambda e + \dot{e} \to \dot{S}_{PD} = \lambda \dot{e} + \ddot{e}} \tag{30}$$

The new discontinuous switching term ($\boldsymbol{\tau_{dis}}$) is computed as [3];

$$\boldsymbol{U_{dis-new} = K_a \cdot \mathrm{sgn}(S) + U_{Filter}} \tag{31}$$

$$\boldsymbol{U_{Filter} = K_a e + \left[K_D e - \frac{K_N}{S} e\right] + \frac{K_i}{S} e + K_v \dot{e}} \tag{32}$$

Based on (31) and (32);

$$\boldsymbol{U_{dis-new} = K_a \cdot \mathrm{sgn}(\lambda e + \dot{e}) + K_a e + \left[K_D e - \frac{K_N}{S} e\right] + \frac{K_i}{S} e + K_v \dot{e}} \tag{33}$$

$$\boldsymbol{U = K_a \cdot \mathrm{sgn}(\lambda e + \dot{e}) + K_a e + \left[K_D e - \frac{K_N}{S} e\right] + \frac{K_i}{S} e + K_v \dot{e} + \left[\frac{1}{S^2 \times (S+1)} + \dot{S}\right]} \tag{34}$$

According to the dynamic formulation of first order delay

$$\boldsymbol{U = \frac{1}{S^2 \times (S+1)}} \tag{35}$$

And the controller formulation

$$\boldsymbol{U = K_a \cdot \mathrm{sgn}(\lambda e + \dot{e}) + K_a e + \left[K_D e - \frac{K_N}{S} e\right] + \frac{K_i}{S} e + K_v \dot{e} + \left[\frac{\widehat{1}}{S^2 \times (S+1)} + \dot{S}\right]} \tag{36}$$

According to (35) and (36), can be expressed:

$$\boldsymbol{\frac{1}{S^2 \times (S+1)} = K_a \cdot \mathrm{sgn}(\lambda e + \dot{e}) + K_a e + \left[K_D e - \frac{K_N}{S} e\right] + \frac{K_i}{S} e + K_v \dot{e} + \left[\frac{\widehat{1}}{S^2 \times (S+1)} + \dot{S}\right]} \tag{37}$$

Assuming that it can be expressed by the following equation:

$$\boldsymbol{S^T \left(\frac{\dot{1}}{S^2 \times (S+1)} - 2V\right) S = 0} \tag{38}$$

If the Lyaponuv function is written by;

$$\boldsymbol{V = \frac{1}{2} S^T \frac{1}{S^2 \times (S+1)} S} \tag{39}$$

we can written the derivative of Lyapunov functions as;

$$\begin{aligned}\dot{V} &= S^T \frac{1}{S^2 \times (S+1)}\dot{S} + \frac{1}{2}S^T \frac{\dot{1}}{S^2 \times (S+1)}S \\ &= S^T\left(\frac{1}{S^2 \times (S+1)}\dot{S} + VS\right) \\ &= S^T\Bigg[K_a \cdot \operatorname{sgn}(\lambda e + \dot{e}) + K_a e + \left[K_D e - \frac{K_N}{S}e\right] + \frac{K_i}{S}e + K_v\dot{e} + \left[\frac{\widehat{1}}{S^2 \times (S+1)} + \dot{S}\right] \\ &\qquad + \Delta f\Bigg]\end{aligned} \tag{40}$$

$$\begin{aligned}\dot{V} &= \frac{1}{2}S^T \frac{\dot{1}}{S^2 \times (S+1)}S - S^T VS \\ &\qquad + S^T\Bigg(K_a \cdot \operatorname{sgn}(\lambda e + \dot{e}) + K_a e + \left[K_D e - \frac{K_N}{S}e\right] + \frac{K_i}{S}e + K_v\dot{e} \\ &\qquad + \left[\frac{\widehat{1}}{S^2 \times (S+1)} + \dot{S}\right] - U\Bigg) \\ &\qquad = S^T\Bigg(K_a \cdot \operatorname{sgn}(\lambda e + \dot{e}) + K_a e + \left[K_D e - \frac{K_N}{S}e\right] + \frac{K_i}{S}e + K_v\dot{e} \\ &\qquad + \frac{1}{S^2 \times (S+1)} + \dot{S}) - U\Bigg)\end{aligned} \tag{41}$$

4. Result and Discussion

Figure 2 illustrate the trajectory tracking for control-free controller, conventional sliding mode controller and filter model reference sliding mode controller.

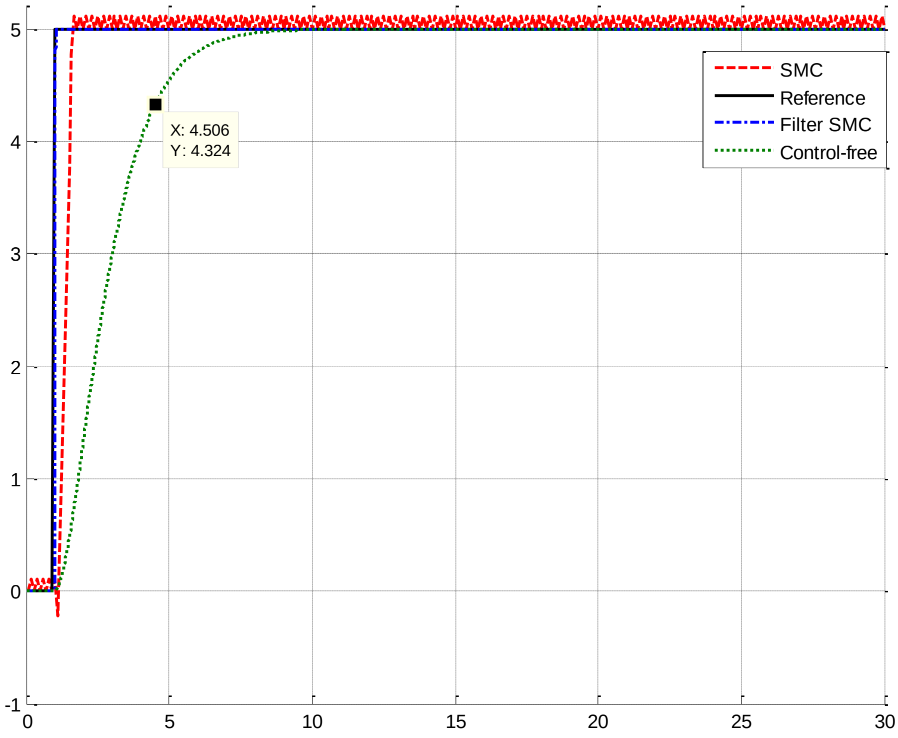

Figure 2. Control-free, SMC and Filter PID Controller: Certain Condition

According to Figure 2, in certain condition proposed method's time response is about zero which in conventional sliding mode controller is about 0.6 second and control-free has about 3.5 second delay time. Regarding to Figure 2 proposed method in certain condition has two main positive points: chattering attenuation and eliminate the delay.

Figure 3 illustrates the power of disturbance rejection in control free, conventional sliding mode controller and filter sliding mode controller. Based on the following graph, however conventional sliding mode is a robust controller but it has two drawbacks: chattering phenomenon, uncertainty limitation.

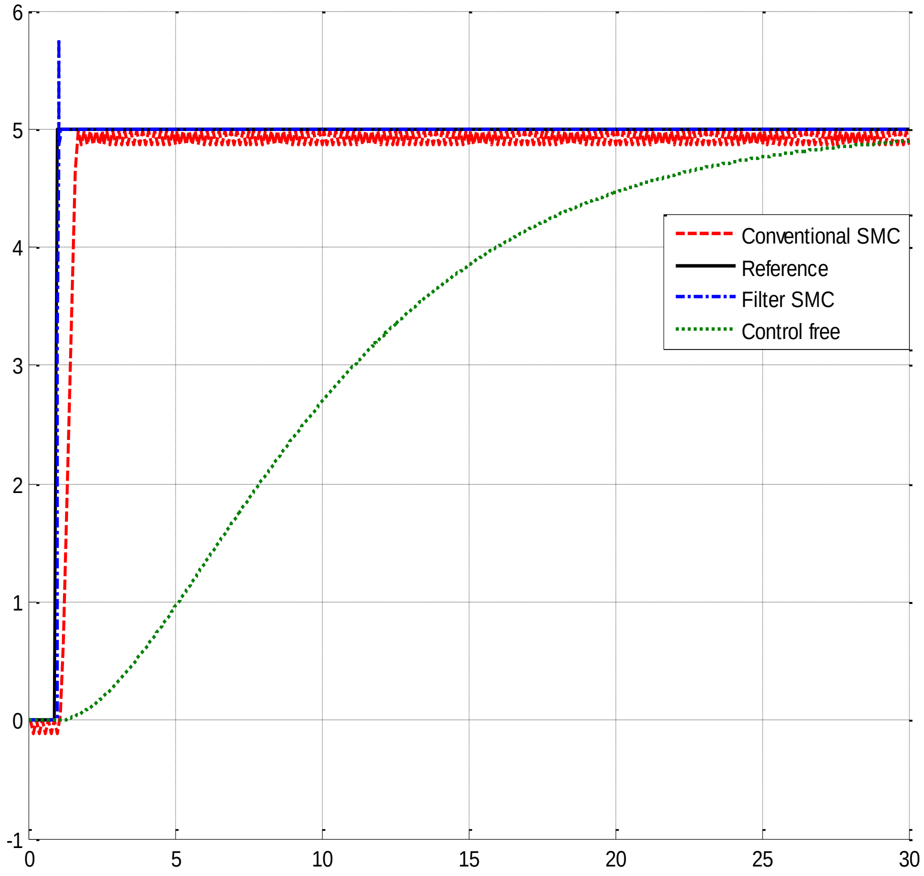

Figure 3. Control-free, SMC and Filter PID Controller: Uncertain Condition

Regarding to Figure 3, in presence of uncertainty the time response in control free is about 19 second and increase about 550% but for conventional sliding mode controller is about 0.6 second and for filter model reference sliding mode controller is about zero. In time response point of view, proposed method has an excellent robustness.

5. Conclusion

In this research, filter model-reference sliding mode algorithm is recommended for first order delay system to reduce the rise time and error performance as well improves other performance. To design robust and stable controller filter-based model-reference sliding mode controller is recommended. Conventional sliding mode controller (SMC) is a nonlinear, stable, robust and reliable controller. To modify the chattering challenge in conventional model reference sliding mode controller, high speed filter is recommended. Regarding to methodology, this algorithm is robust and stable. Based on results, in certain condition (Figure 2), the time response reduce to about zero, and this method eliminate the chattering as well error. In presence of uncertainty (Figure 3), the time response in proposed method is zero, the same as certain condition, and the chattering and error are eliminate like certain condition. Regarding to this method, the response of filter model-reference controller is like the adaptive method but with low computation compare to the adaptive method.

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Project Title:" Design a Micro-electronic Based Nonlinear Controller for First Order Delay System"

Iranian center of Advance Science and Technology (IRAN SSP) is one of the independent research centers specializing in research and training across of Control and Automation, Electrical and Electronic Engineering, and Mechatronics & Robotics in Iran. At IRAN SSP research center, we are united and energized by one mission to discover and develop innovative engineering methodology that solve the most important challenges in field of advance science and technology. The IRAN SSP Center is instead to fill a long standing void in applied engineering by linking the training a development function one side and policy research on the other. This center divided into two main units:

- Education unit
- Research and Development unit

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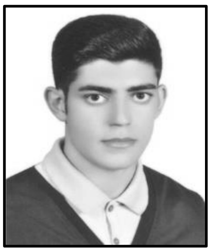
Authors

Arman Jahed, He is currently Research Assistant at Institute of Advanced Science and Technology, Research and Training Center, IRAN SSP. He is research assistant of team (8 researchers) to design a Micro-electronic Based nonlinear controller for first order delay system since March, 2015, research student (45 researchers) to Nonlinear control of Industrial Robot Manipulator for Experimental Research and Education from February 2012 to February 2013, and published 5 journal papers since 2012 to date. His current research interests are nonlinear control, artificial control system, Microelectronic Device, and HDL design.

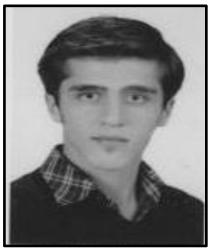
Farzin Piltan, He is an outstanding scientist in the field of Electronics and Control engineering with expertise in the areas of nonlinear systems, robotics, and microelectronic control. Mr. Piltan is an advanced degree holder in his field. Currently, Mr. Piltan is the Head of Mechatronics, Intelligent System, and Robotics Laboratory at the Iranian Institute of Advanced Science and Technology (IRAN SSP). Mr. Piltan led several high impact projects involving more than 150 researchers from countries around the world including Iran, Finland, Italy, Germany, South Korea, Australia, and the United States. Mr. Piltan has authored or co-authored more than 140 papers in academic journals, conference papers and book chapters. His papers have been cited at least 3900 times by independent and dependent researchers from around the world including Iran, Algeria, Pakistan, India, China, Malaysia, Egypt, Columbia, Canada, United Kingdom, Turkey, Taiwan, Japan, South Korea, Italy, France, Thailand, Brazil and more. Moreover, Mr. Piltan has peer-reviewed at least 23 manuscripts for respected international journals in his field. Mr. Piltan will also serve as a technical committee member of the upcoming EECSI 2015 Conference in Indonesia. Mr. Piltan has served as an editorial board member or journal reviewer of several international journals in his field as follows: International Journal Of Control And Automation (IJCA), Australia, ISSN: 2005-4297, International Journal of Intelligent System and Applications (IJISA), Hong Kong, ISSN:2074-9058, IAES International Journal Of Robotics And Automation, Malaysia, ISSN:2089-4856, International Journal of Reconfigurable and Embedded Systems, Malaysia, ISSN:2089-4864.

Mr. Piltan has acquired a formidable repertoire of knowledge and skills and established himself as one of the leading young scientists in his field. Specifically, he has accrued expertise in the design and implementation of intelligent controls in nonlinear systems. Mr. Piltan has employed his remarkable expertise in these areas to make outstanding contributions as detailed follows:Nonlinear control for industrial robot manipulator (2010-IRAN SSP), Intelligent Tuning The Rate Of Fuel Ratio In Internal Combustion Engine (2011-IRANSSP), Design High Precision and Fast Dynamic Controller For Multi-Degrees Of Freedom Actuator **(2013-IRANSSP),** Research on Full Digital Control for Nonlinear Systems (2011-IRANSSP), Micro-Electronic Based Intelligent Nonlinear Controller (2015-IRANSSP), Active Robot Controller for Dental Automation (2015-IRANSSP), Design a Micro-Electronic Based Nonlinear Controller for First Order Delay System (2015-IRANSSP).

The above original accomplishments clearly demonstrate that Mr. Piltan has performed original research and that he has gained a distinguished reputation as an outstanding scientist in the field of electronics and control engineering. Mr. Piltan has a tremendous and unique set of skills, knowledge and background for his current and future work. He possesses a rare combination of academic knowledge and practical skills that are highly valuable for his work. In 2011, he published 28 first author papers, which constitute about 30% of papers published by the Department of Electrical and Electronic Engineering at University Putra Malaysia. Additionally, his 28 papers represent about 6.25% and 4.13% of all control and system papers published in Malaysia and Iran, respectively, in 2011.



Saman Namvarchi, is currently Research Student at Institute of Advanced Science and Technology, Research and Training Center, IRAN SSP. He is research student of team (8 researchers) to design a Micro-electronic Based nonlinear controller for first order delay system since March, 2015. His current research interests are nonlinear control, artificial control system, Microelectronic Device, and HDL design.



Iman nazari, is currently Research Assistant at Institute of Advanced Science and Technology, Research and Training Center, IRAN SSP. He is research assistant of team (8 researchers) to design a Micro-electronic Based nonlinear controller for first order delay system since March, 2015, research student (45 researchers) to Nonlinear control of Industrial Robot Manipulator for Experimental Research and Education from October 2010 to October 2011, and published 7 journal papers since 2011 to date. His current research interests are nonlinear control, artificial control system, Microelectronic Device, and HDL design

Ali Roshanzamir, is currently Research Assistant at Institute of Advanced Science and Technology, Research and Training Center, IRAN SSP. He is research assistant of team (8 researchers) to design a Micro-electronic Based nonlinear controller for first order delay system since March, 2015, research student (45 researchers) to Nonlinear control of Industrial Robot Manipulator for Experimental Research and Education from June 2010 to June 2011, and published 5 journal papers since 2011 to date. His current research interests are nonlinear control, artificial control system, Microelectronic Device, and HDL design.

Nasri Sulaiman, is a Senior Lecturer in the Department Electrical and Electronic Engineering at the Universiti Purta Malaysia (UPM), which is one of the leading research universities in Malaysia. He is a supervisor and senior researcher at research and training center called, Iranian Institute of Advanced Science and technology (Iranssp) since 2012. He obtained his M.Sc. from the University of Southampton (UK), and Ph.D. in Microelectronics from the University of Edinburgh (UK). He has published more than 80 technical papers related to control and system engineering, including several co-authored papers with Mr. Piltan. He has been invited to present his research at numerous national and international conferences. He has supervised many graduate students at doctoral and masters level. He is an outstanding scientist in the field of Micro-Electronics.

Dr. Nasri Sulaiman advisor and supervisor of several high impact projects involving more than 150 researchers from countries around the world including Iran, Malaysia, Finland, Italy, Germany, South Korea, Australia, and the United States. Dr. Nasri Sulaiman has authored or co-authored more than 80 papers in academic journals, conference papers and book chapters. His papers have been cited at least 3000 times by independent and dependent researchers from around the world including Iran, Algeria, Pakistan, India, China, Malaysia, Egypt, Columbia, Canada, United Kingdom, Turkey, Taiwan, Japan, South Korea, Italy, France, Thailand, Brazil and more.

Dr. Nasri Sulaiman has employed his remarkable expertise in these areas to make outstanding contributions as detailed below:

- Design of a reconfigurable Fast Fourier Transform (FFT) Processor using multi-objective Genetic Algorithms (2008-UPM)
- Power consumption investigation in reconfigurable Fast Fourier Transform (FFT) processor (2010-UPM)
- Crest factor reduction And digital predistortion Implementation in Orthogonal frequency Division multiplexing (ofdm) systems (2011-UPM)
- High Performance Hardware Implementation of a Multi-Objective Genetic Algorithm, (RUGS), Grant amount RM42,000.00, September (2012-UPM)
- Nonlinear control for industrial robot manipulator (2010-IRAN SSP)
- Intelligent Tuning The Rate Of Fuel Ratio In Internal Combustion Engine (2011-IRANSSP)

- Design High Precision and Fast Dynamic Controller For Multi-Degrees Of Freedom Actuator (2013-IRANSSP)
- Research on Full Digital Control for Nonlinear Systems (2011-IRANSSP)
- Micro-Electronic Based Intelligent Nonlinear Controller (2015-IRANSSP)
- Active Robot Controller for Dental Automation (2015-IRANSSP)
- Design a Micro-Electronic Based Nonlinear Controller for First Order Delay System (2015-IRANSSP)