

Sliding Mode Controller for Electromechanical System with Chattering Attenuation

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Abstract:

Electromechanical systems (EMS) may be considered as devices transforming electrical into mechanical energy. Every system that belongs to the electromechanical class can be decomposed in an electrical (ES) and a mechanical subsystem (MS). The motion control systems can be quite complicated because many different factors have to be considered in the design of electromechanical systems. These factors can be summarized as the nonlinearity, non-smoothness in its model, the uncertainty in system model parameters and non-satisfying matching condition.

In this paper a new sliding mode control design approach for the EMS is proposed without neglecting the inductance in the electrical part or approximating the non-smooth perturbation. The first step in the proposed controller design consists of transforming the ES to a low pass filter (LPF) and then (the second step) designing a sliding mode controller (SMC) to the MS that will reject system model uncertainty and the effect of non-smooth disturbances. With a suitable selected LPF time constant, the SMC which controls the MS is nearly the equivalent control and as a result the chattering is attenuated greater than that in the case of classical SMC which designed by ignoring the electrical subsystem and also with a smaller control effort. The simulation results, of applying the proposed sliding mode control to an electromechanical system, show its superiority compared with classical SMC designed in two effective SMC features beside forcing the state to follow the desired position where chattering amplitude is greatly reduced with a significant reduction in control action value (approximately equal to third the required input voltage with the classical SMC).

Keywords: Electromechanical systems, Sliding mode control, Low pass filter, Chattering attenuation

1. Introduction:

Electromechanical systems may be considered as devices transforming electrical into mechanical energy. They establish a very important class of

industrial components often found in current practical applications defining the ideal link between computer-based drivers and movement generators systems. From the control point of view their structure is quite interesting since they belong to the class of the so-called under actuated systems in the sense that only the electrical part is directly actuated; the mathematical models that represent their dynamical behavior are, in general, nonlinear and, in many cases, the state is not completely available for measurement [1]. The main assumption is that every system that belongs to the electromechanical class can be decomposed into an electrical and a mechanical subsystem which it can be viewed as the *interconnection* of electrical and mechanical lumped elements, respectively. For the *electrical subsystems* these elements are inductances, capacitances and resistances, while for the *mechanical subsystem* are springs, masses and dampers [1].

Motion control is concerned with manipulating power to control the movement of a mechanical system. A large amount of motion control is now performed using electric motors, so that it will be our main focus. Motion control systems can be quite complicated because many different factors have to be considered in the design. The following issues must typically be considered:

- Reduction of the influence of plant disturbances
- Attenuation of the effect of measurement noise
- Variations and uncertainties in plant behavior

It is difficult to find design methods that consider all these factors, especially for the conventional control approaches where control designs involve compromises between conflicting goals. In order to design control systems to get high performance and robustness when controlling such complicated processes, advanced controllers have been introduced.

From control design point of view there are mainly three problems for the application of many control theories which can be summarized as follows:

- 1) The nonlinearity and non-smoothness in its model due to the friction model and the nonlinear spring.

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Igor Boiko



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Discontinuous Control Systems Igor Boiko, 2008-11-18 This book provides new insight on the problem of closed loop performance and oscillations in discontinuous control systems covering the class of systems that do not necessarily have low pass filtering properties The author provides a practical yet rigorous and exact approach to analysis and design of discontinuous control systems via application of a novel frequency domain tool the locus of a perturbed relay system Presented are a number of practical examples applying the theory to analysis and design of discontinuous control systems from various branches of engineering including electro mechanical systems process control and electronics Discontinuous Control Systems is intended for readers who have knowledge of linear control theory and will be of interest to graduate students researchers and practicing engineers involved in systems analysis and design

Artificial Intelligence: Theories and Applications Mohammed Salem, Juan Julián Merelo, Patrick Siarry, Rochdi Bachir Bouiadjra, Mohamed Debakla, Fatima Debbat, 2023-03-17 This volume constitutes selected papers presented at the First International Conference on Artificial Intelligence Theories and Applications ICAITA 2022 held in Mascara Algeria in November 2022 The 23 papers were thoroughly reviewed and selected from the 66 qualified submissions They are organized in topical sections on artificial vision and artificial intelligence in big data and natural language processing

Intelligent Manufacturing and Mechatronics Zamberi Jamaludin, Mohd Najib Ali Mokhtar, 2019-07-03 This book presents the proceedings of SympoSIMM 2019 the 2nd edition of the Symposium on Intelligent Manufacturing and Mechatronics Focusing on Strengthening Innovations Towards Industry 4.0 the book presents studies on the details of Industry 4.0's current trends Divided into five parts covering various areas of manufacturing engineering and mechatronics stream namely artificial intelligence instrumentation and controls intelligent manufacturing modelling and simulation and robotics the book is a valuable resource for readers wishing to embrace the new era of Industry 4.0

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technologies It will be a perfect gathering to strengthen academic research and discussion promote the development and progress of relevant research and application and promote the development of disciplines and promote talent training

Fast Satellite Attitude Maneuver and Control Dong Ye, You Li, Yan Xiao, 2022-08-02 Fast Satellite Attitude Maneuver and Control introduces the concept of agile satellites and corresponding fast maneuver attitude control systems systematically and comprehensively presenting recent research results of fast maneuver attitude control for agile satellites by using advanced nonlinear control techniques This reference book focuses on modeling and attitude control considering different actuator combinations actuator installation deviation actuator fault and flexible appendage coupling effect for agile satellites The book provides a unified platform for understanding and applicability of agile satellites fast maneuverer and stabilization control for different purposes It will be an excellent resource for researchers working on spacecraft design nonlinear control systems vehicle systems and complex control systems Unifies existing and emerging concepts concerning nonlinear control theory fault tolerant and attitude control for agile satellites Provides a series of the latest results including but not limited to fast maneuverer and stabilization control hybrid actuator control nonlinear attitude control fault tolerant control and active vibration suppression towards agile satellites Comprehensively captures recent advances of theory technological aspects and applications of fast maneuverer and stabilization control in agile satellites Addresses research problems in each chapter along with numerical and simulation results that reflect engineering practice and demonstrate the focus of developed analysis and synthesis approaches Contains comprehensive up to date references which play an indicative role for further study

Intelligent Manufacturing & Mechatronics Mohd Hasnun Arif Hassan, 2018-04-27 This book presents the proceedings of SymptoSIMM 2018 the 1st edition of the Symposium on Intelligent Manufacturing and Mechatronics With the theme of Strengthening Innovations Towards Industry 4.0 the book comprises the studies towards the particularity of Industry 4.0's current trends It is divided into five parts covering various scopes of manufacturing engineering and mechatronics stream namely Intelligent Manufacturing Robotics Artificial Intelligence Instrumentation and Modelling and Simulation It is hoped that this book will benefit the readers in embracing the new era of Industrial Revolution 4.0

Hybrid Intelligent Systems Oscar Castillo, Patricia Melin, Witold Pedrycz, 2007-07-23 This volume offers a general view of recent conceptual developments of Soft Computing SC It presents successful new applications of SC to real world problems leading to better performance than traditional methods The edited volume covers a wide spectrum of applications including areas such as robotic dynamic systems non linear plants manufacturing systems and time series prediction

Sliding Mode Observers for Automotive Alternator De-Shiou Chen, 1998 Abstract Estimator development for synchronous rectification of the automotive alternator is a desirable approach for estimating alternator's back electromotive forces EMFs without a direct mechanical sensor of the rotor position Recent theoretical studies show that estimation of the back EMF may be observed based on system's phase current model by sensing electrical variables AC phase currents and DC

bus voltage of the synchronous rectifier Observer design of the back EMF estimation has been developed for constant engine speed In this work we are interested in nonlinear observer design of the back EMF estimation for the real case of variable engine speed Initial back EMF estimate can be obtained from a first order sliding mode observer SMO based on the phase current model A fourth order nonlinear asymptotic observer NAO complemented by the dynamics of the back EMF with time varying frequency and amplitude is then incorporated into the observer design for chattering reduction Since the cost of required phase current sensors may be prohibitive the most applicable approach in real implementation by measuring DC current of the synchronous rectifier is carried out in the dissertation It is shown that the DC link current consists of sequential windows with partial information of the phase currents hence the cascaded NAO is responsible not only for the purpose of chattering reduction but also for necessarily accomplishing the process of estimation Stability analyses of the proposed estimators are considered for most linear and time varying cases The stability of the NAO without speed information is substantiated by both numerical and experimental results Prospective estimation algorithms for the case of battery current measurements are investigated Theoretical study indicates that the convergence of the proposed LAO may be provided by high gain inputs Since the order of the LAO NAO for the battery current case is one order higher than that of the link current measurements it is hardly to find moderate values of the input gains for the real time sampled data systems Technical difficulties in implementation of such high order discrete time nonlinear estimators have been discussed Directions of further investigations have been provided

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