International Journal of Soft Computing 7 (2): 58-62, 2012
ISSN: 1816-9503
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Soft Computing Based Design of PID Controller for a Linear Brushless DC Motor

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Abstract: This study presents a Particle Swarm Optimization (PSO) Method for determining the optimal Proportional-Integral Derivative (PID) controller parameters for speed control of a linear brushless DC motor. The proposed approach has superior features including easy implementation, stable convergence characteristic and good computational efficiency. The brushless DC motor is modeled in Simulink and the PSO algorithm is implemented in MATLAB. Comparing with Genetic Algorithm (GA) and Linear Quadratic Regulator (LQR) Method, the proposed method was more efficient in improving the step response characteristics such as reducing the steady-states error, rise time, settling time and maximum overshoot in speed control of a linear brushless DC motor.

Key words: Brushless DC motor, particle swarm optimization, PID controller, optimal control, Genetic Algorithm (GA)

INTRODUCTION

There are mainly two types of DC motors used in industry. The first one is the conventional dc motor where the flux is produced by the current through the field coil of the stationary pole structure. The second type is the Brushless DC motor (BLDC motor) where the permanent magnet provides the necessary air gap flux instead of the wire-wound field poles (Hambley, 1997). This kind of motor not only has the advantages of DC motor such as better velocity capability and no mechanical commutator but also has the advantage of AC motor such as simple structure, higher reliability and free maintenance. In addition, brushless DC motor has the following advantages: smaller volume, high force and simple system structure.

So, it is widely applied in areas which needs high performance drive (Kennedy and Eberhart, 1995). From the control point of view, DC motor exhibit excellent control characteristics because of the decoupled nature of the field and armature mmf's (Hambley, 1997). Recently, many modern control methodologies such as nonlinear control (Ong, 1997), optimal control (Jones, 1967), variable structure control (Bhimbra, 1993) and adaptive control have been widely proposed for linear brushless permanent magnet DC motor. However, these approaches are either complex in theoretical bases or difficult to implement. PID control with its three term functionality covering treatment to both transient and steady-states

response, offers the simplest and yet most efficient solution to many real world control problems. In spite of the simple structure and robustness of this method, optimally tuning gains of PID controllers have been quite difficult. Genetic algorithm is a stochastic optimization algorithm that is originally motivated by the mechanism of natural selection and evolutionary genetics. Though, the GA Methods have been employed successfully to solve complex optimization problems, recent search has identified some deficiencies in GA performance (Deb, 2002).

LINEAR BRUSHLESS DC MOTOR

Permanent magnet DC motors use mechanical commutators and brushes to achieve the commutation. However, BLDC motors adopt Hall Effect Sensors in place of mechanical commutators and brushes (Gen and Cheng, 2002).

The stators of BLDC motors are the coils and the rotors are the permanent magnets. The stators develop the magnetic fields to make the rotor rotating. Hall Effect Sensors detect the rotor position as the commutating signals. Therefore, BLDC motors use permanent magnets instead of coils in the armature and so do not need brushes. In this study, a three-phase and two-pole BLDC motor is studied. The speed of the BLDC motor is controlled by means of a three-phase and half-bridge Pulse-Width Modulation (PWM) inverter. The dynamic

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Soft Computing Samir Roy,Udit Chakraborty,2013 Soft computing is a branch of computer science that deals with a family of methods that imitate human intelligence This is done with the goal of creating tools that will contain some human like capabilities such as learning reasoning and decision making This book covers the entire gamut of soft computing including fuzzy logic rough sets artificial neural networks and various evolutionary algorithms It offers a learner centric approach where each new concept is introduced with carefully designed examples instances to train the learner

Applications of Image Processing and Soft Computing Systems in Agriculture Razmjooy, Navid,Estrela, Vania Vieira,2019-02-22 The variety and abundance of qualitative characteristics of agricultural products have been the main reasons for the development of different types of non destructive methods NDTs Quality control of these products is one of the most important tasks in manufacturing processes The use of control and automation has become more widespread and new approaches provide opportunities for production competition through new technologies Applications of Image Processing and Soft Computing Systems in Agriculture examines applications of artificial intelligence in agriculture and the main uses of shape analysis on agricultural products such as relationships between form and genetics adaptation product characteristics and product sorting Additionally it provides insights developed through computer vision techniques Highlighting such topics as deep learning agribusiness and augmented reality it is designed for academicians researchers agricultural practitioners and industry professionals **Advances in Abstract Intelligence and Soft Computing** Wang, Yingxu,2012-12-31 Continuous developments in software and intelligence sciences have brought together the studies of both natural and machine intelligence and the relationship between the function of the brain and the abstract soft mind creating a new multidisciplinary field of study Advances in Abstract Intelligence and Soft Computing brings together the latest research in computer science theoretical software engineering cognitive science and informatics and also their influence on the processes of natural and machine intelligence This book is a collection of widespread research in the constant expansions on this emerging discipline **Hybrid Computational Intelligence** Siddhartha Bhattacharyya,Václav Snášel,Indrajit Pan,Debashis De,2019-09-30 Hybrid computational intelligent techniques are efficient in dealing with the real world problems encountered in engineering fields The primary objective of this book is to provide an exhaustive introduction as well as review of the hybrid computational intelligent paradigm with supportive case studies In addition it aims to provide a gallery of engineering applications where this computing paradigm can be effectively use Finally it focuses on the recent quantum inspired hybrid intelligence to develop intelligent solutions for the future The book also incorporates video demonstrations of each application for better understanding of the subject matter *Soft Computing Applications* Kanad Ray,Millie Pant,Anirban Bandyopadhyay,2018-03-29 This book provides a reference guide for researchers scientists and industrialists working in the area of soft computing and highlights the latest advances in and applications of soft computing

techniques in multidisciplinary areas Gathering papers presented at the International Conference on Soft Computing Theories and Applications SoCTA 2016 which was held in Jaipur Rajasthan India on December 28 30 2016 it focuses on applying soft computing to solve real life problems arising in various domains from medical and healthcare to supply chain management image processing and cryptanalysis The term soft computing represents an umbrella term for computational techniques like fuzzy logic neural networks and nature inspired algorithms In the past few decades there has been an exponential rise in the application of soft computing techniques to address complex and intricate problems in diverse spheres of life The versatility of these techniques has made them a favourite among scientists and researchers alike **Biography of Florentin Smarandache** Mihaly Bencze,2019-12-10 Florentin Smarandache is a professor of mathematics at the University of New Mexico United States He got his MSc in Mathematics and Computer Science from the University of Craiova Romania PhD in Mathematics from the State University of Kishinev and Postdoctoral in Applied Mathematics from Okayama University of Sciences Japan He is the founder of neutrosophy generalization of dialectics neutrosophic set logic probability and statistics since 1995 and has published hundreds of papers and books on neutrosophic physics superluminal and instantaneous physics unmatter quantum paradoxes absolute theory of relativity redshift and blueshift due to the medium gradient and refraction index besides the Doppler effect paradoxism outerart neutrosophy as a new branch of philosophy Law of Included Multiple Middle multispace and multistructure hypersoft set degree of dependence and independence between neutrosophic components refined neutrosophic set neutrosophic over under off set plithogenic set neutrosophic triplet and duplet structures quadruple neutrosophic structures extension of algebraic structures to NeutroAlgebras and AntiAlgebras DSmT and so on to many peer reviewed international journals and many books and he presented papers and plenary lectures to many international conferences around the world **Smarandache** Mihaly Bencze,2019-12-10 Florentin Smarandache is a professor of mathematics at the University of New Mexico United States He got his MSc in Mathematics and Computer Science from the University of Craiova Romania PhD in Mathematics from the State University of Kishinev and Postdoctoral in Applied Mathematics from Okayama University of Sciences Japan He is the founder of neutrosophy generalization of dialectics neutrosophic set logic probability and statistics since 1995 and has published hundreds of papers and books on neutrosophic physics superluminal and instantaneous physics unmatter quantum paradoxes absolute theory of relativity redshift and blueshift due to the medium gradient and refraction index besides the Doppler effect paradoxism outerart neutrosophy as a new branch of philosophy Law of Included Multiple Middle multispace and multistructure hypersoft set degree of dependence and independence between neutrosophic components refined neutrosophic set neutrosophic over under off set plithogenic set neutrosophic triplet and duplet structures quadruple neutrosophic structures extension of algebraic structures to NeutroAlgebras and AntiAlgebras DSmT and so on to many peer reviewed international journals and many books and he presented papers and plenary lectures to many international

conferences around the world   *Recent Advances on Soft Computing and Data Mining* Rozaida Ghazali,Mustafa Mat Deris,Nazri Mohd Nawi,Jemal H. Abawajy,2018-01-11 This book offers a systematic overview of the concepts and practical techniques that readers need to get the most out of their large scale data mining projects and research studies It guides them through the data analytical thinking essential to extract useful information and obtain commercial value from the data Presenting the outcomes of International Conference on Soft Computing and Data Mining SCDM 2017 held in Johor Malaysia on February 6 8 2018 it provides a well balanced integration of soft computing and data mining techniques The two constituents are brought together in various combinations of applications and practices To thrive in these data driven ecosystems researchers engineers data analysts practitioners and managers must understand the design choice and options of soft computing and data mining techniques and as such this book is a valuable resource helping readers solve complex benchmark problems and better appreciate the concepts tools and techniques employed   Soft Computing Approach for Mathematical Modeling of Engineering Problems Ali Ahmadian,Soheil Salahshour,2021-09-02 This book describes different mathematical modeling and soft computing techniques used to solve practical engineering problems It gives an overview of the current state of soft computing techniques and describes the advantages and disadvantages of soft computing compared to traditional hard computing techniques Through examples and case studies the editors demonstrate and describe how problems with inherent uncertainty can be addressed and eventually solved through the aid of numerical models and methods The chapters address several applications and examples in bioengineering science drug delivery solving inventory issues Industry 4 0 augmented reality and weather forecasting Other examples include solving fuzzy shortest path problems by introducing a new distance and ranking functions Because in practice problems arise with uncertain data and most of them cannot be solved exactly and easily the main objective is to develop models that deliver solutions with the aid of numerical methods This is the reason behind investigating soft numerical computing in dynamic systems Having this in mind the authors and editors have considered error of approximation and have discussed several common types of errors and their propagations Moreover they have explained the numerical methods along with convergence and consistence properties and characteristics as the main objectives behind this book involve considering discussing and proving related theorems within the setting of soft computing This book examines dynamic models and how time is fundamental to the structure of the model and data as well as the understanding of how a process unfolds Discusses mathematical modeling with soft computing and the implementations of uncertain mathematical models Examines how uncertain dynamic systems models include uncertain state uncertain state space and uncertain state s transition functions Assists readers to become familiar with many soft numerical methods to simulate the solution function s behavior This book is intended for system specialists who are interested in dynamic systems that operate at different time scales The book can be used by engineering students researchers and professionals in control and finite element fields as well as all engineering applied mathematics economics

and computer science interested in dynamic and uncertain systems Ali Ahmadian is a Senior Lecturer at the Institute of IR 4 0 The National University of Malaysia Soheil Salahshour is an associate professor at Bahcesehir University **Applied Soft Computing and Communication Networks** Sabu M. Thampi,Jaime Lloret Mauri,Xavier Fernando,Rajendra Boppana,S. Geetha,Axel Sikora,2021-07-01 This book constitutes thoroughly refereed post conference proceedings of the International Applied Soft Computing and Communication Networks ACN 2020 held in VIT Chennai India during October 14 17 2020 The research papers presented were carefully reviewed and selected from several initial submissions The book is directed to the researchers and scientists engaged in various fields of intelligent systems Soft Computing and Its Applications Kumar S. Ray,2018-10-03 This two volume set explains the primary tools of soft computing as well as provides an abundance of working examples and detailed design studies The books start with coverage of fuzzy sets and fuzzy logic and their various approaches to fuzzy reasoning and go on to discuss several advanced features of soft computing and hybrid methodologies Toge **Artificial Intelligence and Global Society** Puneet Kumar,Vinod Kumar Jain,Dharminder Kumar,2021-03-15 In the constant battle between human intelligence and machine intelligence machines are close to surpassing human intelligence The unrestrained use of digital technologies in automating processes is one of the prime advantages of the third industrial revolution As a result all developed and developing nations have started to digitalize mundane tasks Thus digital technologies for information and communication technologies ICT have achieved high market space in terms of infrastructure building employment generation education sector reforms funds mobilization electronic governance hardware manufacturing software development etc Hence it is evident that every segment of society has been penetrated by ICT or digitalization This book attempts to spotlight areas where AI is thriving FEATURES Impact of digitalization and AI on governance Novel AI practices being followed across the global community in security healthcare crime prevention and detection education agriculture sensor networks etc Innovative techniques that can be adopted to ensure better quality and better delivery of services to the society Avenues for further research by the research community and student fraternity This book is a guide for university students especially those from technical backgrounds industries NGOs and policy makers *Kansei Engineering and Soft Computing: Theory and Practice* Dai, Ying,Chakraborty, Basabi,Shi, Minghui,2010-08-31 Kansei Engineering and Soft Computing Theory and Practice offers readers a comprehensive review of kansei engineering soft computing techniques and the fusion of these two fields from a variety of viewpoints It explores traditional technologies as well as solutions to real world problems through the concept of kansei and the effective utilization of soft computing techniques This publication is an essential read for professionals researchers and students in the field of kansei information processing and soft computing providing both theoretical and practical viewpoints of research in humanized technology *Cyber Technologies and Emerging Sciences* Sudhanshu Maurya,Sateesh K. Peddoju,Badlishah Ahmad,Ines Chihi,2022-08-29 The book is a collection of best selected research papers presented at International Conference on Cyber

Technologies and Emerging Sciences ICCTES 2021 organized by Graphic Era Hill University Bhimtal Campus Uttarakhand India during 17 18 December 2021 The book covers state of the art applications innovative methods and analyze the unexplored and unsolved challenges to establish the relative solutions to advance the existing applications and theories of Cyber Technologies and Emerging Sciences   **Soft Computing in Software Engineering** Ernesto Damiani,Mauro Madravio,2012-12-06 Soft computing is playing an increasing role in the study of complex systems in science and engineering There is a large spectrum of successful applications of soft computing in very different applications domains such as aerospace communication consumer appliances electric power systems process engineering transportation and manufacturing automation and robotics It has taken a while to bring the early ideas of soft computing to an area and a discipline that seems to be more than appropriate for that Here it is This book studies SOFT computing in SOFTware engineering environment The book is HARD in terms of its results It covers a range of core topics from software engineering that are soft from its very nature selection of components software design software reuse software cost estimation and software processes Soft computing differs from conventional hard computing in its ability to be tolerant of imprecision uncertainty partial truth and approximation The guiding principle of soft computing is Exploit the tolerance for imprecision uncertainty partial truth and approximation to achieve tractability robustness and low solution cost The role model for soft computing is the human mind This seems to be a natural fit with software engineering a human based development activity based on sound engineering principles A recent survey by researchers reveals that Software Engineering research tends to be quite self contained not relying on other disciplines for its thinking   **Internet of Things in Biomedical Engineering** Valentina Emilia Balas,Le Hoang Son,Sudan Jha,Manju Khari,Raghvendra Kumar,2019-06-14 Internet of Things in Biomedical Engineering presents the most current research in Internet of Things IoT applications for clinical patient monitoring and treatment The book takes a systems level approach for both human factors and the technical aspects of networking databases and privacy Sections delve into the latest advances and cutting edge technologies starting with an overview of the Internet of Things and biomedical engineering as well as a focus on daily life Contributors from various experts then discuss computer assisted anthropology CLOUDFALL and image guided surgery as well as bio informatics and data mining This comprehensive coverage of the industry and technology is a perfect resource for students and researchers interested in the topic Presents recent advances in IoT for biomedical engineering covering biometrics bioinformatics artificial intelligence computer vision and various network applications Discusses big data and data mining in healthcare and other IoT based biomedical data analysis Includes discussions on a variety of IoT applications and medical information systems Includes case studies and applications as well as examples on how to automate data analysis with Perl R in IoT   **Computational Intelligence - Volume II** Hisao Ishibuchi,2015-12-30 Computational intelligence is a component of Encyclopedia of Technology Information and Systems Management Resources in the global Encyclopedia of Life Support Systems EOLSS

which is an integrated compendium of twenty one Encyclopedias Computational intelligence is a rapidly growing research field including a wide variety of problem solving techniques inspired by nature Traditionally computational intelligence consists of three major research areas Neural Networks Fuzzy Systems and Evolutionary Computation Neural networks are mathematical models inspired by brains Neural networks have massively parallel network structures with many neurons and weighted connections Whereas each neuron has a simple input output relation a neural network with many neurons can realize a highly non linear complicated mapping Connection weights between neurons can be adjusted in an automated manner by a learning algorithm to realize a non linear mapping required in a particular application task Fuzzy systems are mathematical models proposed to handle inherent fuzziness in natural language For example it is very difficult to mathematically define the meaning of cold in everyday conversations such as It is cold today and Can I have cold water The meaning of cold may be different in a different situation Even in the same situation a different person may have a different meaning Fuzzy systems offer a mathematical mechanism to handle inherent fuzziness in natural language As a result fuzzy systems have been successfully applied to real world problems by extracting linguistic knowledge from human experts in the form of fuzzy IF THEN rules Evolutionary computation includes various population based search algorithms inspired by evolution in nature Those algorithms usually have the following three mechanisms fitness evaluation to measure the quality of each solution selection to choose good solutions from the current population and variation operators to generate offspring from parents Evolutionary computation has high applicability to a wide range of optimization problems with different characteristics since it does not need any explicit mathematical formulations of objective functions For example simulation based fitness evaluation is often used in evolutionary design Subjective fitness evaluation by a human user is also often used in evolutionary art and music These volumes are aimed at the following five major target audiences University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers

Computational Intelligence in Intelligent Data Analysis Christian Moewes,Andreas Nürnberger,2012-08-23 Complex systems and their phenomena are ubiquitous as they can be found in biology finance the humanities management sciences medicine physics and similar fields For many problems in these fields there are no conventional ways to mathematically or analytically solve them completely at low cost On the other hand nature already solved many optimization problems efficiently Computational intelligence attempts to mimic nature inspired problem solving strategies and methods These strategies can be used to study model and analyze complex systems such that it becomes feasible to handle them Key areas of computational intelligence are artificial neural networks evolutionary computation and fuzzy systems As only a few researchers in that field Rudolf Kruse has contributed in many important ways to the understanding modeling and application of computational intelligence methods On occasion of his 60th birthday a collection of original papers of leading researchers in the field of computational intelligence has been collected in this volume   Soft Computing Principles and

<u>Integration for Real-Time Service-Oriented Computing</u> Punit Gupta,Dinesh Kumar Saini,Kashif Zia,2024-03-22 In recent years soft computing techniques have emerged as a successful tool to understand and analyze the collective behavior of service oriented computing software Algorithms and mechanisms of self organization of complex natural systems have been used to solve problems particularly in complex systems which are adaptive ever evolving and distributed in nature across the globe What fits more perfectly into this scenario other than the rapidly developing era of Fog IoT and Edge computing environment Service oriented computing can be enhanced with soft computing techniques embedded inside the Cloud Fog and IoT systems Soft Computing Principles and Integration for Real Time Service Oriented Computing explores soft computing techniques that have wide application in interdisciplinary areas These soft computing techniques provide an optimal solution to the optimization problem using single or multiple objectives The book focuses on basic design principles and analysis of soft computing techniques It discusses how soft computing techniques can be used to improve quality of service in serviceoriented architectures The book also covers applications and integration of soft computing techniques with a service oriented computing paradigm Highlights of the book include A general introduction to soft computing An extensive literature study of soft computing techniques and emerging trends Soft computing techniques based on the principles of artificial intelligence fuzzy logic and neural networks The implementation of SOC with a focus on service composition and orchestration quality of service QoS considerations security and privacy concerns governance challenges and the integration of legacy systems The applications of soft computing in adaptive service composition intelligent service recommendation fault detection and diagnosis SLA management and security Such principles underlying SOC as loose coupling reusability interoperability and abstraction An IoT based framework for real time data collection and analysis using soft computing

Soft Computing Applications in Sensor Networks Sankar K. Pal,Sudip Misra,2016-10-03 This book uses tutorials and new material to describe the basic concepts of soft computing which potentially can be used in real life sensor network applications It is organized in a manner that exemplifies the use of an assortment of soft computing applications for solving different problems in sensor networking Written by worldwide experts the chapters provide a balanced mixture of different problems concerning channel access routing coverage localization lifetime maximization and target tracking using emerging soft computing applications

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