Preface

Most of the research and experiments in the fields of science, engineering, and social studies have spent significant effort to find rules from various complicated phenomena by principles, observations, measured data, and logic derivations. The rules are normally summarized as concise and quantitative expressions or "models." "Identification" provides mechanisms to establish the models from measured data and "control" provides mechanisms to improve the system (represented by its model) performance. The book will reflect the relevant studies in mechatronic fields, with the latest research from interdisciplinary theoretical studies, computational algorithm development to exemplary applications.

Mechatronics system analysis and design include a combination of mechanical engineering, electrical engineering, control engineering, computer engineering, and so on. Mechatronics is a multidisciplinary field of engineering and technology, that is to say, it rejects splitting engineering into separate disciplines. Originally, mechatronics just included the combination of mechanics and electronics, hence the word is a combination of mechanics and electronics; however, as technical systems have become more and more complex to provide high-level functions, the word has been "updated" during recent years to include more technical areas. Research and applications in the synergistic integration of mechanical engineering, electronic control and systems concepts have contributed significantly to the design of systems, devices, processes, and products in modern technology development.

It has been deemed that such fast and highly demanded development and applications should be reported in book, journals, and other media regularly and systematically. So does this book. There are 22 chapters from nine countries in this edited volume presenting a clear route/unique format of each paper, background → motivation → quantitative development (equations) → case studies/illustration/tutorial (curve, table, etc.), which is compiled as an application-oriented reference (Applied Methods and Techniques for Mechatronic Systems—Modelling, Identification, and Control) for readers/users easily tailoring the techniques to accommodate their ad hoc applications. Primary readers could be postgraduate students (M.Sc. and Ph.D.), researchers (post-doc research fellows), and teachers (lecturers and professors) in academia. The secondary readers could be engineers (technical engineers, managers, and directors) in company R&D departments.

The best way to introduce the major contribution from this book is to include a brief abstract of each chapter, which gives readers a clear picture about the book contents.

Chapter 1 *Synchronized Control of Mechanical Systems: A Tutorial*. This study summarizes the work on synchronized control mainly developed from the authors and their colleagues. In the presentation, it tries to use several classical mechanical systems to show the design philosophy of the synchronized control systems, consequently establishes a reader/user-friendly framework with tutorial, survey, applications, and potential research expansion.

Chapter 2 *Control Reconfiguration on Deadlocked Gimballed Thrust of Launch Vehicle*. This study investigates actuator failure compensation for new generation launch vehicle control. A control reconfiguration scheme of fault-tolerant control is developed to enhance the reliability of launch vehicle attitude control systems and prevent the control invalidation caused by the deadlock of the oscillating actuator, based on the congruity of the composite moment before and after the failure happens. This reconfiguration scheme is capable of utilizing the remaining control authority to achieve the desired performance in the presence of deadlock at certain detectable angle occurring in one or several actuators at unknown time instants.

Chapter 3 *Synthesis of an Advanced State Feedback Control for Continuous Nonlinear Polynomial Systems*. This study considers the problem of approximate linearization of affine nonlinear control systems by a static state feedback. First of all, it proposes an analytical method, based on the development into generalized Taylor series expansions and the Kronecker product tools, in order to simplify the complex implementation of the input-state feedback linearization formalism. Next, to improve the synthesized polynomial feedback control, the genetic algorithm, as an optimization method, is used. Finally, the new approach presented in this work is applied to investigate the control problem of a chemical reactor. Moreover, it proves that the controlled process is locally asymptotically stable in a wide region around the operating point, in the Lyapunov sense.

Chapter 4 *Recent Advances on Nonsingular Terminal Sliding Mode Control Method*. This study reviews the research history of the singularity and introduces the recent advance on nonsingular and fast terminal sliding mode (NFTSM) control method. The synthesis of NFTSM controller synthesis is based on a newly proposed nonsingular fast terminal function and a terminal attractor with non-negative exponential coefficient. Both theoretical analyses and computer simulations have proved its effectiveness under the condition that plant uncertainties are bounded.

Chapter 5 *Flocking Behavior via Leader's Backstepping on Nonholonomic Robot Group*. This study aims to improve flocking control for group of nonholonomic robots. It introduces a new flocking control algorithm with potential-based flocking being its foundation. By incorporating Leader's Backstepping algorithm into the flocking strategy, an improved flocking performance is obtained, which leads the flock to the target point swiftly in a smoothed trajectory. Simulations in

this paper test and verify the effectiveness of the algorithm, in which key parameters' influences on system performance are discussed.

Chapter 6 *Performance Comparison Between NCTF and PV Techniques for the Control of Linear Motion Servo System*. This study considers two types of controllers for Proportional-Velocity (PV) and Nominal Characteristic Trajectory Following (NCTF). The experimental results showed that the PV was successfully implemented which controlled the settling time, rise time, and steady-state error of the desired position. However, the overshoot performances show its disadvantages. Additionally, the PV controller design is time-consuming process, since model and parameters of the linear motion servo system are needed. Therefore, the needs for higher performance controller become important for the simplicity of the controller design. Hence, the investigation proceed with the nonmodel-based NCTF controller was to control the cart position of the linear motion servo system. The NCTF controller consists of a Nominal Characteristic Trajectory (NCT) and PI compensator. The NCTF controller was designed based on a simple open-loop experiment of the object. The experimental results showed that the NCTF controller is more effective for controlling position of linear motion servo system than the PV controller.

Chapter 7 *A High-Order PID-Sliding Mode Control: Simulation on a Torpedo*. This study deals with the basic concepts, mathematics, and design aspects of a control for nonlinear systems that make the chattering effect lower. As solution to this problem it adopts as a starting point the high order sliding mode approaches then the PID sliding surface. Simulation results show that this control strategy can attain excellent control performance with no chattering problem.

Chapter 8 *Sliding Mode Control with Self-Turning Law for Uncertain Nonlinear Systems with Time-Delay and External Disturbances*. This study proposes a novel sliding mode control with self-turning law for nonlinear systems with time-delay and external disturbances possessing uncertain parameters. The adjustable control gain and a bipolar sigmoid function are online tuned to force the tracking error to approach zero. The proposed control scheme provides good transient and steady-state performance. Moreover as the proposed controller, the chatting phenomenon can be avoided and the problem of the time-delay and the external disturbances are solved for a class of nonlinear systems. The closed-loop control system stability is proved to use the Lyapunov method. Steady-state system performance and the chattering are considerably improved. Numerical simulation results are given to illustrate the effectiveness of the proposed procedure.

Chapter 9 *Applied Methods and Techniques for Modelling and Control on Micro-Blog Data Crawler*. This study presents an algorithm on modelling and control on microblog data crawler based on simulating browsers' behaviors. This needs to analyze the simulated browsers' behaviors in order to obtain the requesting URLs, to simulate and parse and analyze the sending URLs requests according to the order of data sequence. The experimental results and the analysis show the feasible of the approach. Further works are also presented in the end.

Chapter 10 *Development of an Improved Genetic Algorithm for Resolving Inverse Kinematics of Virtual Human's Upper Limb Kinematics Chain*. This study

presents an Improved Genetic Algorithm (IGA) is proposed to resolve the inverse kinematics problem in upper limb kinematics chain (ULKC). First, the joint units of ULKC and its mathematical models are constructed by using D–H method; then population diversity and population initialization are accomplished by simulating human being population, and the adaptive operators for mutation are designed. The simulation results show that compared with the Standard Genetic Algorithm (SGA), the IGA can provide higher precise solutions in searching process and avoid "premature" stop or inefficient searching in later stage with high probability.

Chapter 11 *Sliding Mode Control for Nonlinear Discrete Time Systems with Matching Perturbations*. This study considers sliding mode control of nonlinear discrete time systems with matching perturbations. The nonlinear sliding mode controller, whose parameters assure the closed-loop system stable, is designed in order to drive the state trajectories toward a small-bounded region. The controller is approximated by a polynomial equation in current control term according to Taylor series expansion. The algebraic solutions can be obtained by resolving a polynomial equation in the latest control term. The integrated procedure provides a straightforward methodology to apply sliding mode control design technique for nonlinear systems. The simulation results are provided to illustrate the effectiveness of the proposed scheme.

Chapter 12 *Type-2 Fuzzy Wavelet Neural Network Controller Design Based on an Adaptive Gradient Descent Method for Nonlinear Dynamic Systems*. This study develops a novel structure of Type-2 Fuzzy Wavelet Neural Networks (T2FWNN) to control a nonlinear system. This has been performed by invoking some of the specific advantages of wavelets, such as dynamic compatibility, compression, and step parameter adaptation along with a combination to type-2 fuzzy concepts regarding the neural networks abilities. The proposed network is constructed based on a set of TSK fuzzy rules that includes a wavelet function in the consequent part of each rule. This can provide appropriate tools on adaptation of plant output signal to follow a desired one. In this regard, the merits of utilizing wavelets and type-2 FLS simultaneously have been discussed and explored to efficiently handle the uncertainties. It is worth mentioning that the stability of the system is effectively dependent on the learning procedure and the initial values of the network parameters. Here, an adaptive gradient descent strategy is used to adjust the unknown parameters. Furthermore, the performance of the proposed T2FWNN is compared with the type-1 FLS networks. As it is investigated, this method has considerably gained high levels of accuracy with the reasonable number of the parameters. Finally, the efficiency of the proposed approach is demonstrated via the simulation results of two nonlinear case studies.

Chapter 13 *Multivariable Closed-Loop Identification and Its Application to Boiler–Turbine System of Power Unit*. This study presents a new technique for multivariable closed-loop identification. On the basis of process input and output data in the control loops, the process frequency–response matrix is estimated with signal decomposition and frequency spectrum analysis, and then a transform function matrix is identified by least square method. The required input and output data are obtained while the processes are still in normal closed-loop operation. The

closed-loop identification is applied to the boiler–turbine coordinated control system of power unit. Simulation example is given to show both effectiveness and accuracy of the identification method for boiler–turbine unit.

Chapter 14 *Tracking and Statistics Method Based on LBTM for Traffic Car Flow*. This study proposes a novel tracking method based on local block graphs targets matching. Car flow tracking is applied to prove the effectiveness of the method. First, the images containing the targets are captured by the video frames to get the targets block graphs. Second, the block graphs can be used to achieve targets matching, and the detection process can be achieved by targets matching to get the optimal targets set. Finally, the targets set can be used to achieve the minimum deviation forecasting of all frames, and the targets tracking can be achieved. A junction video is selected as the experimental data, and a large number of experiments have been done. The results show that the proposed method not only has a great effect to track cars, but also has a better detection rate and tracking accuracy. The car flow statistics can be completed effectively.

Chapter 15 *Object Manipulation Strategy Analysis and Realization for a Humanoid Robot*. This study proposes humanoid robot object operation strategy that integrates the visual feedforward control strategy and the visual feedback control strategy. Using the visual feedforward control strategy, the humanoid robot can walk approaching the target object and make its arm close to the target object; using the visual feedback control strategy, the humanoid robot achieves the robot hand fine alignment with the target object. Based on the visual feedforward control strategy the time of the humanoid robot hand approaching the target object have been reduced; based on the visual feedback control strategy the accuracy of the operation has been improved. Based on the control strategy of this paper proposed, the humanoid robot will be able to walk and operate objects independently.

Chapter 16 *Low Intensity Laser Irradiation Influence Proliferation of Mesenchymal Stem Cells: Comparison of Experimental Data to an Intelligent Agent-based Model Predictions*. This study provides some of the experiments employed to measure influence of low intensity laser on proliferation of mesenchymal stem cells which can vary considerably according to many parameters and biological conditions such as laser nature of emission, irradiation time, wavelength, and energy density. These experiments are compared to an intelligent agent-based model predictions and detailed information about the model description and comparison results is provided. The model is capable of predicting the data for the scenarios fairly well although a few are somewhat problematic.

Chapter 17 *Motor Soft Starter Based on Variable Reactance*. This study establishes the mathematical model of the soft starter which is based on variable reactance, and the relationship between the thyristor conduction angle and the motor current is analyzed. The purpose of the motor and equipment's protection is achieved by selecting the appropriate conduction angle to control the starting current amplitude.

Chapter 18 *Mixed H_2/H_∞ Robust Controller Design-Based LMI Techniques*. This study introduces the work of design of improved LMI-based robust output feedback controller and related simulations.

Chapter 19 *Advanced Control of Atomic Force Microscope for Faster Image Scanning*. This study discusses the design and experimental implementation of an observer-based model predictive control (OMPC) scheme which aims to compensate for the effects of creep, hysteresis, cross-coupling, and vibration in piezoactuators in order to improve the nanopositioning of an AFM. The controller design is based on an identified model of the piezoelectric tube scanner (PTS) for which the control scheme achieves significant compensation of its creep, hysteresis, cross-coupling, and vibration effects and ensures better tracking of the reference signal. A Kalman filter is used to obtain full-state information of the plant. The experimental results illustrate the use of this proposed control scheme.

Chapter 20 *Design of the State Estimation System in the Advanced Drive Assistance System*. This study designs a novel loose coupling senor fusion, which uses the Extended Kalman filtering to fuse the sensor measurements from odometers, accelerometers, gyroscope, and GPS. By using a novel four-wheel vehicle model, the EKF is able to conduct a multioutput rate sensor fusion, compensate the latency for GPS signals, and increase the accuracy of vehicle state estimation even if there exist sensor errors, such as GPS outage, odometer reading error due to wheel slippage. From the road test, it is proved that the designed EKF has achieved good results for vehicle state estimation.

Chapter 21 *A Collaborative Learning Optimization Strategy for Shared Control of Walking-Aid Robot*. This study develops a collaborative learning optimization strategy for shared control of an intelligent walking-aid robot for the purpose of assisting elderly and disabled people. The proposed architecture can adjust two user control weights dynamically by a learning algorithm according to user control habit and walking environment, allowing both human and robot to maintain control of the walking-aid robot. Finally, the experiment results illustrate the validity of the collaborative learning optimization strategy as part of a shared control algorithm.

Chapter 22 *Vibration Suppression of Deformable Linear Object Based on Vision Feedback*. This study proposes an approach based on robot vision to suppress the vibration of a DLO, by means of real-time image processing of high-speed visual feedback to obtain the geometric coordinates and posture of the DLO. A PID controller verifies the validity of the theory along with the expected posture of the DLO. The effectiveness of the proposed strategy is confirmed by experiment. Results show that the proposed method can damp vibrations effectively.

http://www.springer.com/978-3-642-36384-9

Applied Methods and Techniques for Mechatronic Systems
Modelling, Identification and Control
Liu, L.; Zhu, Q.; Cheng, L.; Wang, Y.; Zhao, D. (Eds.)
2014, XV, 440 p. 251 illus., Softcover
ISBN: 978-3-642-36384-9