Intelligent Control Aspects Of Fuzzy Logic And Neural Nets World Scientific Series In Robotics And Automated Systems | f574b8ec4a270a30d47538343331318a

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Volume XVII
Aspects of Soft Computing, Intelligent Robotics and Control
Handbook of Intelligent Control
Fuzzy Logic and Intelligent Systems
Intelligent Control: Principles, Techniques and Applications
Intelligent Control of Robotic Systems
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Intelligent Control Intelligent Control; Aspects of Fuzzy Logic and Neural Nets
Safety, Reliability and Applications of Emerging Intelligent Control Technologies
Intelligent Control Systems Using Soft Computing Methodologies
Fuzzy Control
This edited Book is dedicated to the theory and applications of Evolutionary Computation and Fuzzy Logic for Intelligent Control, Knowledge Acquisition and Information Retrieval. The book consists of 86 selected research papers from the 1999 International Conference on Computational Intelligence for Modelling, Control and Automation - CIMCA'99
The research papers presented in this book cover new techniques and applications in the following research areas: Evolutionary Computation, Fuzzy Logic and Expert Systems with their applications for Optimisation, Learning, Control, Scheduling and Multi-Criteria Analysis as well as Reliability Assessment, Information Retrieval and Knowledge Acquisition.
We describe in this book, hybrid intelligent systems based mainly on type-2 fuzzy logic for intelligent control. Hybrid intelligent systems combine several intelligent computing paradigms, including fuzzy logic, and bio-inspired optimization algorithms, which can be used to produce powerful automatic control systems. The book is organized in three main parts, which contain a group of chapters around a similar subject. The first part consists of chapters with the main theme of theory and design algorithms, which are basically chapters that propose new models and concepts, which can be the basis for achieving intelligent control with interval type-2 fuzzy logic. The second part of the book is comprised of chapters with the main theme of evolutionary optimization of type-2 fuzzy systems in intelligent control with the aim of designing optimal type-2 fuzzy controllers for complex control problems in diverse areas of application, including mobile robotics, aircraft dynamics systems and hardware implementations. The third part of the book is formed with chapters dealing with the theme of bio-inspired optimization of type-2 fuzzy systems in intelligent control, which includes the application of particle swarm intelligence and ant colony optimization algorithms for obtaining optimal type-2 fuzzy controllers.
This book is concerned with Intelligent Control methods and applications. The field of intelligent control has been expanded very much during the recent years and a solid body of theoretical and practical results are now available. These results have been obtained through the synergistic fusion of concepts and techniques from a variety of fields such as automatic control, systems science, computer science, neurophysiology and operational research. Intelligent control systems have to perform anthropomorphic tasks fully systematically or interactively with the human under known or unknown and uncertain environmental conditions. Therefore the basic components of any intelligent control system include cognition, perception, learning, sensing, planning, numeric and symbolic processing, fault detection/reaction, repair, and control action. These components must be linked in a systematic, synergistic and efficient way. Predecessors of intelligent control are adaptive control, self-organizing control, and learning control which are well documented in the literature. Typical application examples of intelligent control systems are intelligent robotic systems, intelligent manufacturing systems, intelligent medical systems, and intelligent space teleoperators. Intelligent controllers must employ both quantitative and qualitative information and must be able to cope with severe temporal and spatial variations, in addition to the fundamental task of achieving the desired transient and steady-state performance. Of course the level of intelligence required in each particular application is a matter of discussion between the designers and users. The current literature on intelligent control is increasing, but the information is still available in a sparse and disorganized way. With increasing demands for high precision autonomous control over wide operating envelopes, conventional control engineering approaches are unable to adequately deal with system complexity, nonlinearities, spatial and temporal parameter variations, and with uncertainty. Intelligent Control or self-organizing/learning control is a new emerging discipline that is designed to deal with problems. Rather than being model based, it is experiential based. Intelligent Control is the amalgam of the disciplines of Artificial Intelligence, Systems Theory and Operations Research. It uses most recent experiences or evidence to improve its performance through a variety of learning schemas, that for practical implementation must demonstrate rapid learning convergence, be temporally stable, be robust to parameter changes and internal and external disturbances. It is shown in this book that a wide class of fuzzy logic and neural net based learning algorithms satisfy these conditions. It is demonstrated that this class of intelligent controllers is based upon a fixed nonlinear mapping of the input (sensor) vector, followed by an output layer linear mapping with coefficients that are updated by various first order learning laws. Under these conditions self-organising fuzzy logic controllers and neural net controllers have common learning attributes. A theme example of the navigation and these conditions. It is demonstrated that this class of intelligent controllers is based upon a fixed nonlinear mapping of the input (sensor) vector, followed by an output layer linear mapping with coefficients that are updated by various first order learning laws. Under these conditions self-organising fuzzy logic controllers and neural net controllers have common learning attributes. A theme example of the navigation and control of an autonomous guided vehicle is included throughout, together with a series of benchmark examples to demonstrate this new theory and its applicability. As robotic systems make their way into standard practice, they have opened the door to a wide spectrum of complex systems. Such applications usually demand that the robots be highly intelligent. Future robots are likely to have greater sensory capabilities, more intelligence, higher levels of manual dexterity, and adequate mobility, compared to humans. In order to ensure high-quality control and performance in robotics, new intelligent control techniques must be developed, which are capable of coping with task complexity, multi-objective decision making, large volumes of perception data and substantial amounts of heuristic information. Hence, the pursuit of intelligent autonomous robotic systems has been a topic of much fascinating research in recent years. On the other hand, as emerging technologies, Soft Computing paradigms consisting of complementary elements of Fuzzy Logic, Neural Computing and Evolutionary Computation are viewed as the most promising methods towards intelligent robotic systems. Due to their strong learning and cognitive ability and good tolerance of uncertainty and imprecision, Soft Computing techniques have found wide application in the area of intelligent control of robotic systems. Intelligent Control considers non-
traditional modelling and control approaches to nonlinear systems. Fuzzy logic, neural networks and evolutionary computing techniques are the main tools used. The book presents a modular switching fuzzy logic controller where a PD-type fuzzy controller is executed first followed by a PI-type fuzzy controller thus improving the performance of the controller compared with a PID-type fuzzy controller. The advantage of the switching-type fuzzy controller is that it uses one rule-base thus minimises the rule-base during execution. A single rule-base is developed by merging the membership functions for change of error of the PD-type controller and sum of error of the PI-type controller. Membership functions are then optimized using evolutionary algorithms. Since the two fuzzy controllers were executed in series, necessary further tuning of the differential and integral scaling factors of the controller is then performed. Neural-network-based tuning for the scaling parameters of the fuzzy controller is then described and finally an evolutionary algorithm is applied to the neurally-tuned-fuzzy controller in which the sigmoidal function shape of the neural network is determined. The important issue of stability is addressed and the text demonstrates empirically that the developed controller was stable within the operating range. The text concludes with ideas for future research to show the reader the potential for further study in this area. Intelligent Control will be of interest to researchers from engineering and computer science backgrounds working in the field of intelligent and adaptive control. The present volume collects selected papers arising from lectures delivered by the authors at the School on Fuzzy Logic and Soft Computing held during the years 1996/97/98/99 and sponsored by the Salerno University. The authors contributing to this volume agreed with editors to write down, to enlarge and, in many cases, to rethink their original lectures, in order to offer to readership, a more compact presentation of the proposed topics. The aim of the volume is to offer a picture, as a job in progress, of the effort that is coming in founding and developing soft computing's techniques. The volume contains papers to report on recent results containing genuinely logical aspects of fuzzy logic. The topics treated in this area cover algebraic aspects of Łukasiewicz Logic, Fuzzy Logic as the logic of continuous t-norms, Intuitionistic Fuzzy Logic. Aspects of fuzzy logic based on similar ity relation are presented in connection with the problem of flexible querying in deductive database. Departing from fuzzy logic, some papers present re sults in Probability Logic treating computational aspects, results based on indishernability relation and a non commutative version of generalized effect algebras. Several strict applications of soft computing are presented in the book. Indeed we find applications ranging among pattern recognition, image and signal processing, evolutionary agents, fuzzy cellular networks, classic fixation in fuzzy environments. The volume is then intended to serve as a reference work for foundational logico-algebraic aspect of Soft Computing and for concrete applications of soft computing technologies. Intelligent control is a rapidly developing, complex and challenging field with great practical importance and potential. Because of the rapidly developing and interdisciplinary nature of the subject, there are only a few edited volumes consisting of research papers on intelligent control systems but little is known and published about the fundamental knowledge in designing, implementing and operating intelligent control systems. Intelligent control system emerged from artificial intelligence and computer controlled systems as an interdisciplinary field. Therefore the book summarizes the fundamentals of knowledge representation, reasoning, expert systems and real-time control systems and then discusses the design, the implementation, verification, implementation verification and operation of real-time expert systems using G2 as an example. Special tools and techniques applied in intelligent control are also described including qualitative modelling, Petri nets and fuzzy controllers. The material is illustrated with simple examples taken from the field of intelligent process control. This book focuses on the fields of fuzzy logic, bio-inspired algorithm, especially the differential evolution algorithm and also considering the fuzzy control area. The main idea is that these two areas together can help solve various control problems and to find better results. In this book, the authors test the proposed method using five benchmark control problems. First, the water tank, temperature, mobile robot, and inverted pendulum controllers are considered. For these 4 problems, experimentation was carried out using a Type-1 fuzzy system and an Interval Type-2 system. The last control problem was the D.C. motor, for which the experiments were performed with Type-1, Interval Type-2, and Generalized Type-2 fuzzy systems. When we use fuzzy systems combined with the differential evolution algorithm, we can notice that the results obtained in each of the controllers are better and with increasing uncertainty, the results are even better. For this reason, the authors consider in this book the proposed method using fuzzy systems and the differential evolution algorithm to improve the fuzzy controllers’ behavior in complex control problems. With a strong emphasis on applications of intelligent control, this extremely accessible book covers the fundamentals, methodologies, architectures and algorithms of automatic control systems. The author summarizes several current concepts to improve industrial control systems, combining classical control techniques of dynamic modeling and control with new approaches discussed in the text. Addresses such intelligent systems as neural networks, fuzzy logic, genetic algorithms, and genetic algorithms. Demonstrates how to develop, design and use intelligent systems to solve sophisticated industrial control problems. Includes numerous worked application examples. Intelligent Control with LabVIEW™ is a fresh and pragmatic approach to the understanding of a subject often clouded by too much mathematical theory. It exploits the full suite of tools provided by LabVIEW™, showing the student how to design, develop, analyze, and visualize intelligent control algorithms quickly and simply. Block diagrams are used to follow the progress of an algorithm through the design process and allow seamless integration with hardware systems for rapid deployment in laboratory experiments. This text delivers a thorough grounding in the main tools of intelligent control: fuzzy logic systems; artificial neural networks; neuro-fuzzy systems; evolutionary methods; and predictive methods. Learning and teaching are facilitated by: extensive use of worked examples; end of chapter problems with separate solutions; and provision of intelligent control tools for LabVIEW™. The book presents recent theoretical and practical information about the field of automation and control. It includes fifteen chapters that promote automation and control in practical applications. In the following thematic areas: control theory, autonomous vehicles, mechatronics, digital image processing, electrical grids, artificial intelligence, and electric motor drives. The book also presents and discusses applications that improve the properties and performances of process control with examples and case studies obtained from real-world research in the field. Automation and Control is designed for specialists, engineers, professors, and students. The emergence of fuzzy logic and its applications has dramatically changed the face of industrial control engineering. Over the last two decades, fuzzy logic has allowed control engineers to meet and overcome the challenges of developing effective controllers for increasingly complex systems with poorly defined dynamics. Today's engineers need a working knowledge of the principles and techniques of fuzzy logic-Intelligent Control provides it. The author first introduces the traditional control techniques and contrasts them with intelligent control. He then presents several methods of representing and processing knowledge and introduces fuzzy logic as one such method. He highlights the advantages of fuzzy logic over other techniques, indicates its limitations, and describes in detail a hierarchical control structure appropriate for use in intelligent control systems. He introduces a variety of applications, most in the areas of robotics and mechatronics but with others including air conditioning and process/production control. One appendix provides discussion of some advanced analytical concepts of fuzzy logic, another describes a commercially available software system for developing fuzzy logic application. Intelligent Control is filled with worked examples, exercises, problems, and references. No prior knowledge of the subject nor advanced mathematics are needed to comprehend much of the book, making it well-suited as a senior undergraduate or first-year graduate text and a convenient reference tool for practicing professionals. Providing equal emphasis on theoretical foundations and practical
issues, this book features fuzzy logic concepts and techniques in intelligent systems, control, and information technology. Uses Fuzzy Logic Toolbox MATLAB to demonstrate exemplar applications and to develop hands-on exercises. In recent years, intelligent control has emerged as one of the most active and fruitful areas of research and development. Until now, however, there has been no comprehensive text that explores the subject with focus on the design and analysis of biological and industrial applications. Intelligent Control Systems Using Soft Computing Methodologies does all that and more. Beginning with an overview of intelligent control methodologies, the contributors present the fundamentals of neural networks, supervised and unsupervised learning, and recurrent networks. They address various implementation issues, then explore design and verification of neural networks for a variety of applications, including medicine, biology, digital signal processing, object recognition, computer networking, desalination technology, and oil refinery and chemical processes. The focus then shifts to fuzzy logic, with a review of the fundamental and theoretical aspects, discussion of implementation issues, and examples of applications, including control of autonomous underwater vehicles, navigation of space vehicles, image processing, robotics, and energy management systems. The book concludes with the integration of genetic algorithms into the paradigm of soft computing methodologies, including several more industrial examples, implementation issues, and open problems and open problems related to intelligent control technology. Suitable as a textbook or a reference, Intelligent Control Systems explores recent advances in the field from both the theoretical and the practical viewpoints. It also integrates intelligent control design methodologies to give designers a set of flexible, robust controllers and provide students with a tool for solving the examples and exercises within the book. This book aims to introduce the state-of-the-art research of stability/performance analysis and optimal synthesis methods for fuzzy-model-based systems. A series of problems are solved with new approaches of design, analysis and synthesis of fuzzy systems, including stabilization control and stability analysis, dynamic output feedback control, fault detection filter design, and reduced-order model approximation. Some efficient techniques, such as Lyapunov stability theory, linear matrix inequality, reciprocally convex approach, and cone complementary linearization method, are utilized in the approaches. This book is a comprehensive reference for researchers and practitioners working on intelligent control, model reduction, and fault detection of fuzzy systems, and is also a useful source of information for senior undergraduates and graduates in these areas. The readers will benefit from some new concepts and methodologies with theoretical and practical significance in system analysis and control synthesis. Fuzzy Control of Industrial Systems: Theory and Applications presents the basic theoretical framework of crisp and fuzzy set theory, relating these concepts to control engineering based on the analogy between the Laplace transfer function of linear systems and the fuzzy relation of nonlinear fuzzy system. Included are generic aspects of fuzzy systems with an emphasis on the many degrees of freedom and its practical design implications, modeling and systems identification techniques based on fuzzy rules, parametrized rules and relational equations, and the principles of adaptive fuzzy and neurofuzzy systems. Practical design aspects of fuzzy controllers are covered by the detailed treatment of fuzzy and neurofuzzy software design tools with an emphasis on iterative fuzzy tuning, while novel stability limit testing methods and the definition and practical examples of the new concept of collaborative control systems are also given. In addition, case studies of successful applications in industrial automation, process control, electric power technology, electric traction, traffic engineering, wastewater treatment, manufacturing, mineral processing and automotive engineering are also presented, in order to assist industrial control systems engineers in recognizing situations when fuzzy and neurofuzzy would offer certain advantages over traditional methods, particularly in controlling highly nonlinear and time-variant plants and processes. The emergence of fuzzy logic and its applications has dramatically changed the face of industrial control engineering. Over the last two decades, fuzzy logic has allowed control engineers to meet and overcome the challenges of developing effective controllers for increasingly complex systems with poorly defined dynamics. Today's engineers need a working knowledge of the principles and techniques of fuzzy logic intelligent control provides the answer. This book presents the traditional control techniques and contrasts them with intelligent control. It then presents several methods of representing and processing knowledge and introduces fuzzy logic as one such method. It highlights the advantages of fuzzy logic over other techniques, indicates its limitations, and describes in detail a hierarchical control structure appropriate for use in intelligent control systems. It introduces a variety of applications, most in the areas of robotics and mechatronics but with others including air conditioning and process/production control. One appendix provides discussion of some advanced analytical concepts of fuzzy logic, another describes a commercially available software system for developing fuzzy logic application, Intelligent Control is filled with worked examples, exercises, problems, and references. No prior knowledge of the subject nor advanced mathematics are needed to comprehend much of the book, making it well-suited as a senior undergraduate or first-year graduate level text and a convenient reference tool for practicing professionals. Model-based fuzzy control uses a given conventional or a fuzzy open loop of the plant under control in order to derive the set of fuzzy if-then rules constituting the corresponding fuzzy controller. Furthermore, of central interest are the consequent stability, performance, and robustness analysis of the resulting closed loop system involving a conventional model and a fuzzy controller, or a fuzzy model and a fuzzy controller. The major objective of the model-based fuzzy control is to use the full available range of existing linear and nonlinear design of such fuzzy controllers which have better stability, performance, and robustness properties than the corresponding non-fuzzy controllers designed by the use of these same techniques. Readings in Fuzzy Sets for Intelligent Systems is a collection of readings that explore the main facets of fuzzy sets and possibility theory and their use in intelligent systems. Basic notions in fuzzy set theory are discussed, along with fuzzy control and approximate reasoning. Uncertainty and informativeness, information processing, and membership, cognition, neural networks, and learning are also considered. Comprised of eight chapters, this book begins with a historical background on fuzzy sets and possibility theory, citing some forerunners who discussed ideas or formal definitions very close to the basic notions introduced by Lotfi Zadeh (1978). The reader is then introduced to fundamental concepts in fuzzy set theory, including symmetric summation and the setting of fuzzy logic. Fuzzy sets and possibility theory and their use in intelligent systems are analyzed. This monograph will be of interest to both students and practitioners in the fields of computer science, information science, applied mathematics, and artificial intelligence. Fuzzy logic control has become an important methodology in control engineering. This volume deals with applications of fuzzy logic control in various domains. The contributions are divided into three parts. The first part consists of two state-of-the-art tutorials on fuzzy control and fuzzy modeling. Surveys of advanced methodologies are included in the second part. These surveys address fuzzy decision making and control, fault detection, isolation and diagnosis, complexity reduction in fuzzy systems and neuro-fuzzy methods. The third part contains application-oriented contributions from various fields, such as process industry, cement and ceramics, vehicle control and traffic management, electromechanical and production systems, avionics, biotechnology and medical applications. The book is intended for researchers both from the academic world and from industry. Soft computing, as a collection of techniques exploiting approximation and tolerance for imprecision and uncertainty in traditionally intractable problems, has become very effective and popular especially because of the synergy derived from its components. The integration of constituent technologies provides complementary methods that allow
developing flexible computing tools and solving complex problems. A wide area of natural applications of soft computing techniques consists of the control of dynamic systems, including robots. Loosely speaking, control can be understood as driving a process to attain a desired goal. Intelligent control can be seen as an extension of this concept, to include autonomous human-like interactions of a machine with the environment. Intelligent robots can be characterized by the ability to operate in an uncertain, changing environment with the help of appropriate sensing. They have the power to autonomously plan and execute motion sequences to achieve a goal specified by a human user without detailed instructions. In this volume leading specialists address various theoretical and practical aspects in soft computing, intelligent robotics and control. The problems are taken from fuzzy systems, neural networks, interactive evolutionary computation, intelligent mobile robotics, and intelligent control of linear and nonlinear dynamic systems. With increasing demands for high precision autonomous control over wide operating envelopes, conventional control engineering approaches are unable to adequately deal with system complexity, nonlinearities, spatial and temporal parameter variations, and with uncertainty. Intelligent Control or self-organising/learning control is a new emerging discipline that is designed to deal with problems. Rather than being model based, it is experiential based. Intelligent Control is the amalgam of the disciplines of Artificial Intelligence, Systems Theory and Operations Research. It uses most recent experiences or evidence to improve its performance through a variety of learning schemes, that for practical implementation must demonstrate rapid learning convergence, be temporally stable, be robust to parameter changes and internal and external disturbances. It is shown in this book that a wide class of fuzzy logic and neural net based learning algorithms satisfy these conditions. It is demonstrated that this class of intelligent controllers is based upon a fixed nonlinear mapping of the input (sensor) vector, followed by an output layer linear mapping with coefficients that are updated by various first order learning laws. Under these conditions self-organising fuzzy logic controllers and neural net controllers have common learning attributes. A theme example of the navigation and control of an autonomous guided vehicle is included throughout, together with a series of bench examples to demonstrate this new theory and its applicability. Contents: An Introduction to Intelligent ControlIntroductory Fuzzy LogicFuzzy Logic Controller Structure and Design The Static Fuzzy Logic ControllerSelf-Organising Fuzzy Logic ControlInDirect Self-Organising Fuzzy Logic ControllersCase Studies of Direct Adaptive Fuzzy ControlNeural Network Approximation Capability for Control and Modelling The B-Spline Neural Network and Fuzzy Logic The Appendix: Mathematical Prerequisites Readership: Computer scientists, engineers and nonlinear scientists. keywords:One of the attractions of fuzzy logic is its utility in solving many real engineering problems. As many have realised, the major obstacles in building a real intelligent machine involve dealing with random disturbances, processing large amounts of imprecise data, interacting with a dynamically changing environment, and coping with uncertainty. Neural-fuzzy techniques help one to solve many of these problems. Fuzzy Logic and Intelligent Systems reflects the most recent developments in neural networks and fuzzy logic, and their application in intelligent systems. In addition, the balance between theoretical work and applications makes the book suitable for both researchers and engineers, as well as for graduate students. This Encyclopedia of Control Systems, Robotics, and Automation is a component of the global Encyclopedia of Life Support Systems EOLSS, which is an integrated compendium of twenty one Encyclopedias. This 22-volume set contains 240 chapters, each of size 5000-30000 words, with perspectives, applications and extensive illustrations. It is the only publication of its kind carrying state-of-the-art knowledge in the fields of Control Systems, Robotics, and Automation and is aimed, by virtue of the several perspectives, at the following five major target audiences: University and College Students, Educators, Professional Practitioners, Research Personnel and Policy Analysts, Managers, and Decision Makers and NGOs. Soft computing is a consortium of computing methodologies that provide a foundation for the conception, design, and deployment of intelligent systems and aims to formalize the human ability to make rational decisions in an environment of uncertainty and imprecision. This book is based on a NATO Advanced Study Institute held in 1996 on soft computing and its applications. The distinguished contributors consider the principal constituents of soft computing, namely fuzzy logic, neurocomputing, genetic computing, and probabilistic reasoning, the relations between them, and their fusion in industrial applications. Two areas emphasized in the book are how to achieve a synergistic combination of the main constituents of soft computing and how the combination can be used to achieve a high Machine Intelligence Quotient. "Recent Advances in Intelligent Control Systems" gathers contributions from workers around the world and presents them in four categories according to the style of control employed: fuzzy control; neural control; fuzzy neural control; and intelligent control. The contributions illustrate the interdisciplinary antecedents of intelligent control and contrast its results with those of more traditional control methods. A variety of design examples, drawn primarily from robotics and mechatronics but also representing process and production engineering, large civil structures, network flows, and others, provide instances of the application of computational intelligence for control. Presenting state-of-the-art research, this collection will be of benefit to researchers in automatic control, automation, computer science (especially artificial intelligence) and mechatronics while graduate students and practicing control engineers working with intelligent systems will find it a good source of study material. This book offers a comprehensive introduction to intelligent control system design, using MATLAB simulation to verify typical intelligent controller designs. It also uses real-world case studies that present the results of intelligent controller implementations to illustrate the successful application of the theory. Addressing the need for systematic design approaches to intelligent control system design using neural network and fuzzy-based techniques, the book introduces the concrete design method and MATLAB simulation of intelligent control strategies; offers a catalog of implementable intelligent control design methods for engineering applications; provides advanced intelligent controller design methods and their stability analysis methods; and presents a sample simulation and Matlab program for each intelligent control algorithm. The main topics addressed are expert control, fuzzy logic control, adaptive fuzzy control, neural network control, adaptive neural control and intelligent optimization algorithms, providing several engineering application examples for each method. "Advances in Intelligent Control" is a collection of essays covering the latest research in the field. Based on a special issue of "The International Journal of Control", the book is arranged in two parts. Part one contains recent contributions of artificial neural networks to modelling and control. Part two concerns itself primarily with aspects of fuzzy logic in intelligent control, guidance and estimation, although some of the contributions either make direct equivalence relationships to neural networks or use hybrid methods where a neural network is used to develop the fuzzy rule base. Great progresses have been made in the application of fuzzy set theory and fuzzy logic. Most remarkable area of application is "fuzzy control", where fuzzy logic was first applied to plant control systems and its use is expanding to consumer products. Most of fuzzy control systems uses fuzzy inference with max-min or max-product composition, similar to the algorithm that first used by Mamdani in 1970s. Some algorithms are developed to refine fuzzy controls systems but the main part of algorithm stays the same. Triggered by the success of fuzzy control systems, other ways of applying fuzzy set theory are also investigated. They are usually referred to as 'fuzzy expert systems', and their purpose are to combine the idea of fuzzy theory with AI based approach toward knowledge processing. These approaches can be more generally viewed as 'fuzzy information processing', that is to bring fuzzy idea into informa tion processing systems. This book describes recent advances in the use of fuzzy logic for the design of hybrid intelligent systems based on nature-inspired optimization and their applications in areas such as intelligent control and robotics, pattern recognition, medical diagnosis, time series.
prediction and optimization of complex problems. Based on papers presented at the North American Fuzzy Information Processing Society Annual Conference (NAFIPS 2017), held in Cancun, Mexico from 16 to 18 October 2017, the book is divided into nine main parts, the first of which first addresses theoretical aspects, and proposes new concepts and algorithms based on type-1 fuzzy systems. The second part consists of papers on new concepts and algorithms for type-2 fuzzy systems, and on applications of type-2 fuzzy systems in diverse areas, such as time series prediction and pattern recognition. In turn, the third part contains papers that present enhancements to meta-heuristics based on fuzzy logic techniques describing new nature-inspired optimization algorithms that use fuzzy dynamic adaptation of parameters. The fourth part presents emergent intelligent models, which range from quantum algorithms to cellular automata. The fifth part explores applications of fuzzy logic in diverse areas of medicine, such as the diagnosis of hypertension and heart diseases. The sixth part describes new computational intelligence algorithms and their applications in different areas of intelligent control, while the seventh examines the use of fuzzy logic in different mathematical models. The eighth part deals with a diverse range of applications of fuzzy logic, ranging from environmental to autonomous navigation, while the ninth covers theoretical concepts of fuzzy models. Introduction; Fuzzy control: the basics; Case studies in design and implementation; Nonlinear analysis; Fuzzy identification and estimation; Adaptive fuzzy control; Fuzzy supervisory control; Perspectives on fuzzy control. This book contains introductory material to neuro-fuzzy systems. Its main purpose is to explain the information processing in mostly-used fuzzy inference systems, neural networks and neuro-fuzzy systems. More than 180 figures and a large number of (numerical) exercises (with solutions) have been inserted to explain the principles of fuzzy, neural and neuro-fuzzy systems. Also the mathematics applied in the models is carefully explained, and in many cases exact computational formulas have been derived for the rules in error correction learning procedures. Numerous models treated in the book will help the reader to design his own neuro-fuzzy system for his specific (managerial, industrial, financial) problem. The book can serve as a textbook for students in computer and management sciences who are interested in adaptive technologies. Increasingly, over the last few years, intelligent controllers have been incorporated into control systems. Presently, the numbers and types of intelligent controllers that contain variations of fuzzy logic, neural network, genetic algorithms or some other forms of knowledge based reasoning technology are dramatically rising. However, considering the stability of the system, when such controllers are included it is difficult to analyse and predict system behaviour under unexpected conditions. Leading researchers and industrial practitioners were able to discuss and evaluate current development and future research directions at the first IFAC International Workshop on safety, reliability and applications on emerging intelligent control technology. This publication contains the papers, covering a wide range of topics, presented at the workshop. This book discusses systematic designs of stable adaptive fuzzy logic controllers employing hybridizations of Lyapunov strategy-based approaches/H∞ theory-based approaches and contemporary stochastic optimization techniques. The text demonstrates how candidate stochastic optimization techniques like Particle swarm optimization (PSO), harmony search (HS) algorithms, covariance matrix adaptation (CMA) etc. can be utilized in conjunction with the Lyapunov theory/H∞ theory to develop such hybrid control strategies. The goal of developing a series of such hybridization processes is to combine the strengths of both Lyapunov theory/H∞ theory-based approaches and stochastic optimization-based global search methods, so as to attain superior control algorithms that can simultaneously achieve desired asymptotic performance and provide improved transient responses. The book also demonstrates how these intelligent adaptive control algorithms can be effectively utilized in real-life applications such as in temperature control for air heater systems with transportation delay, vision-based navigation of mobile robots, intelligent control of robot manipulators etc. This handbook shows the reader how to develop neural networks and apply them to various engineering control problems. Based on a workshop on aerospace applications, this tutorial covers integration of neural networks with existing control architectures as well as new neurocontrol architectures in nonlinear control.