

CHAPTER 58

TECHNOLOGY INSTRUMENTATION AND CONTROL ENGINEERING

Doctoral Theses

01. CHANDRA (Surabhi)
Performance Enhancement of Solar Energy Systems using Soft Computing Techniques.
Supervisor : Prof. Prerna Gaur
Th 25593

*Abstract
(Not Verified)*

The solar photovoltaic (PV) system is becoming a more dynamic renewable energy resource due to its abundance and there is a considerable expansion of technological advancements in control of PV power. In this context, the analysis of special converters and fast and efficient control strategies ensuring stability, reliability and high performance open up the wide area for enhancement in power generation efficiency of PV modules. A simple, efficient-high gain converter topology is proposed along with an improved maximum power point tracking algorithm using soft computing methods to enhance the extraction of output power from the PV array in this thesis. The tracking of peak point power of PV systems is used to attain the PV operating point at its peak under varying temperatures and sunlight variations. A soft computing based maximum power point tracking algorithm i.e. radial basis function neural network (RBFNN) MPPT algorithm is developed and investigated on a solar water pumping system topology and the performance is compared with the classical approach. The RBFNN MPPT technique predicts the duty ratio to the SEPIC to extract the maximum power from the PV array in changing irradiance, temperature, and partial shading conditions (PSC). The performance of the proposed solar water pumping topology is enhanced by implementing the RBFNN MPPT algorithm. A switched inductor-capacitor based high gain SEPIC (HGS) is proposed, designed, modelled, and investigated in this thesis. The proposed converter topology can boost the output voltage at low duty ratio thus achieving a high voltage gain at low duty ratio. The proposed converter is also integrated with the PV array and the impact of the proposed HGS on the performance improvement of the solar PV system is studied. Also, the RT analysis of the proposed HGS with PV array is conducted to show the validation of high gain operation.

Contents

1. Introduction 2. Literature survey 3. System modelling 4. Radial basis function neural network technique for efficient maximum power point tracking in solar photovoltaic system 5. Design of solar water pumping system using RBFNN based MPP tracking for PV-SEPIC-VSI fed BLDC motor 6. Design and analysis of a switched inductor-capacitor based novel non-isolated high gain SEPIC for solar energy applications 7. Conclusion and future scope. Bibliography. Appendices. List of publications.

02. DASS (Anuli)
Application of Artificial Intelligence in Control Systems.
 Supervisor : Prof. Smriti Srivastava
Th25342

Abstract
(Verified)

This thesis deals with the design and implementation of intelligent tools for modeling and control of complex non-linear dynamical systems. The main aim is to develop modeling, control and optimization techniques for improving the performance of traditional fuzzy-logic based systems. In this thesis, we have made an attempt to develop different architectures of Recurrent Fuzzy Systems. The developed models are capable of dealing with systems without requiring information of their order or structure. Advantages of the recurrent fuzzy system have been highlighted and explained using suitable examples. The developed structures have been optimized using various methods like Gradient descent, Lyapunov stability-based method and nature inspired algorithms for obtaining parameter update equations. We have developed a novel framework using Intelligent Water Drop algorithm to update the parameters of the fuzzy-based system. Next, we performed a comparative analysis between the IWD based learning algorithm and a very recently developed learning algorithm based on the behavior of the grasshoppers known as Grasshopper Optimization Algorithm. The simulation results are compared and the analysis shows the superiority of the developed IWD learning algorithm. Now coming to the stability aspect of developed algorithms, we have developed a Lyapunov stability-based parameter update scheme which ensures global optimization and stability of the system. Next, the ability and efficiency of the fuzzy system must be improved so as to deal with situations with an even higher level of vagueness in the system or available data. Fuzzy type-2 systems are capable of handling such situations where the information about the membership function is also vague. A classic example of such a situation is the requirement to analyze the environmental data. Lastly, we have developed a fuzzy type-2 based system to model, predict and control the level of carbon monoxide in three metropolitan cities of India namely Delhi, Mumbai and Bengaluru.

Contents

1. Introduction 2. Identification and control of nonlinear dynamic systems using recurrent fuzzy systems 3. Modeling and control of fuzzy-based systems using intelligent water drop algorithm 4. Study and implementation of grasshopper optimization algorithm and its comparison with intelligent water drop algorithm 5. Modeling and control of nonlinear dynamic systems using Lyapunov stability-based fuzzy techniques 6. Application fuzzy techniques for analysis of CO level in Indian scenario 7. Conclusion and future work. Bibliography. Work published based on this thesis. Technical biography of author.

03. GOYAL (Sonal)
Some Aspects of Image Processing for Medical Applications.
 Supervisors : Prof. Vijander Singh and Prof. Asha Rani
Th25338

Abstract
(Not Verified)

The primary aim of this work is to design efficient automatic medical image analysis tools, as manual examination of these images is quite costly, irreproducible, time consuming and difficult task. Therefore, denoising, multi-modal image fusion and classification of medical images are considered in this work. The speckle noise present in ultrasound images limits the contrast resolution and

complicates the diagnosis. Thus hybrid denoising techniques are designed by incorporating Savitzky-Golay smoothing (SGS) filter to speckle reducing anisotropic diffusion (SRAD) filter and total generalized variation leading to SGS-SRAD and FPRSG filters, respectively. The proposed hybrid filters are implemented on synthetic images, B-scan simulated images and real ultrasound images. A multiscale decomposition and sparse representation-based technique is designed to integrate the important information of multimodal medical images into a single image. The medical images are denoised using FPRSG filter and then decomposed using non-subsampled shearlet transform (NSST). The sparse representation is used for fusion and finally NSST reconstruction is applied to generate the fused multimodal image. Another fusion scheme uses non-subsampled contourlet transform (NSCT) to extract features, Siamese convolutional neural network (sCNN) for weighted fusion of important features and fractional order total generalized variation (FOTGV) for noise removal, which leads to NSCT + sCNN + FOTGV scheme. Further a new methodology for classification of brain magnetic resonance (MR) image is suggested. The scale-invariant feature transform is employed to extract features of SGS-SRAD denoised MR image. Principal component analysis is applied for feature reduction and images are classified using support vector machine (SVM). The parameters of SVM are optimized using gray wolf optimization. It is revealed from the qualitative and quantitative analysis of results that the proposed hybrid techniques for denoising, image fusion and classification provide superior performance as compared to the traditional methods available in the literature.

Contents

1. Introduction 2. Literature survey 3. Research methodology 4. Results and discussion 5. Conclusion and future scope of work. List of publication. Bibliography. Biodata of author. Appendix.

04. GUPTA (Sangeeta)

Application of Fractional Systems in Signal Processing and Control.

Supervisors : Dr. Pragya Varshney and Prof. Smriti Srivastava

Th 25540

Abstract (Not Verified)

In this thesis, an attempt has been made to explore the application of fractional calculus in the field of control and signal processing. Conventional methods like least square method, symbolic time series analysis-based method and adaptive control methods, face difficulties in estimating the accurate parameters of fractional order chaotic systems due to its complex and unstable dynamic behaviour. To overcome the shortcomings of traditional approach, their parameter estimation has been converted into multidimensional optimization problem. This approach has yielded better results as compared to the conventional ones. Modified Artificial bee colony and Ant colony optimization algorithms are employed for parameter estimation on Financial, Chen, Lorenz's and 3-cell net fractional order chaotic systems. Estimation of parameters and fractional orders of Fractional order Financial Chaotic System is performed using Whale optimization algorithm, Grey wolf optimization, Modified Artificial bee colony, Ant colony optimization. All of which are swarm-based optimization algorithm with distinct characteristics of having high exploration rate and less tendency to get trapped in local minima, thereby giving improved results. Control and synchronization of the selected Fractional order Financial Chaotic System is performed based on Pecora & Carroll synchronization scheme with the help of Fractional order Proportional Integral Derivative controller. Whale optimization algorithm and Particle Swarm optimization algorithms are applied to tune the parameters of controllers. This has enabled in better control of the mentioned system. Fractional order mask operator is applied on image for the purpose of edge detection and compared with integer order-based mask operators. Since the proposed technique is fractional in nature, the degrees of freedom of the system have increased,

thereby yielding better detection of image and also overcoming the shortcomings occurring in traditional methods.

Contents

1. Introduction 2. Modeling parameters of fractional order chaotic systems using modified ABC and ACO 3. Modeling of Parameters of fofcs using swarm based optimization technique 4. Synchronization of two identical fractional order financial chaotic systems 5. Image edge detection using fractional mask 6. Conclusion and future scope. Bibliography. Technical biography of author. List of publications.

05. KUKKER (Amit)
Adaptive Intelligent Classification and Control for Bio-Medical and Non-Linear Control Systems.
 Supervisor : Prof. Rajneesh Sharma
Th25341

Abstract (Verified)

Adaptive Intelligent system is an emerging area in the field of Artificial Intelligence (AI). Several systems/processes have been successfully optimized by the use of Adaptive Intelligence. This thesis outlines applications of some novel adaptive intelligence techniques to bio-medical signal processing and non-linear control systems. We have implemented various feature extraction and classification methods for forearm movements along with implementation of optimized reinforcement learning based approaches for robotic manipulator control. In addition to this, transformer faults and epileptic seizures are also detected. Our first application uses Electromyogram (EMG) signals for controlling a prosthetic hand. These EMG signals are acquired through surface electrodes which are placed on target muscle set of healthy subjects. Six forearm movements, typing key task identification and elbow angle prediction have been chosen for classification purpose for both left and right hands. Feature extraction and classification techniques have been developed using Hilbert-Huang Transform (HHT) with Artificial Neural Network (ANN), Empirical Mode Decomposition (EMD) with Decision Tree Algorithm and HHT with Neural Reinforcement Learning (NRL) classifier for multi-tasking forearm movements. High classification accuracy achieved by our proposed NRL classifier shows that the approach could serve as a stepping stone for building a multi-tasking prosthetic hand. For non-linear (NL) control systems, optimization in Fuzzy Q-Learning (FQL) approach through Genetic Algorithm (GA) has been developed. In conventional FQL, an agent attempts to find most optimal action at each stage by choosing an action having the lowest Q-value or the greedy action. However, in our view, Q-function is an unknown function and an attempt to find minima of such a function based on a limited set of values, is inaccurate and insufficient. GA has been employed for finding optimal action value in each iteration of the algorithm rather than plain algebraic minimum.

Contents

1. Introduction 2. Algorithms used I problem formulation 3. EMG signal based forearm movements identification 4. NRL classifier for elbow, finger and hand movements 5. GA assisted FQL for non-linear control systems 6. Transformer fault detection using intelligent genetic fuzzy classifier 7. Epileptic seizure classification using GAFQL 8. Conclusions and scope for future work. Reference. Vita. List of publication.

06. NAVDEEP

Hybrid Edge Detection Techniques for Medical and Industrial Applications.

Supervisor : Prof. Asha Rani

Th25340*Abstract*
(Not Verified)

Edge detection is an important step in image processing to reduce the dimension of data and focus on the important information. Accurate edge detection of medical and industrial images is very difficult because of the presence of noise, complex features and artifacts. Further these images are used in highly important applications and help in taking crucial decisions, therefore this work focuses on enhancement of conventional local binary pattern (LBP) technique. An improved hyper function-based LBP (IHLBP) is designed by introducing logarithmic hyper-smoothing function and counting scheme based on weighted threshold. A function is designed on the basis of neighborhood information to evaluate the threshold weight. Another scheme based on hyper smoothing function, similarity distance measure and LBP i.e. HY-LBP is designed. A combination of hyper-smoothing function, counting scheme and LBP leading to HLBP-F edge detector is also proposed to calculate fat percentage from meat images. The threshold weight in counting scheme is obtained using trial and error approach. Further a low dimensional edge descriptor based on local relationship of middle pixel to diagonal/non-diagonal maxima-minima, is designed for medical images. The designed methods are validated on X-ray and ultrasound images. An improved local extrema peak valley pattern (ILEPVP) scheme is developed for edge detection of thermography images. The current pixel information is extracted by calculating the local difference between middle and surrounding pixels. An improved depth local binary pattern (IDLBP) edge detector based on counting scheme and adaptive threshold is proposed for depth images. ILBP technique is developed by incorporating counting scheme and pixel difference matrix to LBP. The proposed algorithms are tested on a wide variety of noisy and clean images used in industrial and medical applications. The experimental results reveal the superiority of proposed methods under noisy, blur and low contrast conditions in terms of the commonly used performance measures.

Contents

1. Introduction 2. Literature review 3. Digital image processing 4. Research methodology 5. Results and discussion 6. Conclusion and future scope. List of publication. Bibliography. Appendix. Biodata of author.

07. SRISHTI

Cost Effective, Efficient and Stable Standalone Hybrid Energy System.

Supervisor : Dr. Perna Gaur

Th25339*Abstract*
(Not Verified)

The present work embodies development of a more effective and efficient system that can transfer maximum power to the load. Implementation of the new MPPT techniques such as Artificial Neural Network (ANN), Fuzzy Logic Control (FLC) and Cuckoo Search Algorithm (CSA) is carried out to in PV system to identify the most efficient system and the results are compared with conventional Perturb and Observe (P&O) and are also presented in this work. The proposed models are simulated and obtained results are analyzed and compared with the conventional method using MATLAB/Simulink, while the real-time implementation of similar prototype is carried out using a novel dSPACE DS1202 MicroLabBox and highly accurate PV emulator. The simulated results are validated with the hardware prototype to assess the feasibility and viability of the system. Further this work also comprises the comparison of steady state accuracy of D.C. link voltage, output power of proposed techniques i.e. ANN, FLC, CSA vis-a-vis conventional P&O using MATLAB/Simulink and dSPACE. The results of

the proposed techniques are also presented by varying the irradiance and temperature. A comparison of tracking efficiency of MPPT, steady state accuracy of D.C. link voltage, settling time and duty cycle of proposed techniques i.e. ANN, FLC, CSA with conventional P&O is also presented in the present work. Further, Microgrid based EMS (Energy Management System) is designed and implemented in this work to manage the energy balance between renewable resources and the load. The results of the comparative study of the proposed MPPT techniques i.e. CSA, ANN, FLC with conventional P&O using MATLAB/SIMULINK in terms of accuracy, electric power efficiency, duty cycle, D.C. link voltages, load power of proposed techniques are presented in the present work. The working of the proposed EMS for hybrid PV-Wind-Battery system is verified through simulation results using various control algorithms.

Contents

1. Introduction 2. Literature review 3. Soft computing techniques applied to renewable energy systems 4. Hardware set up for operation of various control algorithms 5. Simulation and real-time implementation of MPPT techniques for PV systems using high precision PV emulator and dSpace DS1202 microlab box 6. Effect of variation in parameters with various AI based MPPT techniques used in PV system with A.C load using dSpace DSI1202 microlab box 7. Soft computing techniques in PV-Wind-Battery renewable energy island systems 8. Conclusion and future prospects. References. List of Publications.

08. SRIVASTAVA (Vishal)

Soft Computing Techniques for Modeling and Control of Nonlinear Systems.

Supervisor: Prof. Smriti Srivastava

Th25539

Abstract (Verified)

Most of the practical systems are nonlinear in nature due to their dynamic behavior. The uncertainties, parameters variations and other constraints make nonlinear systems very complex. To deal with such system dynamics, soft computing techniques are widely used. Optimization algorithms are one of the most effective and simple soft computing techniques. In almost all applications in engineering, optimization takes place in the form of minimization or maximization. Major reasons for the development in the field of control are need to handle complex nonlinear processes. A suitable controller with optimized parameters should be used to improve the performance of these systems. In this thesis, swarm based algorithms such as particle swarm optimization (PSO), grasshopper optimization (GOA), grey wolf optimization (GWO), whale optimization (WOA), physics based namely gravitational search (GSA) and human based namely Teaching learning based optimization (TLBO) have been used with PID controller on inverted pendulum, ball and beam, robotic arm manipulator, continuous stirred tank reactor (CSTR) and blood glucose system. By utilizing the exploration and exploitation ability of individual algorithm, hybrid algorithms such as, PSOGSA and PSGWO are also implemented on aforementioned systems. The performance of these mentioned algorithms has been evaluated in terms of rise time, peak time, settling time, mean square error (MSE), disturbance and computational effort. Next, a very recent topic COVID-19, which is a dynamic system is also discussed. A systematic approach has been used for the analysis of COVID-19. The SIR model is used for analysis in terms of infected population, speed of infection. The model is simulated and analyzed with different conditions like before lockdown, after lockdown and light switch for India. An endemic disease model has been used for stability analysis by LaSalle's principle. Novel prevention methods like convalescent plasma method, who acquires infection from whom (WAIFW) method has been discussed.

Contents

1. Introduction 2. Literature review 3. On comparing the performance of swarm based algorithms with human based algorithm for nonlinear systems 4. Performance improvement and stability analysis of nonlinear systems using hybrid optimization techniques 5. Hybrid algorithms based control and stability analysis of diabetic blood glucose system 6. A systematic approach for the COVID-19 prediction and parameters estimation 7. Conclusion and future scope. Bibliography.