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Nature Inspired Optimization for Electrical Power System

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Preface

Nature-inspired optimization algorithms have become very popular during the last three decades for solving complex real-world problems. Nature-inspired optimization methods are motivated by the behaviour and problem-solving skills of living beings and have their origin in some or the other natural phenomenon. These algorithms usually mimic natural processes like mutation, selection, foraging behaviour of an organism, group movement, human intelligence or physical laws. Ease of implementation, a parallel search mechanism facilitated by a population of agents, non-dependence on nature of the objective function and ability to process non-differentiable, discontinuous and non-convex functions have resulted in the unprecedented popularity of nature-inspired techniques over other numerical methods, for solving practical problems.

The electrical power systems are highly interconnected, geographically distributed over large areas, have complex dynamic constraints and possess linear/nonlinear, static/dynamic and continuous/discrete variables. Hence, nature-inspired algorithms are particularly suitable for solving the complex power system optimization problems which are high dimensional, nonlinear, non-convex, discontinuous and have a large number of equality and inequality constraints.

This book provides a compilation of a few popular algorithms and their applications to different types of problems of the power system domain. It contains nine chapters. Chapters 1–2 deal with human intelligence-based teacher learner-based optimization, Chaps. 3–6 focus on swarm intelligence, Chap. 7 deals with differential evolution, Chap. 8 presents a real-world application of the genetic algorithm, and Chap. 9 reviews various optimization techniques.

The objective of dispatching generating units in an electrical power system is to compute an optimal generation schedule to minimize the cost without violating the operating limits. Earlier, this problem comprised mainly fossil fuel generating units. Now, the system complexity increases due to the widespread involvement of a large number of renewable distributed energy resources (DERs) which are random, uncertain and introduce discrete variables in the objective function.

Chapter 1 provides a metaheuristic technique inspired by the interaction between teacher and students in the classroom named as teacher learner-based optimization (TLBO), which is implemented for solving a complex static and dynamic economic load dispatch problem with ramp rate limits, prohibited operating zones, valve point loading as well as transmission losses. Chapter 2 presents the application of elitist TLBO to solve the problem of optimal power flow during transmission network congestion through active power rescheduling for the pool-based competitive electricity market model. Chapter 3 presents the popular particle swarm optimization (PSO) algorithm which has been implemented for determining optimal values of parameters of proportional–integral–derivative (PID) controller for the load frequency control (LFC) of single area power network. Levelized cost of energy (LCOE) concept helps in establishing the economic viability of the system with renewable energy sources over a long run and also helps in deciding a feasible tariff for the hybrid renewable energy system (HRES). In Chap. 4, PSO is used to determine LCOE for a hybrid energy system. Artificial bee colony (ABC) optimization algorithm is a well-accepted swarm intelligence-based method. It is applied for solving combined economic emission dispatch (CEED) of a hybrid thermal solar PV system in Chap. 5. Grey wolf optimization (GWO) is a novel swarm intelligence approach inspired by the hierarchical hunting mechanism of grey wolves. Chapter 6 presents the solution to a multi-objective problem for a microgrid in a dynamic environment using GWO. Microgrids are becoming popular for power supply with renewable energy resources due to their adaptability and ability to work independently. In Chap. 7, a mixed-integer differential evolution (MIDE) algorithm with continuous and binary variables is used to solve static and dynamic optimal scheduling for a microgrid. In Chap. 8, non-dominated sorting genetic algorithm-II (NSGA-II) is used to solve multi-objective reactive power management (MORPM) problem for minimization of active power losses, improvement of voltage profile and minimization of the total capacity of reactive power sources (RPS) in radial distribution systems (RDS). Short-term hydrothermal scheduling (SHTS) problem deals with the scheduling of hydro and thermal generating units to fulfil required power demand. As the operating cost of the hydro units is understandably almost negligible, the primary objective is the minimization of fuel cost of thermal units while satisfying a large number of nonlinear equality/inequality constraints associated with both hydro and thermal power generating units. Chapter 9 attempts to present a state-of-the-art review of nature-inspired algorithms applied for solving SHTS problems with different dimensions and complexities.

This book is expected to be very useful to the researchers/academicians/UG and PG students who wish to work and explore the applications of nature-inspired algorithms in the power system or any other interdisciplinary area.

We sincerely appreciate the time, effort and contribution of the authors and esteemed reviewers in maintaining the quality of the papers. Special thanks to the editors and supporting team of Springer for helping in publishing this book. We would also like to acknowledge the director and management of Madhav Institute of Technology and Science, Gwalior, India, for providing facilities and necessary support.

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Synopsis

Problems related to electrical power systems are usually very complex due to massive dimensions, nonlinearity, non-convexity and discontinuity associated with objective functions. Also, it has a large number of equality and inequality constraints, which give rise to a complex optimization problem which is difficult to solve using classical numerical methods. Nature-inspired optimization algorithms are found to be very effective as compared to traditional optimization methods due to their ease of implementation, population-based parallel search mechanism, non-dependence on the nature of the problem and ability to handle non-differentiable, non-convex problems. The analytical model of nature-inspired techniques mimics the natural happenings and intelligence of life forms. They are mainly based on evolution, swarm intelligence, ecology, human intelligence and physical science.

This book presents a wide range of optimization methods and their applications to different electrical power system problems such as economic load dispatch, demand supply management in microgrid, levelized pricing of energy, load frequency control and congestion management, reactive power management in radial distribution system.

Contents

Chapter 5
Combined Economic Emission Dispatch of Hybrid Thermal PV System Using Artificial Bee Colony Optimization

Salil Madhav Dubey, Hari Mohan Dubey, and Manjaree Pandit

Abstract Economical and reliable provision of electricity has been one of the most significant research objectives since decades. With time, various economic load dispatch (ELD) techniques have emerged in power market. Apart from using these methods, changes in the use of conventional source of energy and incorporating non-conventional sources have emerged in recent years. Solar photovoltaic (PV) generation helps reducing emissions and dependency on fossil fuels. This chapter presents combined economic emission dispatch (CEED) of a hybrid thermal solar PV system. Artificial bee colony (ABC) algorithm is used as optimization tool for the scenario involving six thermal plants and thirteen solar plants. The effectiveness of this method is compared and validated with other methods available in recent literature.

Keywords Economic load dispatch · Economic emission dispatch · Artificial bee colony algorithm · Solar PV system

Nomenclature

Min C	Objective function
$F_i(P_i)$	Fuel cost (in \$/h) for i-th power generating unit
$E_i(P_i)$	Emission (in kg/h) for i-th power generating unit
w	Weight ratio
ppf	Price penalty factor

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