Grey Wolf Optimization to Solve Load Frequency Control of an Interconnected Power System: GWO Used to Solve LFC Problem

Dipayan Guha, Electrical Engineering Department, Dr. B. C. Roy Engineering College Durgapur, Durgapur, India
Provas Kumar Roy, Electrical Engineering Department, Jalpaiguri Government Engineering College, Jalpaiguri, India
Subrata Banerjee, National Institute of Technology Durgapur, Durgapur, India

ABSTRACT

In this article, a novel optimization algorithm called grey wolf optimization (GWO) with the theory of quasi-oppositional based learning (Q-OBL) is proposed for the first time to solve load frequency control (LFC) problem. An equal two-area thermal power system equipped with classical PID-controller is considered for this study. The power system network is modeled with governor dead band and time delay nonlinearities to get better insight of LFC system. 1% load perturbation in area-1 is considered to appraise the dynamic behavior of concerned power system. Integral time absolute error and least average error based fitness functions are defined for fine tuning of PID-controller gains employing the proposed method. An extensive comparative analysis is performed to establish the superiority of proposed algorithm over other recently published algorithms. Finally, sensitivity analysis is performed to show the robustness of the designed controller with system uncertainties.

KEYWORDS

Grey Wolf Optimization, Least Average Error, Load Frequency Control, Quasi-Oppositional Based Learning, Sensitivity Analysis

1. INTRODUCTION

The main idea behind the power system operation and control is to maintained balance between the total powers generation and total load demand plus losses accompanying to the system under normal and disturbed conditions. Load frequency control (LFC) of an interconnected power system network places an attention’s towards balancing between generations and demands such that system frequency and tie-line exchange power can be upheld to their predefined levels. Literature review reveals that the work on load frequency control (LFC) was proposed by Chon, 1957. However, the concept of optimal control theory in LFC area is established by Elgerd and Fosha (1970). Thereafter, many types of research have been performed in LFC area to improve the existing results. An extensive literature survey on LFC problem for conventional and distributed generation is available in Ibraheem, Kumar, and Kothari (2005). Saikia, Nanda, and Mishra (2011) presented a comparative analysis between several classical controllers in the area of LFC and established the superiority of designed controller. The effectiveness of double-stage reheat turbine and electrical governor in an interconnected hydro-thermal system over single stage turbine and the mechanical governor is elaborated in Nanda, Mangla,
Suri (2006). Authors also gave a clear idea for the selection of speed regulation parameter $R_i$ and sampling time period for the said system. Gozde and Taplamacioglu (2011) proposed proportional-integral (PI) controller for two-area automatic generation control (AGC) system with governor dead-band (GDB) nonlinearity. Recently, a number of researchers like Roy, Bhatt, and Ghoshal (2010), Guha, Roy, and Banerjee (2015), Mohanty, Panda, and Hota (2014) proposed proportional-integral-derivative (PID) controller in lieu of PI-controller for further expansion of existing results.

In the recent times, researchers addressed LFC problem with some advanced controllers like adaptive controller Tripathy, Balasubramanian, and Nair (1992), robust controller Ray, Prasad, and Prasad (1999), 2-degree-of-freedom controller Sahu, Panda, and Rout (2013), intelligent controller based on artificial neural network (ANN) Chaturvedi, Satsangi, and Kalra (1999), fuzzy logic controller (FLC) Karnavas, and Papadopoulos (2002), ANFIS controller Khuntia, and Panda (2012), state feedback controller Ouassaïd, Maaroufi, and Cherkaoui (2012), sliding mode controller Vrdoljak, Peric, and Petrovic (2010), etc. Saikia (2012) designed a multilayer perception neural network using reinforcement learning for a three-area thermal power system. Karnavas, and Papadopoulos (2002) have employed FLC for studying the dynamic stability of an interconnected power system. However, the performance of FLC is highly sensitive to the selection of rules in knowledge base process. Fuzzy neural network (FNN) includes the advantages of FLC and ANN to handles the disturbances and to improve the degree of stability to a great extent. Although, FNN shows remarkable performance over LFC and ANN, but it is not appreciable for the measurement of noise and parametric uncertainties of a power system. Additionally, the aforesaid advanced controllers require (i) large computational time, (ii) sound knowledge for their design and analysis, (iii) large training data set etc. The use of state feedback controller for the solution of LFC problem is available in Ouassaïd, Maaroufi, and Cherkaoui (2012). To design an optimal state feedback controller, availability of all output state variables is required. However, in actual practice, it is not possible to observe all the state variables, especially for the large power system, either due to the cost consideration or unavailability of suitable sensors that minimizes the applicability of said controller in the real-time system. The robust controllers are designed to cope up with parametric variation and/or uncertainties of the system. But most of them are designed on the theory of state feedback controller. Since the availability of all state variables for large power system network is unrealistic that minimizes the degree of applicability of robust controller to practical AGC system. Moreover, some of them have unified characteristics resulting higher order of designed controller, which is practically not feasible to design for the large power system.


www.igi-global.com/e-resources/library-recommendation/?id=2

Related Content

Optimal Energy System for Single Household in Nigeria

www.igi-global.com/article/optimal-energy-system-for-single-household-in-nigeria/93098?camid=4v1a

Applications of DC Motors

www.igi-global.com/chapter/applications-of-dc-motors/131311?camid=4v1a

1D Electromagnetic Band Gap Analysis and Applications
Abdelmoumen Kaabal, Mustapha El Halaoui, Saida Ahyoud and Adel Asselman (2019). *Emerging Innovations in Microwave and Antenna Engineering* (pp. 147-191).

www.igi-global.com/chapter/1d-electromagnetic-band-gap-analysis-and-applications/214455?camid=4v1a
Transient Stability Constrained Optimal Power Flow Using Teaching Learning Based Optimization
[www.igi-global.com/article/transient-stability-constrained-optimal-power-flow-using-teaching-learning-based-optimization/124744?camid=4v1a](www.igi-global.com/article/transient-stability-constrained-optimal-power-flow-using-teaching-learning-based-optimization/124744?camid=4v1a)