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Seeker optimization algorithm for global optimization: A case study on optimal modelling of proton exchange membrane fuel cell (PEMFC)

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ABSTRACT

In order to optimize the proton exchange membrane fuel cell (PEMFC) model parameters, a novel approach based on seeker optimization algorithm (SOA) is proposed. The SOA is based on the concept of simulating human searching behaviors, where the choice of search direction is based on the empirical gradient by evaluating the response to the position changes and the decision of step length is based on uncertainty reasoning by using a simple Fuzzy rule. In this study, after evaluated on benchmark function optimization, the SOA is applied to optimal modelling of the PEMFC by using a fuel cell test system in Fuel Cell Application Centre (FAC) at the Temasek Polytechnic, and compared with several state-of-the-art versions of differential evolution (DE) and particle swarm optimization (PSO) algorithms. The simulation results show that the proposed approach is superior to other compared algorithms, and the PEMFC model with optimized parameters by SOA fitted experimental data well. Hence, SOA is an effective and reliable technique for optimizing the parameters of PEMFC model, and can be helpful for system analysis, optimization design and real-time control of the PEMFCs.

1. Introduction

Fuel cell is one of the promising energy technologies for the sustainable future with its high energy efficiency and environment friendly when the world is facing the global warming problem [1,2]. Among different types of fuel cells, proton exchange membrane fuel cells (PEMFCs) have many charming features such as relatively low operating temperatures, fast response, superior durability, high power density, high modularity and zero emission. With these characteristics, PEMFCs have been widely recognized as the most promising candidates for future power generating devices, especially in the automotive, distributed power generation and portable electronic applications [3–5].

For the better understanding of the characteristics and evaluation of the performance of PEMFCs, thereby to optimize fuel cell system, various models have been developed in the literature [4]. However, models which are easy to be solved and feasible for engineering applications are seldom available. Moreover, although model parameters must be precisely identified in order to obtain accurate simulation results, the methods for parameter optimization of PEMFC stack models were rarely discussed [6,7].

The performance of PEMFC is mainly represented by its polarization curve which describes the cell voltage–load current (*V*–*I*) characteristics [1,3,8]. Optimization of fuel cell operating points, design of the power conditioning units, design of simulators for fuel cell stack systems, and design of system controllers depend on such characteristics. Therefore, it is important to exactly model the *V*–*I* characteristics of fuel cells [1].

The polarization curve model adopted in this paper applies the empirical equations proposed in [9]. Although the model can fit very well with experimental results [3,10], its parameters depend on the operating condition and the stack itself, so that it cannot be transposed to another fuel cell without a new identification of the parameters [10]. Hence, it is necessary to optimize the model parameters for the specific applications.

It is well known that the polarization curves of PEMFC are highly non-linear and excellent search methods are needed for the optimal model parameters in order to obtain accurate simulation results [1,3,8]. In the recent years, some local and global optimization techniques have been applied to this type of problem, such as conventional gradient-based search algorithms, mathematical programming methods and global stochastic optimization approaches including genetic algorithms (GAs), simulated annealing (SA), Tabu search, particle swarm optimization (PSO), etc. [6,7,11]. However, these algorithms have their respective limits [12], and a better algorithm for optimal modelling of the PEMFCs is expected.

Recently, seeker optimization algorithm (SOA), as a novel population-based heuristic search algorithm, was originally proposed in [13]. It has been applied to function optimization [14], optimal reactive power dispatch [15,16], and digital IIR filter design [12].

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