SA-PSO Hybrid Algorithm for Gas Path Diagnostics of Gas Turbine

Shixi Ma, Gas Turbine Research Institute, Shanghai Jiao Tong University , China ,
Dengji Zhou , Gas Turbine Research Institute, Shanghai Jiao Tong University , China
Huisheng Zhang , Gas Turbine Research Institute, Shanghai Jiao Tong University , China

Long Abstract

Introduction

With an ever-increasing power demand in the world and also growing share of power generation by gas turbines, continuous and risk-free performance of these devices is of high significance. All types of gas turbines are susceptible to performance deterioration because of the site and working conditions and polluting environment. As a result, health monitoring and performance diagnosis are two of the most important priorities of gas turbine manufacturers and users. [1]
Non-linear model based diagnostic method, with high diagnostic accuracy, is suitable for gas path diagnostics. One way of non-linear model based diagnostic method is to transfer the Fault Diagnosis into an optimization problem. Genetic algorithms have been applied to solve this high-dimensional optimization problem[2-3]. Although it has overcome the shortcomings of other traditional methods for easily being plunged into the local minima, it is criticized for the slow convergence speed and sensitive to algorithm parameters[4]. Additionally it may eventually cause diagnostic delay and error diagnosis. In this paper, a new diagnosis method is used for the gas path fault diagnosis of gas turbine. The method used particle generator which was designed by means of fast SA (Simulated Annealing) to produce an optimized initial swarm of particles for PSO (Particle Swarm Optimization). Combining the global search ability of SA and the high efficiency of PSO, the new method have a good performance in diagnosis speed and accuracy.

1. Method

SA-PSO hybrid algorithm is usded as an effective optimization tool to predicte health parameters based on a self-adaptive gas turbine model, in this diagnostic method. The main process of this diagnostic method includes two parts: particles generator based on fast SA to produce an optimized initial swarm of particles for PSO, PSO algorithm is responsible for the precise search in diagnosis. The main process of diagnosis is shown in Figure 1.

(1) SA init of particle position

Firstly, In this method, simulated annealing algorithm firstly process a global search in feasible area, trying to lock in the approximate location of the global optimum, using the result as the initial point of particle swarm optimization

(2) Objective function

the objective function is should reflect the difference between the gas turbine simulating result and the measurement data. Many works has focus on the effect of different function [4.5],and Function 1 is regarded as the preferred choice because it provide a robust estimation.

$$Goal = \sum_{i=1}^{M} | z_j - h_j(x) | \quad (1)$$

where z_j is the value of the jth measurement , $h_j(x)$ is the simulating result .

(3) PSO seach specific region effectively

In each cycle, the speed and position of the Particles is updated in PSO algorithm accordance with

the above equation for different PSO mode 1-IV. So the algorithm can achieve a accurately and fast seaching in the particular region to get the global optimal solution.

(4) Termination criteria

Termination condition is the maximum number of iterations or minimum difference in every generation.

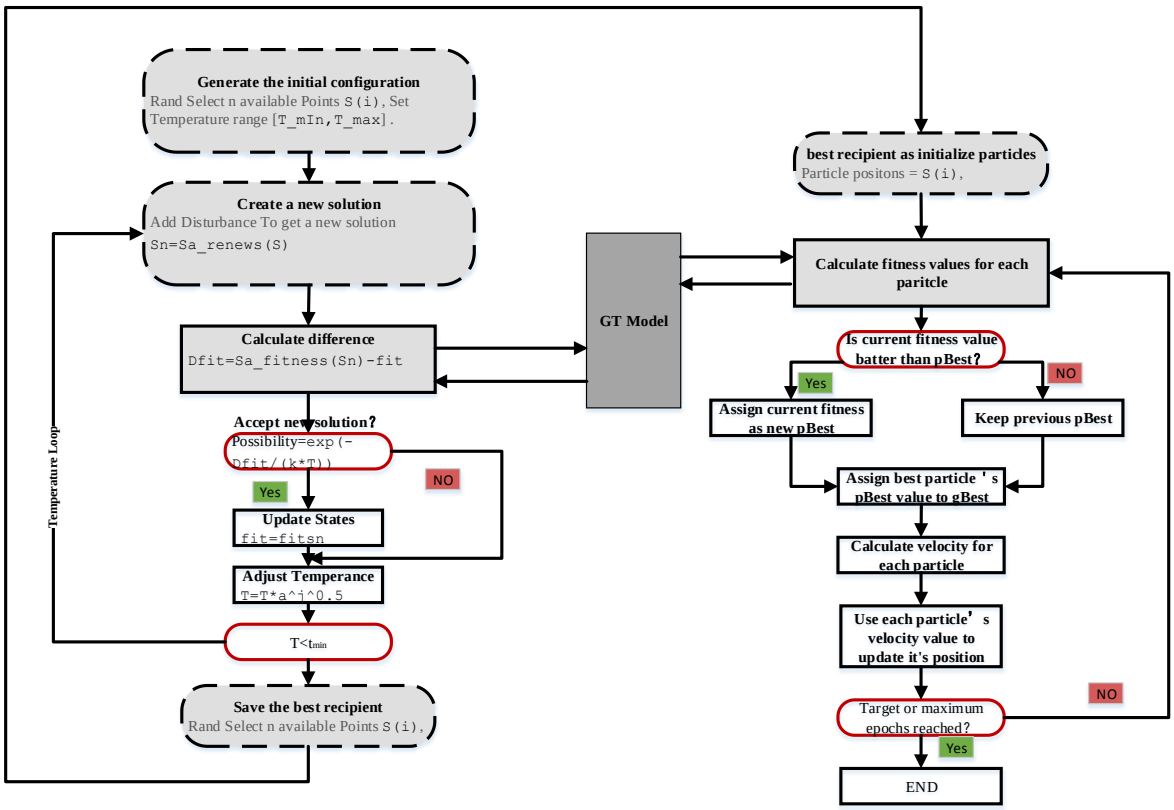

Figure 1. Schematic of SA -PSO based gas turbine diagnostic method

2. Results

It is tested in a diagnostic platform for LM2500 gas turbine. The procedure is illustrated using the field data of an engine. Firstly, the effect of algorithm parameters on diagnostic accuracy and speed are studied. In addition the diagnostic result of this new algorithm is compared with other algorithms, such as GA (genetic algorithm), the standard PSO, SA, and hill-climbing algorithm. The numbers of iterations and population for diagnosis are substantially smaller than the GA-based method while guarantee the accuracy. Diagnostic time, on a PC with Pentium processor of 1.83GHz and 2GB RAM, is on the range of 3.2-5s, which is much lower than GA based method (12-20s). The result shows that the method can be used effectively and successfully in gas path diagnostics of gas turbine

.

References

[1] Salar, A., et al. A Hybrid Ekf-Fuzzy Approach to Fault Detection and Isolation of Industrial Gas Turbines. *Proceedings of the Asme Turbo Expo.* 3: 251-260.2011

[2] Pan, C., et al.. Fault diagnostic method of power transformers based on hybrid genetic algorithm evolving wavelet neural network. *Electric Power Applications.* 2(1): 71-76. 2008.

[3] Li, L. M., et al. Genetic algorithm for Lagrangian support vector machine optimization and its application in diagnostic practice. *Journal of Vibroengineering.* 15(1): 1-8. 2013.

[4] Zedda, M. and R. Singh f. Gas turbine engine and sensor fault diagnosis using optimization techniques. *Journal of Propulsion and Power*, 18: 1019-1025, 2002.

[5] Li, Y. G. and T. Korakiantis. Nonlinear Weighted-Least-Squares Estimation Approach for Gas-Turbine Diagnostic Applications *Journal of Propulsion and Powe*r. 27(2): 337-345. 2011.