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An improved chaotic hybrid differential evolution for the short-term hydrothermal scheduling problem considering practical constraints

Key words: Valve-point effect, Prohibited discharge zones, Differential evolution, Chaotic sequences, Constraint handling

Corresponding author: Salman Zafar
E-mail: salman.zafar@ucp.edu.pk
ORCID: http://orcid.org/0000-0002-7449-5275

Introduction

- Short-term hydrothermal scheduling (STHTS) is a non-linear and complex optimization problem with a set of operational hydraulic and thermal constraints.
- Due to limitations such as non-linearity and non-convexity in cost curves, artificial intelligence tools based techniques are being used to solve the STHTS problem.
- In this paper an improved chaotic hybrid differential evolution (ICHDE) algorithm is proposed to find an optimal solution to this problem taking into account practical constraints such as ramp rate limits and prohibited discharge zones.

Problem formulation

Objective function and constraints considered in this paper are:

- **Objective function**: Minimization of total fuel cost

subjected to:

(i) Active power demand balance; (ii) Generation capacity;

(iii) Discharge rates limit; (iv) Reservoir volume storage;

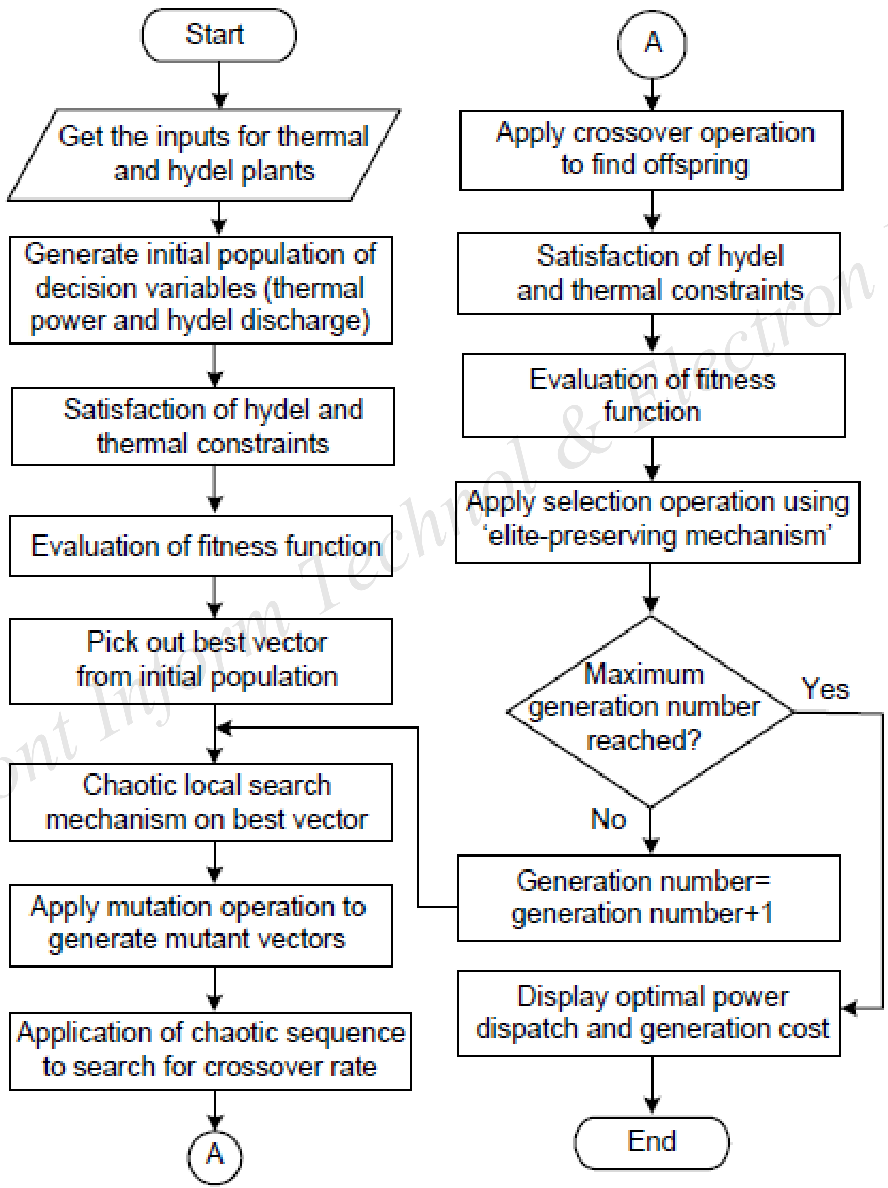
(v) Hydraulic continuity equation/water dynamic balance;

(vi) Reservoir end conditions; (vii) Ramp rate limits of thermal plants; (viii) Prohibited discharge zones; (ix) Transmission line losses

Proposed improved chaotic hybrid differential evolution (ICHDE) algorithm

- Differential evolution (DE) is an efficient population-based stochastic optimization algorithm for solving non-linear, non-differentiable optimization problems.
- However, due to limitations (manually parameter setting, pre-mature convergence) in conventional DE algorithm, we developed ICHDE algorithm to solve STHTS problem.
- A self-adjusted parameter setting is obtained in differential evolution (DE) with the application of chaos theory and a chaotic hybridized local search mechanism is embedded in DE to prevent it from premature convergence effectively.

Flowchart of ICHDE



Application of ICHDE algorithm

The proposed ICHDE algorithm was applied to two test systems composed of four cascaded hydel plants and several thermal plants.

Test system 1: 4 cascaded hydel plants and one equivalent thermal plant

Case study 1 (STHTS problem with quadratic cost function)

Case study 2 (STHTS problem considering valve-point effect)

Case study 3 (STHTS problem considering valve-point effect and prohibited discharge zones)

Test system 2: 4 cascaded hydel plants and three thermal plants

Case study 1 (STHTS problem with valve-point effect)

Case study 2 (STHTS problem with valve-point effect and transmission line losses)

Case study 3 (STHTS problem with valve-point effect, TL losses, ramp rate limits and prohibited discharge zones)

Simulation results

The brief summary of results obtained from ICHDE algorithm is given below:

		Proposed ICHDE cost ($)	Best result so far from literature ($)
Test system 1	Case study 1	917131.80	917237.70
	Case study 2	921784.24	924661.53
	Case study 3	922825.55	923016.29
Test system 2	Case study 1	40393.00	40627.92
	Case study 2	41223.41	41281.75
	Case study 3	42071.55	43790.33

Conclusions

- In this paper, the chaotic sequences based on iterative logistic and the tent map are employed to obtain the self adjusted CR parameter setting and to implement the chaotic hybridized local search mechanism in DE.
- In this developed evolutionary optimization model, not only the non-convex non-linear relationship for power generation characteristics is dealt conveniently, but also the complicated coupling among hydel reservoirs, water transport time delays, and prohibited discharge zones are effectively modeled.