Reconfiguration of Distribution Networks with Distributed Generation Based on Chaotic Gravitational Rat Swarm Optimization

ACSE 2023

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Introduction

With the emergence of the double carbon era, a multitude of wind turbines, photovoltaic systems, and other forms of distributed generation (DG) have been widely integrated into the power grid, resulting in significant economic advantages. However, this widespread integration has also posed considerable hurdles in maintaining the power system's safe operation [1]. Distribution network reconfiguration can change the opening and closing status of switches in the system to alter the flow distribution and achieve the goal of reducing system loss and enhancing safety [2]. Therefore, reconfiguring the distribution network that includes distributed generation (DG) holds significant practical value. In terms of solving the distribution network reconfiguration model, existing methods mainly include mathematical optimization algorithms, heuristic algorithms, and artificial intelligence algorithms. this paper introduces a novel approach called the chaotic gravity rat swarm algorithm (CGRSO) to address the multi-objective reconfiguration optimization model of power distribution networks with distributed power generation. The objective functions in this model aim to minimize network loss while maximizing both average safety distance and minimum safety distance. Through simulation and verification, the proposed method demonstrates its superiority by improving solution efficiency.

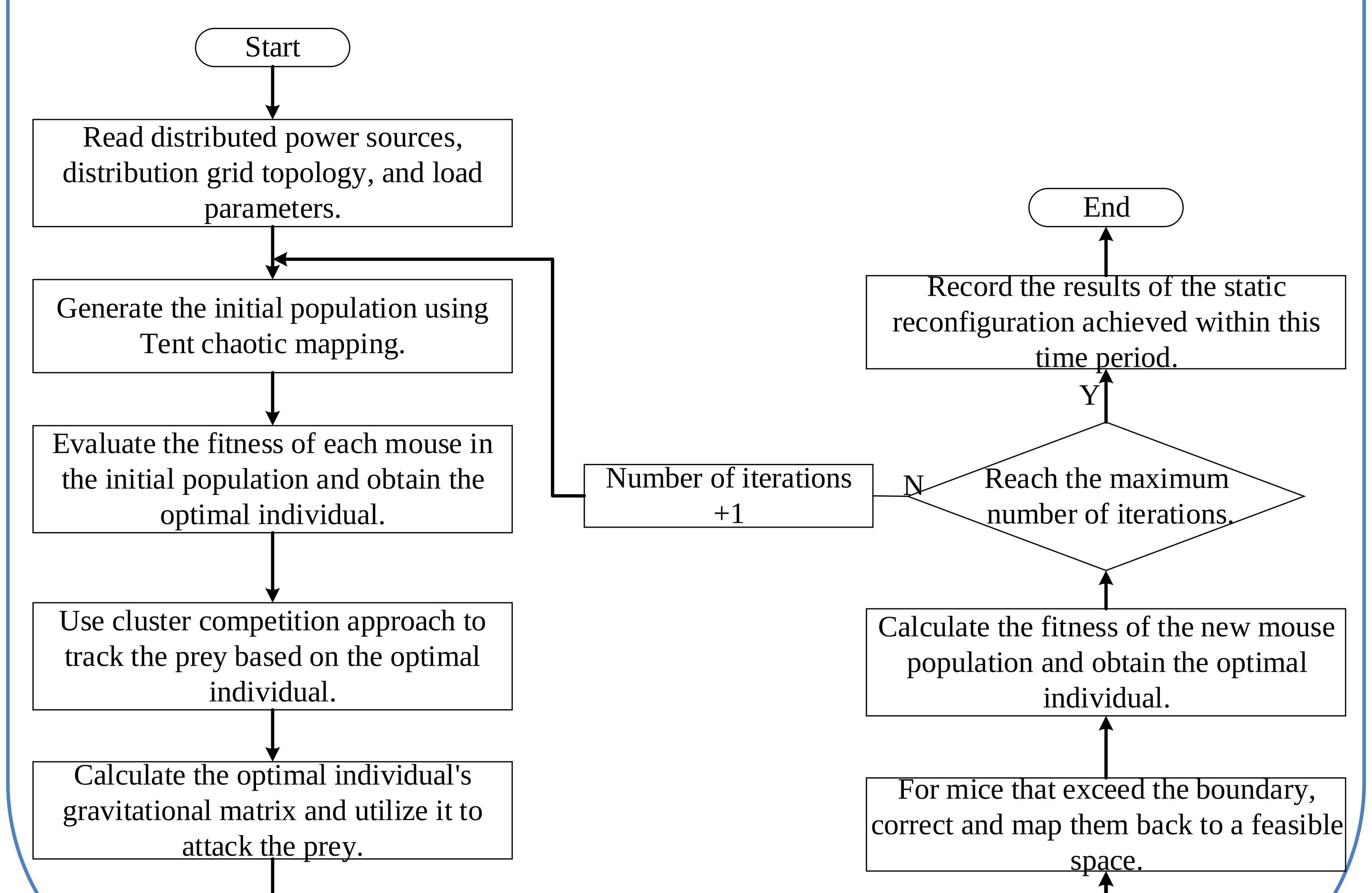
Research objectives

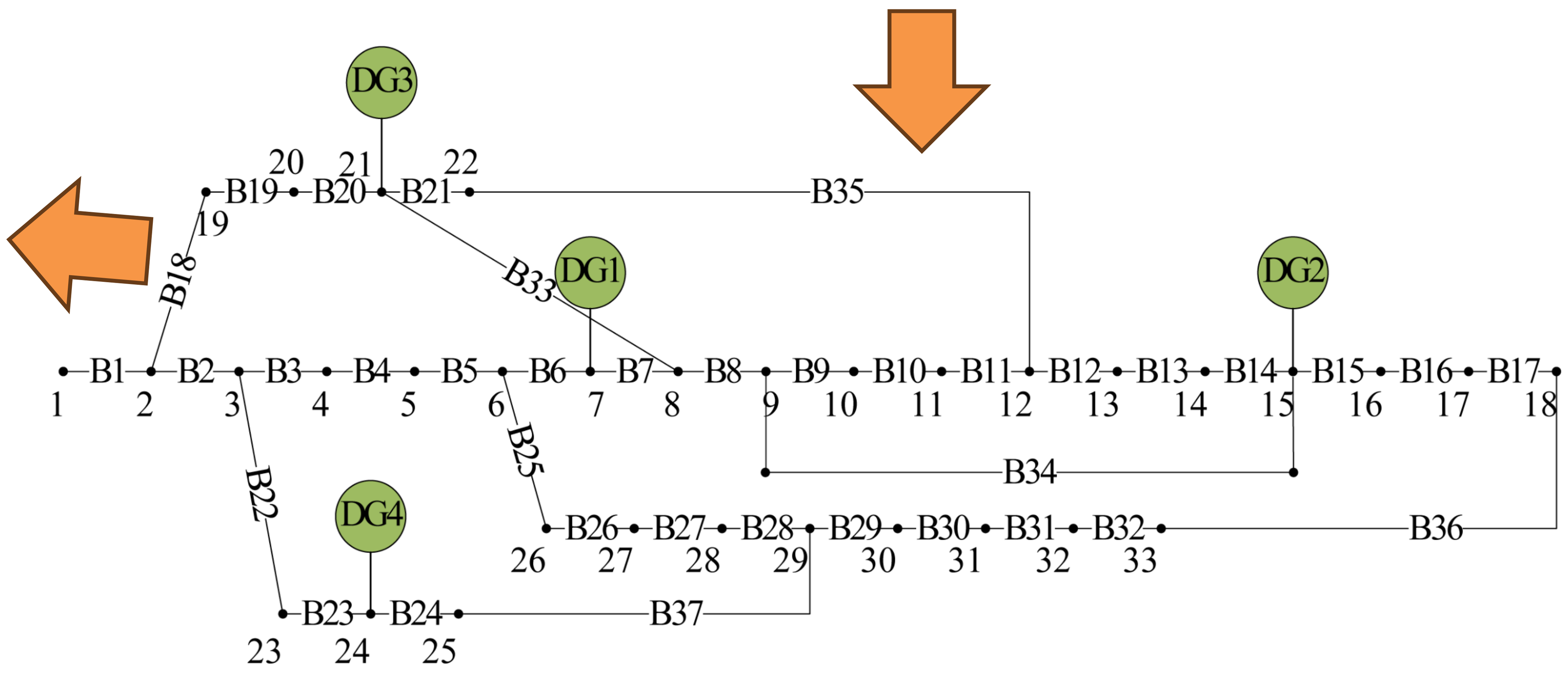
1. In terms of economic considerations, minimizing the active loss of the system serves as the primary objective function.

2. In terms of safety, the objective functions are to maximize the average safety distance and the minimum safety distance.

Methods

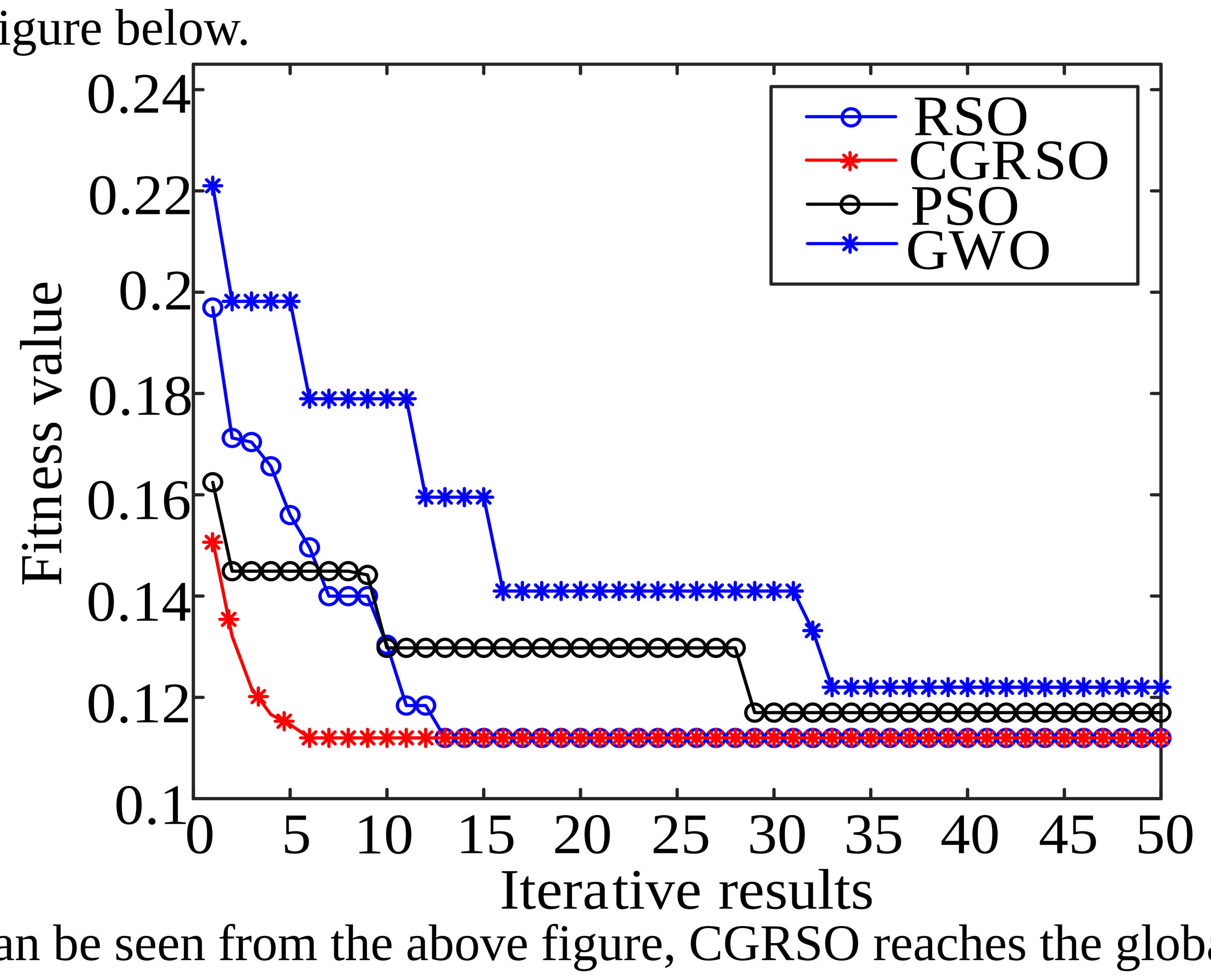
To address the issues of uneven initial population, poor optimization efficiency, and susceptibility to local optima in the rat swarm algorithm, the introduction of chaotic mapping and gravity matrix enhances the uniformity and convergence capability of the algorithm's initial population.





Results

The proposed algorithm is compared with Gray Wolf Optimizer (GWO), Particle Swarm Optimization (PSO), and traditional Rat Swarm Algorithm. Each algorithm is set with a population size of 30 and iterated for 50 times. The experiments are repeated 50 times, and a set of data from each algorithm's 50 repeated experiments is selected to plot the iteration curve, as shown in the figure below.



As can be seen from the above figure, CGRSO reaches the global optimum after 6 iterations, demonstrating a significant improvement over the other three algorithms.

Conclusion/References

The traditional swarm algorithm is improved by introducing the Tent chaotic map and the gravitational matrix, which improves the ability to conduct comprehensive searches and optimization efficiency of the algorithm. The proposed algorithm outperforms other algorithms with its shorter execution time and reduced number of iterations, indicating clear superiority.

[1]Li R, Wong P, Wang K, et al. 2020 Power quality enhancement and engineering application with high permeability distributed photovoltaic access to low-voltage distribution networks in Australia *Protection and Control of Modern Power Systems* **5**(03): 1-7.

[2]Chen S, Yang Y, Xu Q 2021 A coordinated approach of multi-energy system considering the off-design characteristics of the devices in energy hub *International Transactions on Electrical Energy Systems* **31**(11): 13037.