

Introduction

Most of the studies seem to have defaulted to metaheuristics for solving wind farm layout optimization problems. Compared with the metaheuristics, the branch-and-bound method used in mathematical programming is an exact algorithm with several advantages. The existing studies that use mathematical programming approach make an inequivalent simplification of the wind farm layout optimization problem. This paper employs the Ishihara 3D Gaussian wake model for optimization. Besides, the 3D Gaussian wake model-based wind farm layout optimization problem is formulated and solved by genetic algorithm and mathematical programming approach without simplification.

Mathematical Model

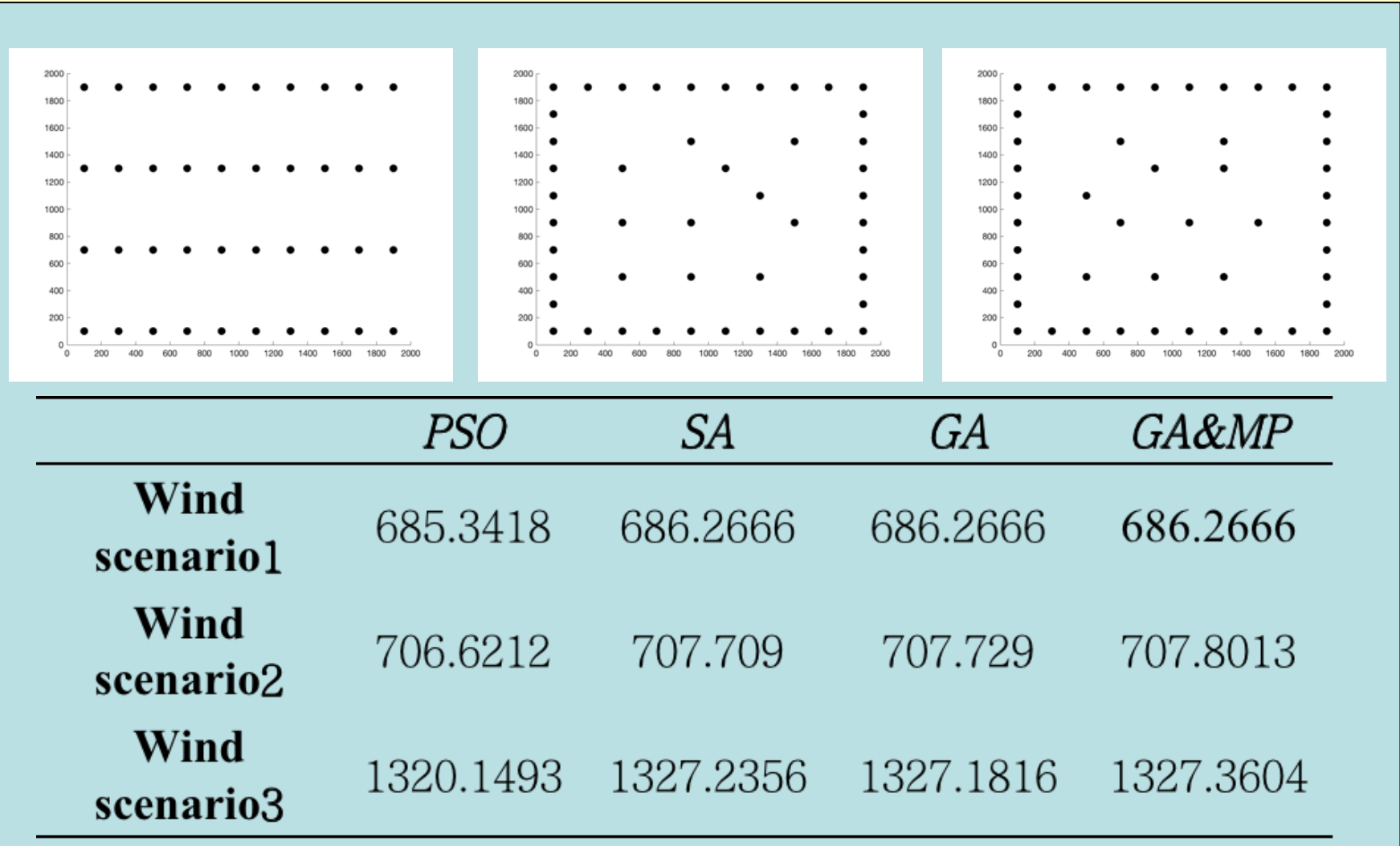
$$\text{objective} = \text{maximize} \sum_{j=1}^N u_j^3$$
$$u_j = q_j u_0 \left[1 - \sqrt{\sum_{i=1}^Y q_i \left(2a \left(\frac{r_1}{r_1 + kx(i,j)} \right)^2 \right)^2 \sqrt{\frac{A_{\text{overlap}}}{A_r}}} \right]$$
$$q_i \in \{0,1\}$$
$$\sum_{j=1}^N q_j = K$$

The cases set up in this paper divides the 2 km × 2 km wind farm into a 10 × 10 grid and labels it, where N represents the total number of the grids and the size is 100. For each grid, q is taken as 1 if there is a wind turbine in that grid and as 0 if there is no wind turbine in that grid. As a result, the total power generated by the wind farm can be expressed as the formula in objective function, where qj represents whether the wind speed at that grid is zero when calculating the total power and qi determines whether the velocity loss term under the root sign is accounted for in the wake loss.

Optimization Method

Genetic Algorithm
(1) Generate initial population (2) Calculate individual fitness (3) Using roulette algorithm to select the next generation (4) To perform cross operation (5) To perform mutation operation
Mathematical Programming
Use branch and bound method after convex relaxation or convex transformation of the problem

Optimization Results



Wind farm layout optimization using genetic algorithm and mathematical programming approach and the value of objective function obtained by different algorithms

The table gives a comparison of the results of the four algorithm. Now, we give the conclusion of this work. A new mathematical programming approach for optimizing wind farm layout is proposed. The distance between the solutions obtained by the GA&MP and the absolute optimal solution is less than 0.3%. The results show that the combined approach outperforms the other three algorithms.

Summary

Nowadays, reducing the wake losses of wind farms to generate more power through layout optimization is of great significance. In this paper, unlike most studies that use metaheuristics, we modeled the 3D Gaussian wake model-based wind farm layout optimization problem as formulas, and a method combining genetic algorithm and mathematical programming was proposed to solve the optimization problem. Compared with the results obtained by particle swarm algorithm, simulated annealing algorithm and genetic algorithm, the proposed approach shows better performance.