Competition on

Application of Modern Heuristic Optimization

Algorithms for Solving Optimal Power Flow Problems

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A Modified Chu-Beasley's Genetic Algorithm to Solve the Optimal Power Flow Problem

Outline

- Chu-Beasley genetic algorithm
- Modifications on the Chu-Beasley genetic algorithm
- Local search on initial population
- Genetic operators: selection and crossover
- Local improvement
- Results
- Conclusions

Chu-Beasley Genetic Algorithm

The genetic algorithm proposed by Chu and Beasley was first used to solve the generalized assignment problem. Some of its characteristics:

- a random initial population;
- objective function and unfeasibilities are considered separately;
- selection by tournament;
- in each iteration, only one descendant is generated using selection, recombination, mutation and local improvement;
- the improved descendant replace one element in the population taking into consideration unfeasibility, quality and diversity criteria.

Modifications on Chu-Beasley Genetic Algorithm

The proposed method, used to solve the optimal power flow problem, modifies Chu-Beasley algorithm in the following aspects:

- the initial population is generated randomly, but the individuals are improved by a local search;

- the mutation operator is not used.

Initial Population

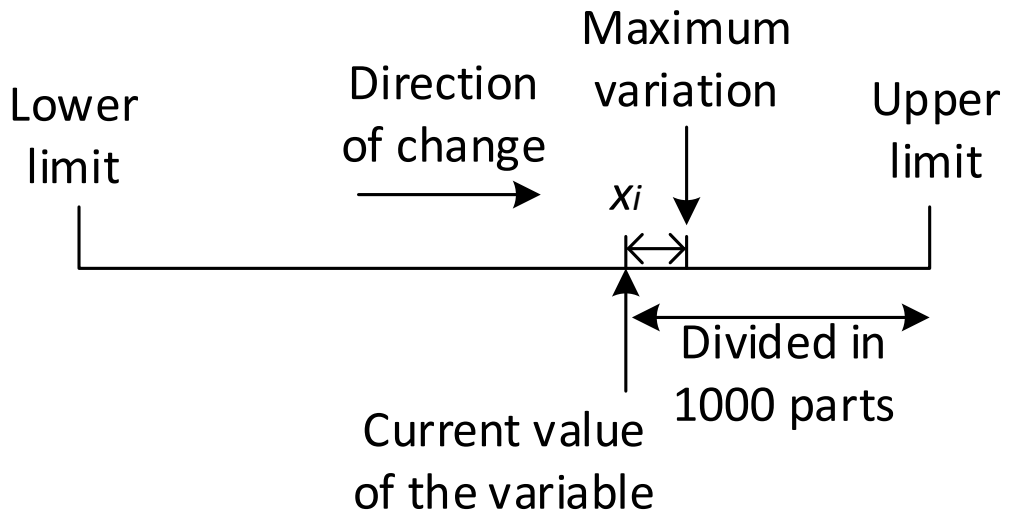
- Generated randomly within variables limits;
- Small, i.e., five individuals (Micro-genetic Algorithm);
- The initial population is then improved by a local search algorithm.

Local Search on Initial Population

- A control variable (continuous or discrete) is chosen randomly to be changed;
- Changes on continuous variables are discretized and they must be small;
- Integer variables may change increasing or decreasing one unit, depending on the previous sensitivity state;
- Binary variables change from 0 to 1 or from 1 to 0 if they are chosen.

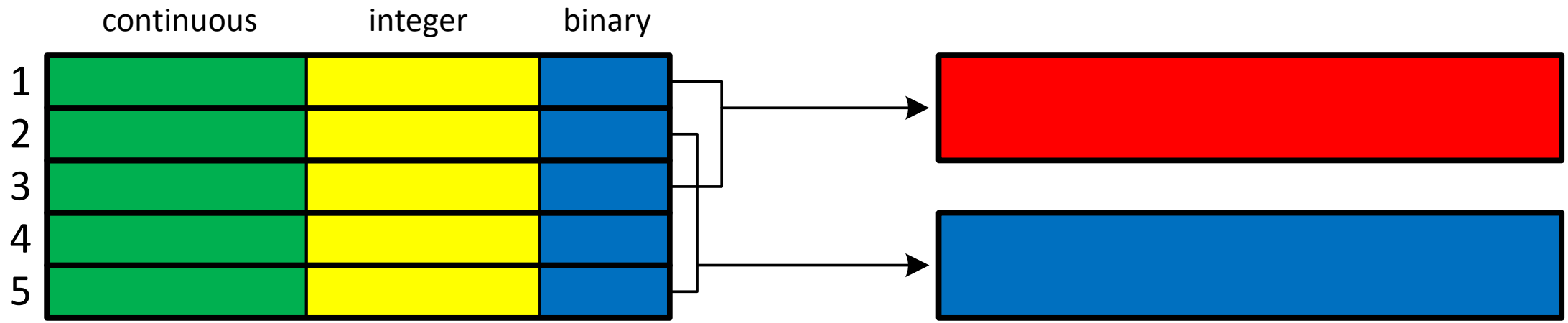
Local Search on Initial Population

- If an increase (decrease) on the chosen variable **improves** the fitness, then, next time this variable is chosen, it will be increased (decreased).
- If an increase (decrease) on the chosen variable **deteriorates** the fitness, then, next time this variable is chosen, it will be decreased (increased).



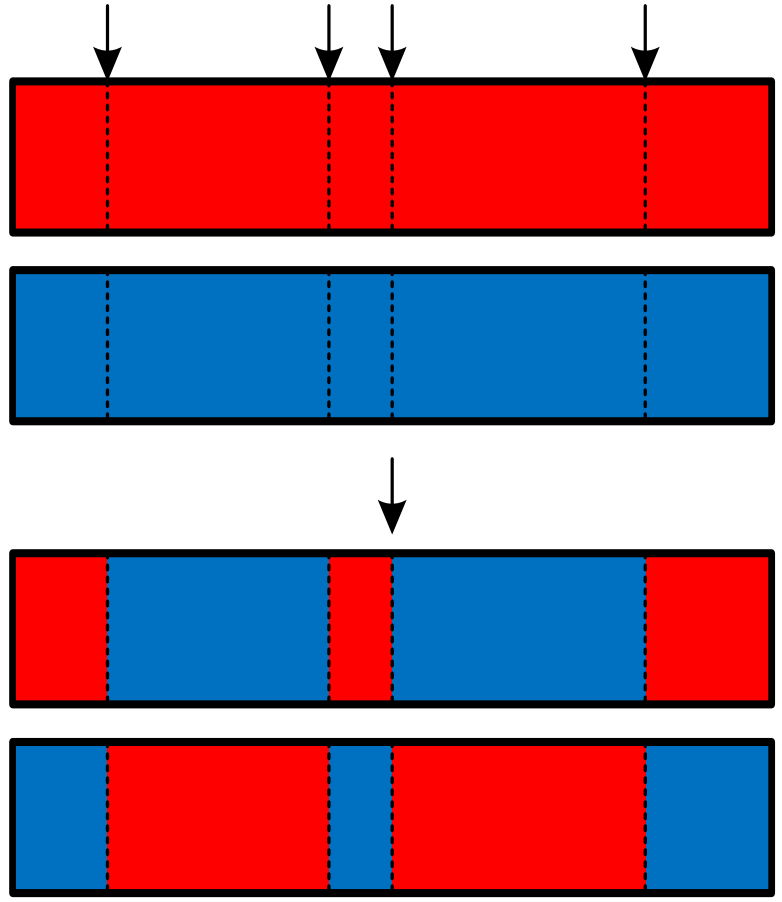
Genetic Algorithm: Tournament Selection

- Two individuals are chosen.
- The individual with best fitness is selected.
- This operation is repeated once again.



Genetic Algorithm: Crossover

- Two selected individuals are combined using the crossover operator.
- Multiple recombination points were used;
- These points are selected randomly;
- Only the descendant with best fitness is kept;
- A local improvement is performed on the best descendant.



Local Improvement

- Similar to the local search performed on the initial population;
- Changes on continuous variables are discretized;
- Integer variables may change increasing or decreasing one or two units, depending on the previous sensitivity state;
- Binary variables change from 0 to 1 or from 1 to 0 if they are chosen.

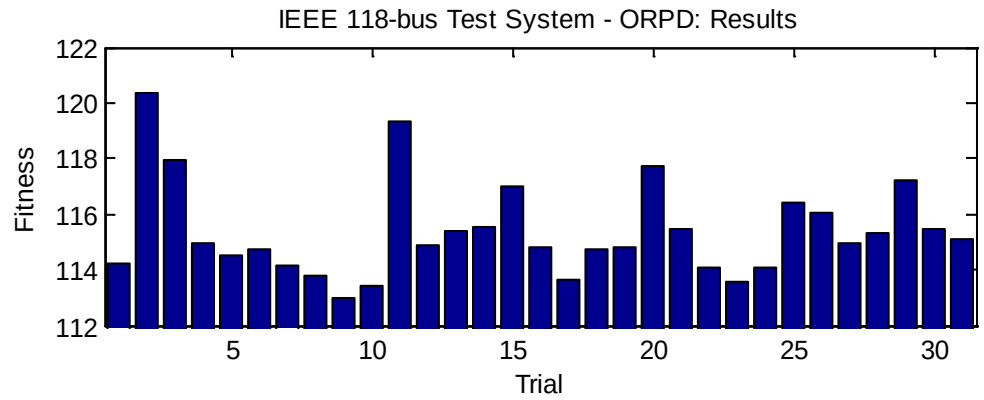
Local Improvement

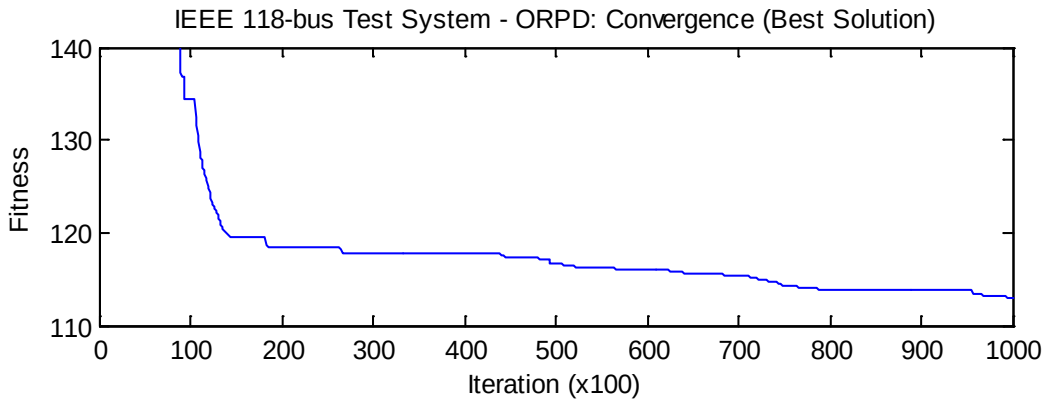
- If there are no improvements in one iteration, on the next iteration two variables are chosen to change.
- The limit of variables that can change is four.
- If the solution keeps improving, more iterations are made.

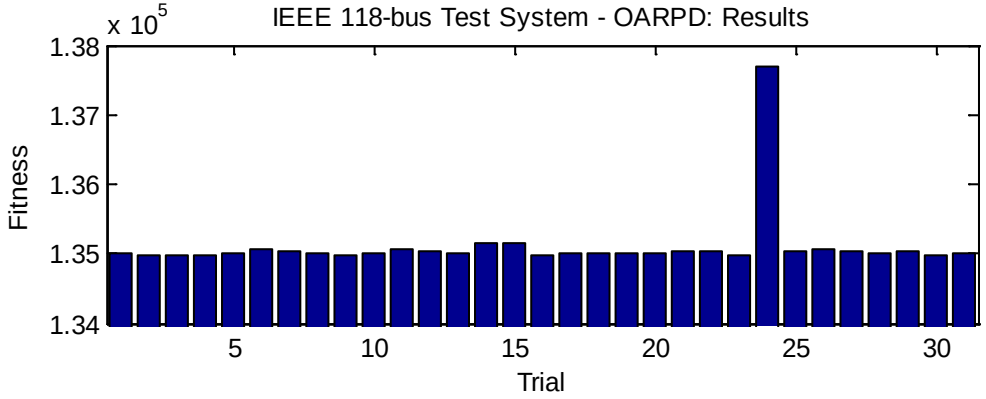
Results

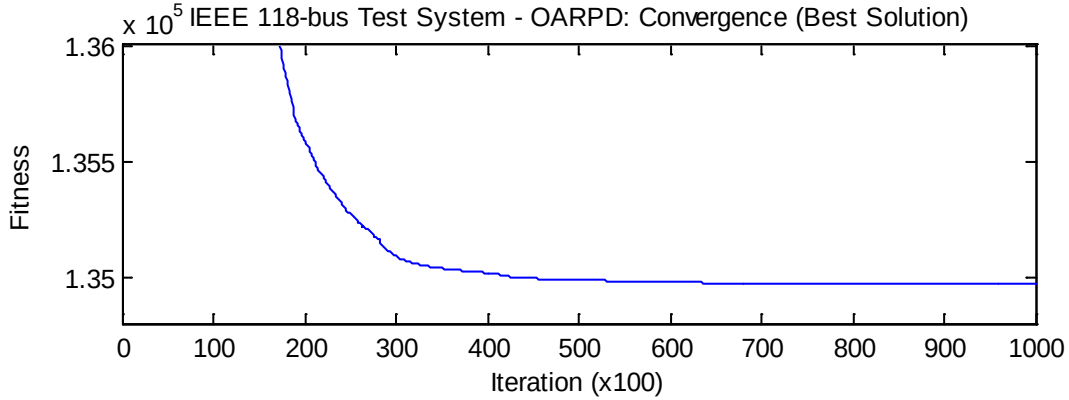
- Offshore WWP
  - ORPD
    - 96 scenarios: most solutions are good and feasible for all of them
- IEEE 57-bus test system
  - ORPD: good solutions for almost all trials
  - OARPD: good solutions for almost all trials
- IEEE 118-bus test system
  - ORPD: good solutions for almost all trials
  - OARPD: good solutions for almost all trials
- IEEE 300-bus test system
  - ORPD: good solutions for almost all trials
  - OARPD: good solutions for only few trials

IEEE 118-bus Test System

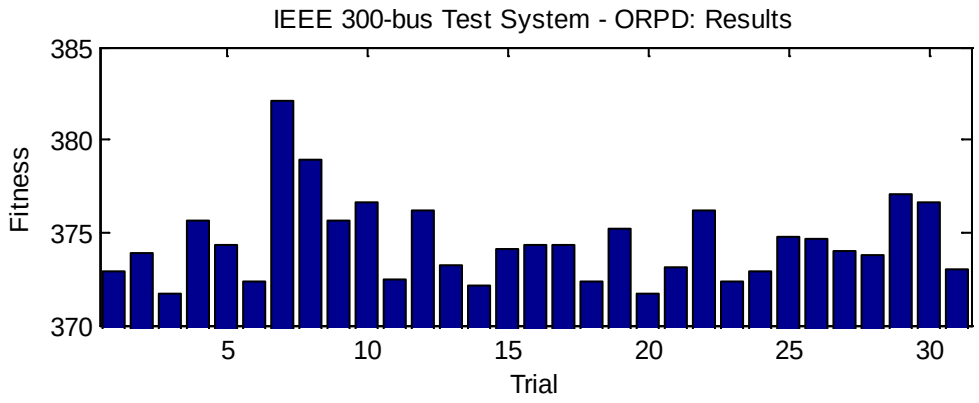


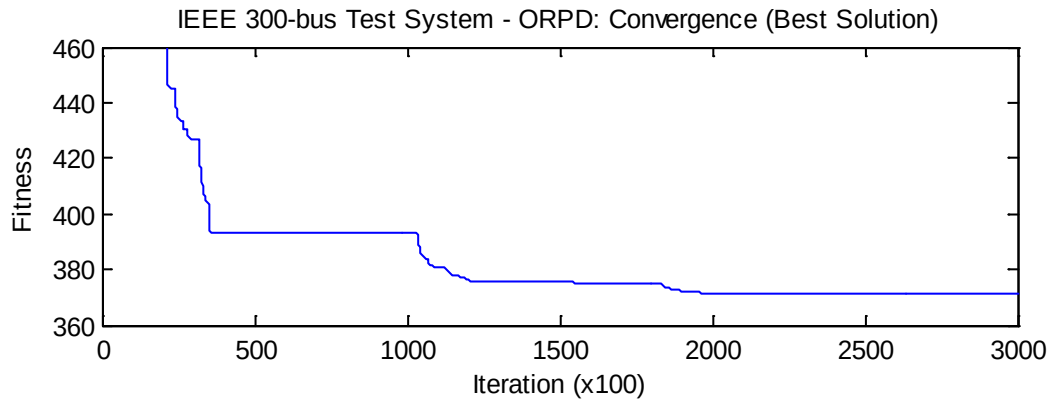


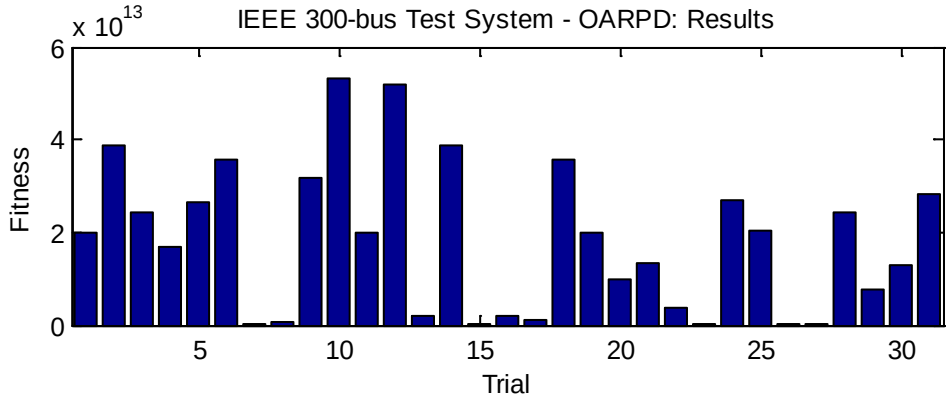


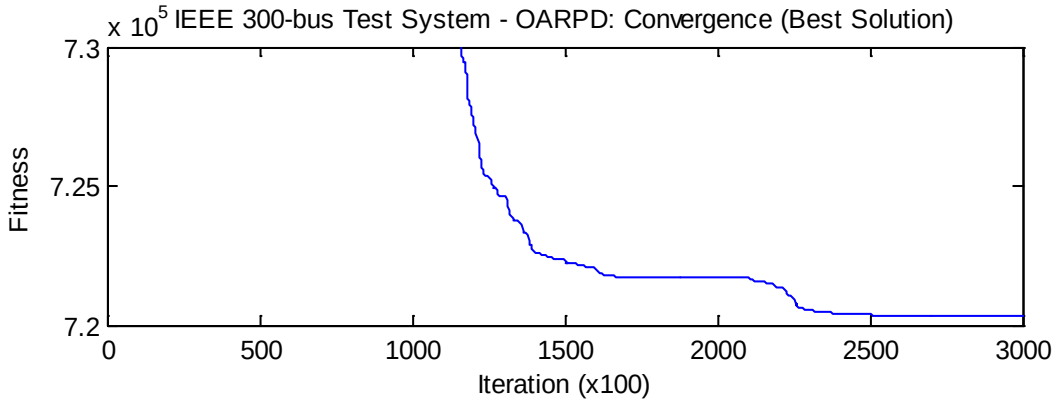


IEEE 300-bus Test System









Conclusions

- The proposed Chu-Beasley genetic algorithm presented good performance and found feasible solutions for all test systems for both reactive and active-reactive OPF problems;

- The local search based on sensitivities was robust to find good quality solutions;

Thank You!