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Optimal placement of distributed generation units in distribution systems via an enhanced multi-objective particle swarm optimization algorithm

Key words: Distributed generation, Multi-objective particle swarm optimization, Optimal placement, Voltage stability index, Power loss

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Motivation

- **Disadvantages of existing methods: 1.** Most methods formulate the problem as a single objective to determine the optimal location(s) or capacity. **2.** The method that converts the multi-objective problem (MOP) to a single-objective fails to provide alternative options. **3.** Performance of multi-objective optimization needs to be further explored.
- **Our method: 1.** A multi-objective optimization model is constructed for optimally placing distributed generation (DG) units considering both economic and technical issues. **2.** An enhanced multi-objective particle swarm optimization algorithm is proposed to solve the MOP with non-linear constraints and objectives. **3.** Both locations and capacities of dispersed DG units are optimized.

Framework of our method (I)

The multi-objective model for optimally placing DG units:

$$\min \begin{cases} f_{\mathrm{P\,loss}} = \sum_{k=1}^{N_{\mathrm{bra}}} G_k (V_i^2 + V_j^2 - 2V_i V_j \cos\theta_{ij}) \\ f_{\mathrm{VSI}} = \max\{\mathrm{VSI}_1, \mathrm{VSI}_2, ..., \mathrm{VSI}_{N_{\mathrm{bra}}}\} \end{cases}$$

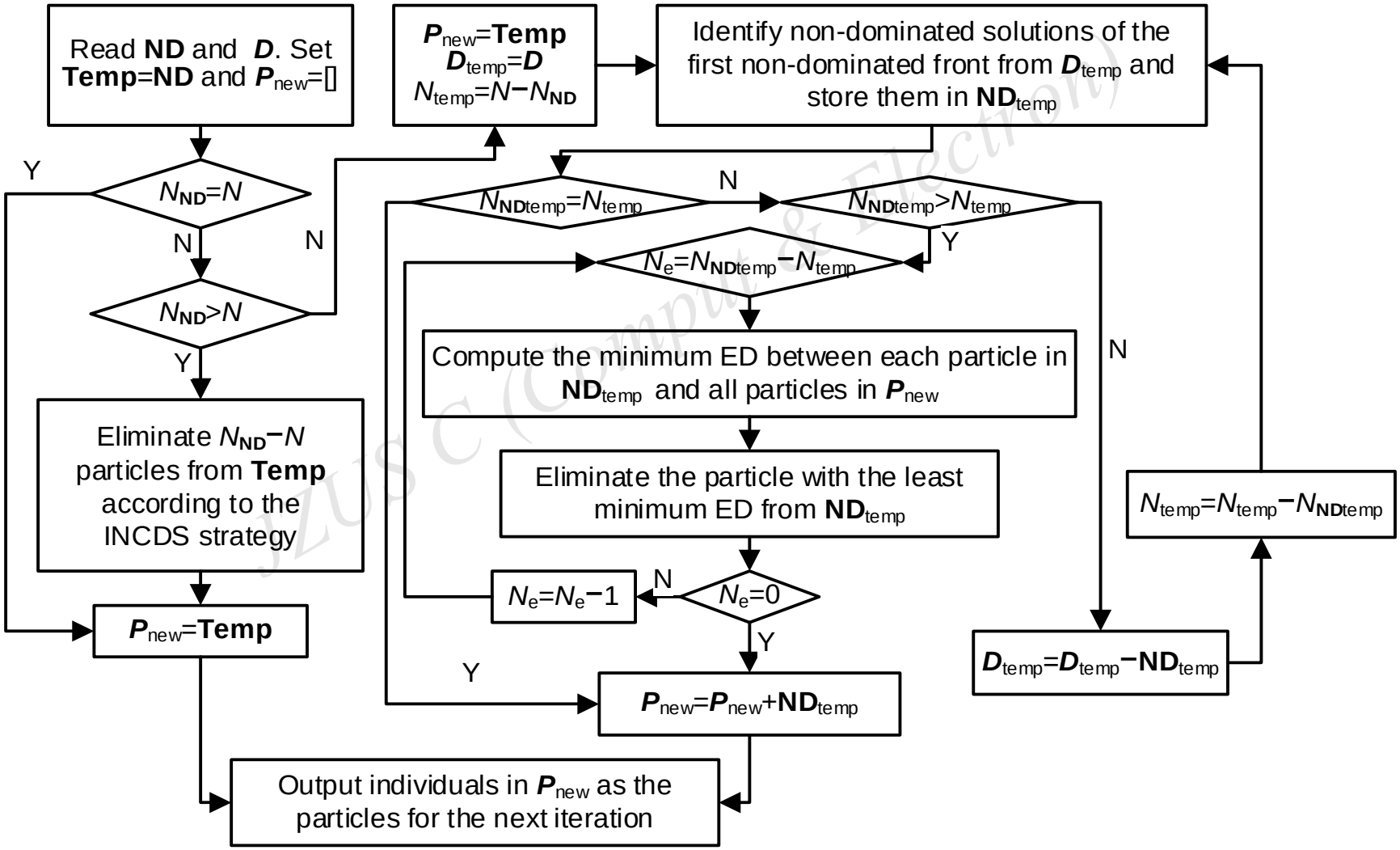
$$\text{s.t.} \begin{cases} P_i + P_{\mathrm{DG}i} - P_{\mathrm{L}i} = V_i \sum_{j=1}^{N\mathrm{bus}} V_j (G_k \cos\theta_{ij} + B_k \sin\theta_{ij}) \\ Q_i - Q_{\mathrm{L}i} = V_i \sum_{j=1}^{N\mathrm{bus}} V_j (G_k \sin\theta_{ij} + B_k \cos\theta_{ij}) \end{cases}$$

$$V_{i\min} \le V_i \le V_{i\max}, \quad S_k \le S_{k\max}$$

$$\sum_{i=2}^{N_{\mathrm{bus}}} P_{\mathrm{DG}i} \Big/ P_{\mathrm{load}} \le \eta, \quad P_{\mathrm{DG}i} \le P_{\mathrm{DG\,max}}$$

Framework of our method (II)

The method for enhancing the diversity of non-dominated solutions:



Summary

- **Motivation:** Design a method to determine the optimal locations and capacity of DG units to be installed in the distribution system.
- **Methodology:** Establish a multi-objective optimization model with various constraints for optimally placing DG units with consideration of both economic and technical attributes, and propose an enhanced multi-objective particle swarm optimization algorithm (EMOPSO) with introduction of specific techniques to solve the complex MOP.
- **Performance:** Numerical simulations revealed the feasibility and effectiveness of the proposed model and the application of EMOPSO.