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Optimal power dispatch within wind farm based on two approaches to wind turbine classification

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ABSTRACT

A priority classification model of wind turbine units has been established using both a self-organizing feature map (SOFM) neural network algorithm and a fuzzy C-means clustering algorithm based on a simulated annealing genetic algorithm. Ten minute average wind turbine power output, wind speed and their root-mean-square deviations (RMSD) are taken as the measured parameters. In this model, which also takes into account line losses of collection system in wind farm, wind turbine units with the highest performance are allocated to a priority group, while others within the wind farm were divided across two further classes (making 3 classes in total), thus achieving power distribution meeting the dispatching need of the grid while decreasing the power loss of the wind farm. The two approaches to clustering are compared. The results of the simulation show that the fatigue damage resulting from application of the fuzzy C-means clustering algorithm based on the simulated annealing genetic algorithm (SAGA-FCM) is reduced relative to the results from the SOFM, the number of turbine units stop is more relative to the number from the SOFM, which proves that this approach to the classification of wind turbine units before optimization and dispatching is superior and is beneficial to the operation of wind turbine units and to the improvement of the power quality.

1. Introduction

Wind power is renewable energy, at present wind power has the most mature of development technology and the lowest cost of development, which is received extensive attention from many countries. Because wind power is a kind of intermittent energy and the wind power output is random, the stochastic volatility of wind power constitutes a challenge to operation and security of traditional power system [1], which presents in power quality and system stability, power generation and dispatching plan, and many others aspects [2]. Increasing spinning reserve capacity and limiting wind power output can alleviate the problem in a certain extent, but it adds the cost of power system and wind farm operation, wastes the clean energy, dispels the wind power owner's enthusiasm, and it is adverse to the benign development of wind power in the future. Optimized dispatching in wind farm can not only improve the given level of wind power, but also improve the market competitiveness of wind power, promote the scientific development of wind power.

For wind widely participate in the grid, some scholars put forward some solutions on the dispatching problem of wind power system within wind farm. According to the wind power prediction data, Carlos F. Moyano [3] put forward the solution on units dispatching and allocation of active power, reactive power in small wind farm. Liu J.Z [4] analyzed the data of all units in the wind farm, according to the different clusters characteristics, the units were divided into regular units and dispatching units, defined wind turbine relative wear index, established an optimized target function, used genetic algorithm to multi-objective optimization dispatching planning in wind farm, got in optimization dispatching strategy in wind farm. Liu Wei [5] studied the wind turbine power output control, which was based on the power allocation mathematical model of optimal power flow in wind farm; realized the optimal distribution of wind power. R.G. de Almeida [6] researched the wind power based on each unit short-term wind power, put the wind power into the wind turbine control system, and controlled

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the output of wind farm to meet the requirements of grid dispatching. But the above literature about the units losses were not specific quantitative, and did not study the reasonable of units classification, output optimization within the wind farm must solve the problems.

Optimized dispatching of turbine units within a wind farm with full consideration of the limitations of power prediction and system load should be able to minimize unnecessary turbine operation, reduce ware and fatigue damage and thus lower the operating costs. In addition generation power quality can be improved and the impacts of the stochastic volatility of wind power on the grid diminished, so improving power system economics and operational security [3,6].

Medium or large scale wind farms, with their large number of turbine units, extensive coverage, distance between units, complex landforms and varying surface roughness, in addition to varying wake impacts, exhibit considerable differences in the power output, and dynamic characterizes, of individual turbines [4].

During the process of optimal scheduling of individual wind turbines within a wind farm, a high dimensional objective function is involved so that the direct application of an optimization algorithm may result in long delays that would make real time application infeasible, [7]. To accelerate the process with the proposed approach, wind turbine units within a wind farm are firstly classified into a limited number of groups by using a clustering algorithm based on historical operational data, so as to give dispatching priority to turbines of higher mean power and smaller fluctuations in power. Secondly, using the results of the classification an optimization algorithm is applied to allocate loads to the individual turbines to minimize fatigue damage and to achieve

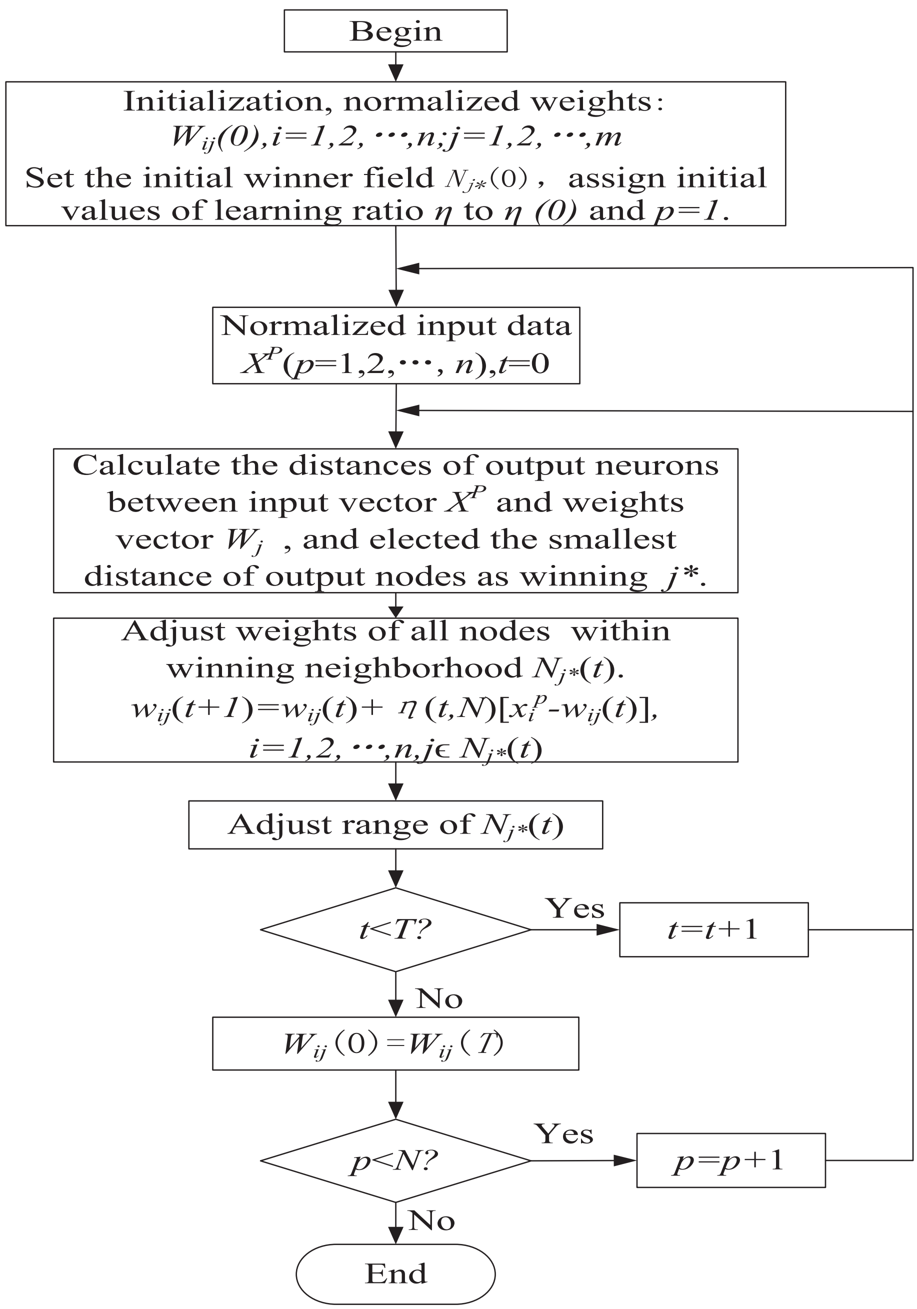

Fig. 1. The flow chart of SOFM neural network algorithm.

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