Distribution Network Optimization Planning Based on Genetic Algorithms

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Abstract. Nowadays, with the development of the times, many times we will use new technology to facilitate our lives, and as a closely related part of our lives - electricity, let alone, it can be said that the pillar of modern society is electricity, if there is no electricity we will collectively return to the original society. However, with the development of the times and the increase of electricity scale, the load of power supply system is getting bigger and bigger, but there is a lot of electricity wasted, so the purpose of this paper is to use genetic algorithms to optimize the distribution network planning. This paper explores how to reasonably optimize the plan by retrieving relevant literature at home and abroad and consulting relevant examples, and then analyzes the experimental data by obtaining some data to simulate the real situation by using sandbox simulation and genetic algorithm modeling. Experimental data show that the distribution network optimization planning scheme designed by genetic algorithm will reduce the original loss by 40%.

Keywords: Genetic Algorithms; Power Distribution Networks; Optimization Planning; Mathematical Modeling.

1. Introduction.
In this era of rapid development, due to the unreasonable power allocation of power grid, although China's total power generation is very large, but due to the large loss, so that the state is still vigorously developing the power grid, sometimes supply exceeds demand. Therefore, in order to solve this problem, this paper proposes the optimization planning of distribution network based on genetic algorithm, in order to save resources, reduce unnecessary loss to control, so as to optimize the efficiency and increase the output effect under the condition of the total amount unchanged. Although the distribution mode of high and low peak load has been implemented in some places, the actual results are not satisfactory, so the optimization planning is still a big problem at this stage. However, it is unreasonable for this situation to continue, because the city is still developing and the power consumption is still increasing. Therefore, we need to make an optimization plan so that we can save resources with maximum efficiency. So the purpose of this paper is to use genetic algorithm to optimize the configuration of power grid.

Most of the scheduled maintenance downtime for large and important users are customized or determined by the equipment owner, and the voltage level is high [1]. The load transfer plan will be
developed in advance to ensure that such UPS is provided to customers [2]. Compared with the power grid company, the power users have less dimensions in the evaluation of a power outage, and their main feelings are not the reasons for the outage, the scope of the outage, and the load loss, but the outage arrangements related to the outage duration, peak outage and frequent blackouts [3-4]. Reactive power optimization of distribution network is an important measure to improve the economic operation level and security stability of distribution network [5]. However, its optimization model is a very complex mathematical programming model, which has the characteristics of nonlinearity, many constraints, and many variables to solve [6]. However, in recent years, the distributed generation with random output has been developed rapidly. The grid connected situation of distributed generation in the distribution network is increasing, and there is a general imbalance between three phases in the distribution network, which makes it more difficult to optimize the reactive power of the distribution network [7-8].

Therefore, it is necessary to study the reactive power optimization of three-phase unbalanced distribution network after distributed generation access [9]. The results show that the method proposed in this paper can make reasonable and correct scheduling of distributed energy storage in the distribution network, and reduce the load fluctuation and voltage deviation of the distribution network [10].

### 2. Genetic Algorithms.

Genetic algorithms generate new solutions to target problems by simulating processes such as cross-mutation of biological genes until optimal solutions are found. The main requirements of traditional genetic algorithms are shown below.

#### 2.1. Population Initialization

The production of the initial population is the pre-preparation of the genetic algorithm. The initial population produces many solutions, depending on the size of the population. The size and quality of the initial population will have a great impact on the search space and search speed of the genetic algorithm. Traditional genetic algorithms mainly use random strategies to generate populations to complete initialization, but the uncertainty brought about by random algorithms will have a great impact on the search for optimal space for genetic algorithms.

#### 2.2. Select the Optimal Child

Genetic algorithms simulate the rules of the survival of the fittest in nature. For the current population that exists. The algorithm divides large populations into N sub-populations. In each subseed, subgenres with high adaptability are selected for retention, and children with low adaptability are eliminated. To ensure the quality of the population.

#### 2.3. Cross and Variation

Crossover and variation algorithms are part of the population of genetic algorithms. Cross-calculaters bring new gene combinations to genetic algorithms and expand the search range. Cross and mutate operations with a certain probability. Where the cross probability of individual c  \( p_c = \frac{f_c}{\sum_{k=1}^{N} f_k} \)

is , which \( f_c \) represents the adaptation value of individual c, and so is \( p_m \) the value.

The 2.2 and 2.3 processes are then repeated until the algorithm converges.

Although the genetic algorithm has a faster speed of seeking excellence in solving the problem of smaller scale in the city, the defects such as precocious and slow convergence become more and more obvious in the problem of TSP in the large city point set, which affect the performance of the algorithm. Among them, the main factors affecting the genetic algorithm are the probability of cross-mutation and the initialization of population.

#### 2.4. Pointer Network
Pointer network is a neural network proposed by Vinyals et al. that can learn the probability of output sequence conditions from discrete input sequences, and it is a variant of the sequence to sequence (seq2seq) network model, which can be effectively used to learn the combination optimization problem of low and medium dimensions, and can predict the solution of the problem with high accuracy. The principle of a pointer network is to map inputs to a series of pointers to input sequence elements by probability, and xn and yn represent input network data.

The pointer network is modified on the basis of the original seq2seq model, not by weighting all the results, but by directly using the result value as the conditional probability of the output, which can be expressed as: 

\[ u_j = v^T \tanh(W_1 e_j + W_2 d_j), \quad j \in (1, 2, \ldots, n) \]

\[ p(C_t | C_1, C_2, \ldots, C_{t-1}, p; \theta) = \text{softmax}(u_j) \]

where \( v \) and \( d \) are parameters that the model can train, the vector is a pointer to the input \( W_1 W_2 u_j \) element, and the distribution of \( j \) into the input sequence in the output element softmax represents the conditional probability that the input element is selected as the output element. 

\[ U_j \in \{C_1, C_2, \ldots, C_{t-1}, p; \theta\} \]

2.5. Near-Domain Search Strategy

Near-field search, also known as nearest initialization, is a kind of greedy initialization. NN starts from a random city and each time selects the city closest to the current city from the remaining city as the next city, repeating the process until all the cities within the range have been completed. The available formulas are:

\[ T_t = T_{t-1} + \min \left( D_{c_c r} \right) \]

Where is \( T_t \) the current path length, which represents the distance between the current city and the remaining city collection \( D_{c_c r} \)

3. Experiment.

3.1. Select an Urban Area in A Central China Area as the Subject of the Survey

Due to distance, we chose the city to investigate it. First, we asked the city's power grid workers to conduct a general survey of grid configuration. From the staff we got sample data and configuration processing for each zone grid over the years, and so on. Then we went to make a questionnaire to ask nearby residents about the configuration of the power grid and their feelings. Then we start analyzing the data from the grid.

3.2. Test Sets and Datasets

Prior to this experiment, it was important to use data sets for test algorithms, and different algorithms needed different data sets to support them, so that better classification accuracy could be obtained. In order to get more effective data, the download data should be pre-processed first, and the suitable data pre-processing method can greatly improve the accuracy of the experiment. So the data subject of this experiment is the calendar year data of the urban power grid.

3.3. Selection of Experimental Data

Before this grid modeling experiment, using data sets for test algorithms was a very important part, and different algorithms needed different data sets to support them, so that better classification
accuracy could be obtained. Therefore, the data source used in the experiment of this paper is the multi-group data of the power grid in each district of the city. In order to obtain more efficient data, the download data is pre-processed first, and the suitable data pre-processing method can greatly improve the accuracy of data mining.

4. Evaluation Results.

4.1. The Impact of Multiple Algorithms on Grid Configuration Optimization Planning

Table 1. Grid Zone 1 predicts classification results

| Grid Zone 1. | Euclid. | Cosine classification | Genetic algorithms. |
|--------------|--------|-----------------------|---------------------|
| The accuracy of the training dataset. | 71.22% | 84.31% | 98.12% |
| Check accuracy. | 81.21% | 96.27% | 99.32% |
| Standard error. | 0.1631 | 0.0122 | 0.0012 |

Table 2. Grid Zone 2 predicts classification results

| Grid Zone 2. | Euclid. | Cosine classification | Genetic algorithms. |
|--------------|--------|-----------------------|---------------------|
| The accuracy of the training dataset. | 72.11% | 85.11% | 98.42 |
| Check accuracy. | 82.17% | 98.21% | 99.51% |
| Standard error. | 0.1693 | 0.1025 | 0.0461 |

From the data described in Table 1, Table 2, it can be known that, through the analysis of the power grid zone group 1 and 2 forecast results, according to all the above data, after different data pre-processing operation, Euclid's algorithm accuracy is the lowest, in the application of LIBSVM data SMOTE processing, while the calculation of optimal parameters results are more satisfactory but unstable, and genetic algorithm in the prediction of grid ration has been better prediction accuracy and more stable.

At present, the relatively novel genetic algorithm is a kind of method commonly used in modern times, which is similar to the judgment described in the classical iterative algorithm. In classification problems, because variables are generally classification variables, to solve the classification problem does not meet this condition, you need to discrete continuous variables into the form of classification variables. In general, the classification analysis can directly solve the common classification problem, but if the argument contains more classification variables, then the judgment analysis is no longer applicable, we can try some methods in the genetic algorithm to solve this classification problem.
According to the data of the inflection point graph of the prediction accuracy of the genetic algorithm in Figure 1, in the early stage of the current algorithm construction, the algorithm is not stable in the prediction of power grid ration, but according to the above seven experiments, we compare the prediction results of each experiment with the actual results, in order to be able to improve the prediction model to the current grid ration efficiency, improve the accuracy of the prediction data, make it more accurate.

4.2. Distribution Network Power Rations
Distribution network is generally closed-loop design, open-loop operation, its structure is radiation-like. The closed-loop structure is adopted to improve the flexibility of operation and power supply reliability, and the open-loop operation is to limit the short-circuit fault current on the one hand, to prevent the circuit breaker from exploding beyond the obstructed capacity, and on the other hand to control the fault spread and avoid the expansion of the fault power failure range.

Distribution network planning refers to the analysis and study of future load growth and urban distribution network status quo, based on the design of a system expansion and transformation plan. In order to meet the future user capacity and power quality as far as possible, the possible various wiring forms, different lines and different wire cross-sections, to run economy as an indicator, choose the best or sub-optimal scheme as a planning and transformation program, so that the power company and its relevant departments get the best benefit of the process. The main contents of distribution network planning are as follows: load prediction, substation optimization, distribution network frame optimization, distribution network trend calculation, reliability analysis in normal and fault conditions, etc.

The basic functions of power distribution automation can be divided into operational automation functions and management automation functions. Data collection and monitoring, automatic isolation of faults and restoration of power supply, high-voltage and reactive management, load management, automatic reading of tables, etc., called distribution network operation automation functions;

According to the relevant provisions of the State Grid Corporation 95598 Complaint Classification Rules, three or more power outages in two months are considered frequent power outages; On this basis, the threshold can be determined according to the time between power outages, so the indicator is a negative deteriorating indicator.

For the "Twin Peaks" and "Three Peaks" load characteristics of the Taiwan area, the power outage period is too long will inevitably lead to the blackout period covering the peak period of the blackout, but the decisive factor of the power outage time is the planned work content, and will be due to the weather conditions and maintenance of the quality of construction personnel and changes, so the
optimization of the power outage time needs to take full account of the original planned power outage arrangement constraints. The work content is generally large-scale maintenance work or multiple maintenance work of the power failure easily lead to a long time, according to the specific equipment operating life and equipment health status, take replacement equipment instead of large-scale maintenance to shorten the power outage time.

5. Conclusion.
In short, genetic algorithms are born out of the current mainstream computer technology, is the product of the continuous development of science and technology. Genetic algorithm, as a more commonly used one in today's social development, has developed many branches, bringing many new changes to people's learning, life and work, which can make people better adapt to and enjoy life and work. But we can't stop there, although the algorithm has made a little achievement, but in the future we will look for better algorithms or ways to solve the problem that can not be completely solved yet, in order to improve the distribution efficiency of the distribution network. Therefore, we believe that with the development of the times, new algorithms and technologies are proposed and applied, we will certainly improve this.

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