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A Survey on Optimize Scheduling of Generation using Unit Commitment Method (UCM) and ANN

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Abstract: With continuous growing fuel cost and depreciation in fossil fuel-based reserves, it is of great concern and demands usage of it with utmost care. The first step is by utilizing this reserve carefully so as they may last long and thus may optimize their usage. This problem needs a good tool to solve it efficiently and providing a reliable result. One of such method which has extreme power to solve this problem by having a minimum cost generation along with fulfilling equilibrium between generation and demand is unit commitment. Different constraints ranging from reserve capacity to fuel cost to transmission cost and other factors are required to take in consideration. To solve this problem by meeting all these constraints an efficient solution tool is expected one which can optimize generators operation while having a logical approach to solve it. This paper presents a comprehensive survey on the unit commitment based techniques for design of optimized scheduling.

Keywords: Optimized Scheduling, Unit Commitment Method (UCM), Artificial Neural Networks (ANN)

Introduction:

Unit commitment problem is basically scheduling generators of any interconnected regulated/unregulated power system to minimize cost of generation while fulfilling load demand. This problems solution is an hourly based plant of next couple of days ahead about how different generators should be operated and generators should supply what amount of power. Unit commitment problem differs from the ELD by the fact that it does not care about which load is to be supplied by which generator. Unit commitment is no new problem. It has been there from years. Initially it had been solved manually on the basis of priority of generator. Even today in some cases it is preferred. Unit commitment problem is solved by system operators in real time. System operators in every power system has the duty to finetune the supply demand in real time operation. Any difference in supply demand may have direct impact on all peripherals of power system including generators and load. Also, due presence of many constraints of power system solving unit commitment problem is a very complex problem to solve hence require efficient tool to solve. Fuzzy logic is one of such tools which will prove to be very superior in solving such complex problems. Fuzzy logic tool box is used with different constraints like generating limits, power balance constraints, minimum uptime, minimum down time and spinning reserve are used to form required rules and membership functions to solve unit commitment problem.

Previous Work:

Operating schedule of generators of any power system has been done using many different methods by taking different parameters for optimizing the solution. In this section we will discuss the literature review of works done in part by various authors. The contribution of all of them is recognized here and present work is further done based on their past research experiments.

Farhad Bavafa et al. in [1] have discussed that to increase the penetration of renewables in power system specially of wind power an affective model of unit commitment will go very handy. However, while forming unit commitment for wind station the risk of unit outrage is always there and hence needed attention towards it also.

Harun Rashid Howlader et al. in [2] has presented a unit commitment method for smart grid operation which consists of battery energy storage system and thermal/renewable generator. The objective of authors work is to minimize cost of generation by reducing battery storage systems capacity buy optimal unit commitment of thermal system. According to author in this regulated power system for every company to maximize profit while suppling quality power to all consumers with fulfilling transmission system constraints is effectively tackled by unit commitment method.

Mostafa Nick et al. in [3] proposes a climbable and additionally effective method aimed at mixing the DLR in SCUC problem. The work understands the case of the SCUC with AC load flow constraints. The AC-optimal power flow (AC-OPF) is combined into the problem. A decomposition process relying on the Benders decomposition is worked in order to eliminate the problem and mix a set of exigencies representing both generators and line outages.

Jingrui Zhang et al. in [4] has propounded that majority shareholder of power generation both globally and local market are thermal and hydro. Hence an optimization of two sources will aim to reduce generation cost along with fulfilling spinning reserve capacity while considering all system constraints. Author has utilized particle swarm optimization to solve given problem. Results are obtained for binary value and crisp values both, and they are further compared.

Anupam Trivedi et al. in [5] has utilized Evolutionary algorithm for solving UC problem. The reason author wants to perform optimization in this work is to minimize cost of generation along with minimizing carbon emission from thermal power plant. According to author in this regulated power system for every company to maximize profit while suppling quality power to all consumers with fulfilling transmission system constraints is effectively tackled by unit commitment method.

Xiaohui Yuan et al. in [6] majority shareholder of power generation both globally and local market are thermal and hydro. Hence an optimization of two sources will aim to reduce generation cost along with fulfilling spinning reserve capacity while considering all system constraints. Author has utilized particle swarm optimization to solve given problem. Results are obtained for binary value and crisp values both, and they are further compared.

Ray-Hua Horng et al. in [7] proposed a method which is utilized in this work is using fuzzy logic-based algorithm to unit commitment problem. The result of this algorithm is compared with the dynamic programing approach. On comparing the results on studying the output results of two techniques it has been concluded that fuzzy is superior than the later technique.

Vamsi Krishna Tumuluru et al. in [8] proposed a thermal unit commitment for a day ahead hourly time for helping system operator to take decision regarding selling and buying power from market for forecasted next day load demand. According to author Unit commitment problem is basically scheduling generators of any interconnected regulated/unregulated power system to minimize

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cost of generation while fulfilling load demand.

Bin Ji et al. in [9] have discussed that supply to all load demands at all time is by connecting all generators at their peak to all loads through bus. The method is highly inaccurate since during off peal hours many of the generators will operate regardless of no requirement. Hence a planning has to be done to supply power to load at all time while maintaining quality of supply.

Dimitris Bertsimas et al. in [10] proposed that the AFLC value of each generator is calculated separately and the one with least value will be most economical and hence will be switched OFF at the last and the one with highest value will be least economical and hence will be switched of at first. The planning is for each step of load variation ranging from the maximum value to the minimum value of peak load. For each step a combination is formed of generators to operate to fulfill that demand and be economical.

Basics of Neural Networks

Artificial Neural Networks (ANN) are computing systems or technique that are inspired by the learning architecture of human brain to discover the relations between the input and target variables of a system. Human brain consists of a large set of structural constituents, known as neurons, which form a well-connected network to respond to an input signal to perform all its computations / calculations in a certain complex task such as image and voice recognition task and they do this with incredible speed and accuracy. Neurons are simple processing units, which has the ability to store experimental data and which work as parallelly distributed processor. A network of connected artificial neurons can be designed, and a learning algorithm can be applied to train it. Signals (Input data) are passed between neurons over connection links and Each connection link has an associated weight, which in a neural network, multiplies the signal transmitted. The weights represent information being used by the network to solve a problem. Then the weighted sum is operated upon by an activation function (usually nonlinear), and output data are conveyed to other neurons. The weights are continuously altered while training to improve accuracy and generalize abilities.

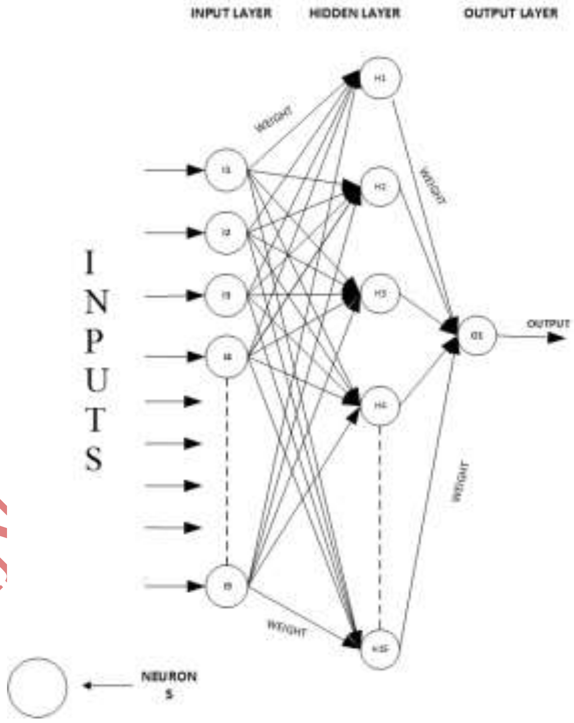

Fig.1 Architecture of ANN

Introduction to UCM

The unit committment method means the real and reactive power of the generator vary within the certain limits and fulfils the load demand with less fuel cost. The sizes of the electric power system are increasing rapidly to meet the energy requirement. So, the number of power plants is connected in parallel to supply the system load by an interconnection of the power system. In the grid system, it becomes necessary to operate the plant units more economically.

The economic scheduling of the generators aims to guarantee at all time the optimum combination of the generator connected to the system to supply the load demand.

Mathematical Modelling of UCM Technique

Consider n generators in the same plant or close enough electrically so that the line losses may be neglected. Let C_1, C_2, …, C_n be the operating costs of individual units for the corresponding power outputs P_1, P_2,.,P_n respectively. If C is the total operating cost of the entire system and P_R is the total power received by the plant bus and transferred to the load, then:

$$C = C_1 + C_2 + \dots\dots + C_n = \sum_{i=1}^{n} C_i \dots\dots\dots equ(1)$$

$$P_R = P_1 + P_2 + \dots\dots P_n = \sum_{i=1}^{n} P_i$$

The equation (1) and equation (2) can be minimized as

$$C = \sum_{i=1}^{n} C_i$$

$$P_R - \sum_{i=1}^{n} P_i = 0$$

The above equation shows that if transmission losses are neglected, the total demand P_R at any instant must be met by the total generation. The above equation is the equality constraint.

This a constrained minimizing problem. This problem can be solved by Using Lagrangian multiplier technique.

$$C^* = C + \lambda f \dots\dots\dots equ(3)$$

where f is the equality constraint equation given by

$$P_R = \sum_{i=1}^{n} P_i = f(P_1, P_2 \dots\dots P_n) = 0 \dots\dots equ(4)$$

And λ is the Lagrange multiplier. Combination of equations (3) and (4) gives

$$C^* = C + \lambda\left(P_R - \sum_{i=1}^{n} P_i\right) \dots\dots equ(5)$$

Equation (5) can be solved for minimum by determining the partial derivate of the function C* on variable Pi and equating it equal to zero.

$$\frac{\partial C^*}{\partial P_i} = \frac{\partial C}{\partial P_i} + \lambda \frac{\partial}{\partial P_i}\left(P_R - \sum_{i=1}^{n} P_i\right) = 0 \dots\dots\dots equ(6)$$

$$\frac{\partial C^*}{\partial P_i} = \frac{\partial C}{\partial P_i} + \lambda(1 - 0) = 0$$

$$\frac{\partial C}{\partial P_i} = \lambda \dots\dots equ(7)$$

Since C_i is a function of P_i only. The partial derivates become full derivates, that is,

$$\frac{\partial C_i}{\partial P_i} = \frac{dC_i}{dP_i}$$

Therefore, the condition for optimum operation is

$$\frac{dC_1}{dP_1} = \frac{dC_2}{dP_2} = \dots\dots = \frac{dC_n}{dP_n} = \lambda$$

Since the dc_i / dp_i is the increment cost generation for the generator. The above equation shows that the criterion for a most economical division of load between within a plant is that all the unit is must operate at the same incremental fuel cost. This is known as the principle of equal λ criterion or the equal incremental cost-loading principle for economic operation.

When the energy is transported over relatively larger distances with low load density, the transmission losses in some cases may amount to about 20–30% of the total load. Hence, it becomes very essential to take these losses into account when formulating an economic dispatch problem.

Consider the objective function:

i.e., $C = \sum_{i=1}^{n} C_i(P_{G_i})$

Minimize the above function subject to the equality and inequality constraints.

Equality constraints: The real-power balance equation, i.e., total real-power generations minus the total losses should be equal to real-power demand:

i.e., $\sum_{i=1}^{n} P_{G_i} - P_L = P_D$

Inequality constraints:The inequality constraints are represented as:

1. In terms of real-power generation as

$P_{Gi\,(min)} \leq P_{Gi} \leq P_{Gi(max)}$

1. In terms of reactive-power generation as

$Q_{Gi\,(min)} \leq Q_{Gi} \leq Q_{Gi(max)}$

1. In addition, the voltage at each of the stations should be maintained within certain limits.

i.e., $V_{i(min)} \leq V_i \leq V_{i(max)}$

Current distribution factor of a transmission line w.r.t a power source is the ratio of the current it would carry to the current that the source would carry when all other sources are rendered inactive i.e., the sources that do not supply any current.

If the system has 'n' number of stations, supplying the total load through transmission lines, the transmission line loss is given by

$$P_L = \sum_{p=1}^{n}\sum_{q=1}^{n} P_{G_p} B_{pq} P_{G_q}$$

The coefficients B_{11}, B_{12} and B_{22} are called loss coefficients or B-coefficients and are expressed in $(MW)^{-1}$. The transmission loss is expressed as a function of real-power generations.

The incremental transmission loss is expressed as $\frac{\partial P_L}{\partial P_{G_i}}$

The penalty factor of any unit is defined as the ratio of a small change in power at that unit to the small change in received power when only that unit supplies this small change in received power and is expressed as

$$L_i = \frac{1}{1 - \frac{\partial P_L}{\partial P_{G_i}}}$$

The condition for optimality when transmission losses are considered is

$$\frac{\partial C_1}{\partial P_{G_1}} L_1 = \frac{\partial C_2}{\partial P_{G_2}} L_2 = \cdots = \frac{\partial C_n}{\partial P_{G_n}} L_n = \lambda$$

Conclusion:

In this paper, we have discussed the unit committment method for any interconnected power system using different techniques. The literature review has been discussed in detail and past work on optimizing unit commitment from different author has been discussed in detail in second chapter. Further the problem solution is discussed in chapter four and it is estimated based on literature review to outperform previous techniques.

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