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A Review on Electrical Power System Contingency Ranking Using Artificial Intelligence Techniques

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Abstract: *Contingency analysis is an important aspect of power system security assessment. Various probable outages is analyzed .Some cases may lead to transmission overload or bus limit violation. Such critical contingencies should be quickly identified for further detailed evaluation and for corrective measures. This process of identifying the critical contingencies is referred to as contingency selection. Conventional methods of contingency analysis are complete bounding methods; concentric relaxation methods [P]-Q method Zero miss match methods and Expert systems. Artificial intelligence techniques like Fuzzy Logic, Artificial neural network, Genetic algorithms, Particle swarm optimization techniques are used to do contingency analysis. In this paper bibliography of all the artificial intelligence techniques used for contingency analysis is listed. In addition to that data mining techniques used in the contingency analysis is also listed.*

Key words: *Contingency Analysis, Neural Network, Genetic Algorithms, Particle swarm Optimization, Data mining*

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I. Introduction

Electricity is the indispensable form of energy in modern societies; its demand has been increasing year by year. The optimum supply and utilization of this form of energy can be ensured by an effective power system. The effectiveness with which the power system fulfills this function is measured in terms of voltage regulation, service continuity, flexibility, efficiency and cost. The economic importance of the power system is very high, and the amount of investment involved dictates careful planning, design, construction and operation. The planning, design and operation of power systems require continuous and comprehensive analysis in order to evaluate the system performance to determine the effectiveness of alternative plans for system expansion. The main objective of an electric power system is to supply high quality energy where the interruption and interruption duration are minimized. Steady state security analysis is therefore one of the most important task of the power system planning and operation studies. As a frame work of security, it is important to investigate the influence of potential component failures on the overall behavior of the power system. The process of investigating whether the system is secure or not in a set of proposed contingencies is called contingency analysis or the effect of the line outage when the rest of the system is stable is called contingency study. The study of contingency is an essential activity in planning operation and control of power systems. The outage or change in the independent parameters of the power systems gives rises to transient phenomena in the electrical and electromechanical states of those power systems. Large power systems require the analysis of all the credible contingence within a very short time so as to exercise the control in the short time available for corrective action. Contingency analysis behaves like a fictions test performed on a list of postulated contingency cases single or multiple equipment outages. Those cases that would create line flow voltage and reactive power violation should be identified and ranked in order of their severity for more detailed study. Usually contingency analysis is divided in to three parts: contingency definition, selection and evaluation. For more than two decades contingency selection has received considerable attention whose aim is to reduce the original long list of contingencies by selecting only those that would result in limit violation. There are two approaches for performing contingency selection ranking methods and screening methods. In screening methods the most severe cases are identified and they are given top priority in the contingency list for more detailed AC analysis, at same time the non-critical cases due removed from the list. These methods depend basically on the local solution methods and bounding methods. Which are the local nature of an outage and the network is divided in to two or three sub networks. The main difficulty of this method is the determination of the first network. Ranking methods use a performance index (PI) as scalar function to describe the effects of an outage on the whole network. Ranking methods can be divided in to two sub groups depending on the way in which the performance index is formulated by direct methods and indirect methods. For line flows or MW ranking direct

methods are used and they give good results. Those methods are many time faster than indirect schemes. However the application of direct scheme for voltage ranking gives reliable results. There have been considerable effects to use the direct methods for voltage ranking, but results obtained are not as accurate as the indirect scheme. The indirect scheme is lower than the direct scheme. The main drawback of this method is masking effect. By masking effect it means that a non-critical contingency care can take the position of a critical one. The second order term is the main cause for the masking effect and it is recommended that a higher exponent index should be used. But the use of high exponent index for all values of the bus voltage magnitude will increase the computational time. In recent years, intelligent system applications have received increasing attentions in various areas of power systems such as operation, planning, control, and management. A number of research papers indicate the applicability of intelligent system to power systems for wider operating conditions and uncertainties. In conventional schemes, power system operation, planning, control, and management are based on strict mathematical models to find solutions; however, power systems have many uncertainties in practice. Namely, those mathematical models provide only for specific situations of the power systems under respective assumptions. With these assumptions, the solutions of power system problems are not trivial. Therefore, there exist some limitations for the mathematical model based schemes. In order to overcome these limitations, applications of artificial intelligent technologies such as fuzzy system, neural networks, and genetic algorithms have been investigated in different areas of power systems for reliable and high quality power supply at low cost. [1-18]

II. Artificial intelligence techniques in contingency analysis:

Artificial intelligence and machine learning techniques provide a qualitative as well as quantitative assessment of the power system.

1. Fuzzy Logic: The Fuzzy logic system (FLS) is a logic system which represents reasons and knowledge in a fuzzy manner for reasoning under uncertainty or describes in imprecise manner for human interpretation. Not like Boolean logic and classic logic which assumes that entire fact is either true or false, but fuzzy logic allows Boolean logic to tackle with vague and imprecise expressions of human understanding. Not like the classic logic systems, it models the reasoning for imprecision model that plays important role in ability of human knowledge to understand an estimated or inexact answer for a question which is based on store of knowledge which is approximate, not complete or totally unreliable. It is the best approach and way to go for fuzzy logic when it is too difficult to encode a mathematical model which may exist or does not exist and when it is very much difficult to do evaluation for real time operation. Knowledge of human experts forms the base of the accuracy of fuzzy logic systems (FIS). The results of post contingent state of line power flows and performance indices are obtained using Newton Raphson or any other load flow method .The membership functions for these post contingent quantities are first recognized and defined and with these formed membership functions, the computation of overall severity index is done to obtain the contingency ranking. For each post contingent quantities which is obtained by the conventional load flow method is known by different linguistic variable and with the membership function associated with it. The inputs to the fuzzy inference system are line loadings, and voltage profiles indices and the outputs to the same FIS are the severity indices, which are computed using the simple set of rules of Fuzzy. The post contingent quantities of line flows and bus voltage must be expressed in fuzzy set rules notation first, and then only it can be further processed for reasoning rules of fuzzy logic. [3, 5, 19-34]

2. Artificial Neural Network: Artificial neural networks have attracted much attention due to their computational speed and robustness. Artificial neural networks have become an alternative to modeling of physical systems. Absence of full information is not as big problem in artificial neural networks as it is in the other methodologies. A major advantage of the artificial neural network approach is that the domain knowledge is distributed in the neurons and information processing is carried out in a parallel distributed manner. Therefore, artificial neural network reaches the desired solution rather efficiently. Since heuristic, expert knowledge, experience, and intuition are essential in distribution system operation and planning; fuzzy logic can be effectively used in power system problems to represent uncertainties by fuzzification of ambiguous variables assigning membership functions based on preferences and / or experience. Thus artificial neural network and fuzzy logic are two powerful tools in AI based techniques. These tools can be used as planning tools in power system. [35- 57]

3. Pattern recognition (PR) approach: Pattern recognition technique can be used to overcome the shortcomings of computer simulation in security evaluation. In pattern recognition, the main bulk of the simulation is done off-line. Using the off-line results, a security function is designed, aiding in quick security evaluation. [58-60]

4. Particle swarm optimization (PSO): is an evolutionary computation technique developed by Dr. Eberhart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling .The system is initialized with a population of random solutions and searches for optima by updating generations. Unlike GA,

PSO has no evolution operators such as crossover and mutation. A particle swarm is a population of individuals each containing the appropriate amount of features to place it in a swarm problem space. The individuals are arranged in neighborhoods in which they can share information. Security systems designed based on pattern recognition approach described now are ideal for on-line implementation. In on-line mode, real time data measurements of selected features are fed to the security function S (z) with weighting coefficients determined by PSO algorithm and hence the static security status is evaluated. This calculation involves only a finite number of multiplications and additions, in order to evaluate value of security function. The use of first order security function further enhances the suitability of security evaluation in on-line mode. Therefore, a very short time is needed for accessing system security status, when implemented in on-line. When there occurs any change in system topology, the security function can be adapted to these changes by simply modifying the weighting coefficients. [61-77]

5. Pattern Analysis and Data Mining: Support vector machine (SVM) is a new and very popular technique for data classification in the machine learning community. SVMs work on the concept of statistical learning theory and structural minimization principle when using SVM for pattern classification, the basic idea is to find the optimal separating hyper plane that gives maximum margin between the positive and negative samples. The aim of SVM for linear classification task is to construct linear decision boundaries that explicitly separate data into different classes .Smart Grid that could efficiently respond to the actual system conditions and provide autonomous control actions to enhance the system reliability The Self-Healing Grid has some specific requirements such as an adaptive control and protection system, adequate measurement equipment, sophisticated communication networks, and appropriate tools to analyze huge volumes of data in real time such as appropriate data mining techniques. A fundamental task of this smart structure is the vulnerability assessment (VA), since it has the function of detecting the necessity of performing global control actions. Most VA methods are based on steady state or dynamic simulations of N-x critical contingencies .The aim of these methods is to determine whether the post-contingency states are within a "safe region", and accordingly, to decide the most effective preventive control actions [78-84]

III. Conclusion

Contingency analysis is a software application run in energy management system to give the operators and indication of what might happen to the power system in the event of an unplanned equipment outage. A list of contingencies is listed and from this the most severe contingency is selected in short duration of time. Sometimes not severe contingencies will be selected as severe ones and it is called as masking effect. Fuzzy logic techniques are system oriented. Artificial neural techniques are general but to train the network it will take time. Hence a combination of fuzzy logic, ANN and Genetic algorithms is used to select the contingency. Particle swam optimized artificial neural networks are found to select contingency in shorter time. Recently data mining techniques are used for contingency analysis and they are much faster. hence data mining techniques can be used in smart grids .

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