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A Review on Power System Transient Stability Assessment Using A Feed-Forward Artificial Neural Network with Increased Feature Selection

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Abstract-This paper outlines a method for predicting the stability of a power system using an artificial neural network. For on-line transient stability assessment of the power system, this efficient and robust method combines the benefits of time–domain integration techniques and artificial neural networks. The extended equal area criterion approach was utilized to calculate the transient stability index, which was then employed as a neural network output. To choose the input variables that are most suitable for training, two feature selection strategies were applied.

Keywords: Data Generation, Transient Stability Index, ANN Design

I. INTRODUCTION

One of the most complicated control systems in existence is the power system. Because expenditures in generation and transmission have not kept pace with the expansion in load demand, the complexities of operating interconnected power networks have grown dramatically. The assessment of security is one of the most difficult difficulties in the real-time operation of power systems. The ability of electric systems to withstand abrupt disruptions such as short circuits or unplanned system element loss is referred to as security.

Static and dynamic security assessments are two types of security analysis that can be used interchangeably. After a disturbance, DSA examines the system's performance. The ability of a power system to withstand a specific set of eventualities and transition to an acceptable steady state condition is termed as dynamic security assessment. DSA requires a thorough examination of power system stability.

Rotor angle stability, frequency stability, and voltage stability are the three types of power system stability. Small signal stability analysis and transient stability analysis are both concerned with rotor angle stability.

On-line transient stability assessment is the focus of the research reported in this publication. Any on-line TSA tool must not only provide a quick stability evaluation but also a measurement of the system's "stability."

Because typical analytical techniques are ineffective for on-line TSA on their own, there has been a lot of interest in using additional methodologies.

II. TRANSIENT STABILITY INDEX

Time–domain methods, direct methods, and automatic learning approaches are the three basic categories of transient stability analysis methods.

The time–domain approaches can handle any power system modeling and stability circumstances, and may provide a complete image of synchronous generator angles and other power system characteristics as a result of a defined contingency, using appropriate differential equation solvers.

These methods, on the other hand, provide no particular information on the system's stability margin and cannot recommend any control actions. In general, the Lyapunov direct criteria are used in the direct techniques.

III. SELECTION OF CRITICAL CONTINGENCIES

Critical contingencies are determined based on the operator's experience for dynamic security evaluation in the power system operating environment. Contingencies closer to the generators (i.e. three-phase fault at a generating station's high voltage bus, and three-phase fault at transmission lines) are deemed essential in this study.

The artificial neural network that will be detailed below is designed to map the pre-fault operating condition to the TSI for a given contingency.

IV. DESIGN OF THE ARTIFICIAL NEURAL NETWORK

The feed-forward form of ANN was used in this research. It has three layers: an input, a concealed layer, and an output layer. The input pattern's size determines the input layer's size. The number of outputs dictates the output layer's size. The hidden neuron size is chosen to provide the system the best test results.

Potential nodes are potential input neurons in a feed-forward circuit. They send information in a weighted format to the neurons in the buried layer. This information is processed nonlinearly by the neurons in the buried layer.

V. DATA GENERATION

Within reasonable bounds, the input data is generated by altering the loading and generation pattern. Simulating the system in response to various disturbances and then collecting a collection of pre-disturbance features together with the corresponding system transient stability index is a typical approach.

Applying a three-phase fault and disconnecting the line attached to the defective bus generates the data for ANN training and testing. It is trained off-line, so the on-line application does not have to deal with the significant computational load.

It's crucial to lower the dimension of the input characteristics once the features have been chosen.

VI. ANN DESIGN AND DATA GENERATION

The data generation contingencies were chosen based on the criteria described in Section 3, and the input features chosen were all of those listed. The ANN produces a transient stability index.

Applying three-phase faults at the end of each line, then clearing the fault by opening one of the lines connecting to the faulted bus, produces the data needed for ANN training and testing.

Two hidden layers and one output unit make up the ANN used here. It is decided to utilize a learning rate of 0.1. After sending each pattern to the ANN, the network is trained by adjusting the ANN weights.

VII. LITERATURE REVIEW

The authors provide an effective method for determining the transient stability of a multi-machine power system. The method finds the key machine for a particular disturbance by examining the change in accelerating power of the seriously affected machines. The critical machine is thought to be the one that has a proclivity for causing instability. The system's transient stability is determined by using a modified equal-area criterion to check the stability limit of only the critical machine.

The authors provide a practical method for determining the transient stability of a multi-machine power system. By observing the variance in accelerating power of the severely disturbed machines, the approach finds the crucial machine for a given disturbance. A critical machine is one that has a proclivity for causing instability. A modified equal-area criterion is used to determine the system's transient stability.

The simultaneous occurrence of zero accelerating power and speed of the crucial machine during the postfault period is used to diagnose the stability limit or critical situation.

The suggested method does not necessitate the computation of an unstable equilibrium point, unlike the earlier equal-area criteria method. Furthermore, the latter strategy dispels some of the assumptions of the former. Three power networks were used to evaluate the suggested method, and the findings were compared to the real values and those previously reported.

VIII. CONCLUSION

An artificial neural network-based method for assessing the online transient stability of power systems is provided in this research.

The suggested methodology is based on an accurate and efficient ANN-based method that enables easy system stability identification. The output of the transient stability index is a reliable signal for on-line transient stability assessment.

For the selection of the ideal collection of neural network training features, two feature selection methods have been suggested and used.

The selected set of features is reduced using principal component analysis. Several operational circumstances were investigated, ranging from unstressed to highly stressed network settings.

The findings of the test emphasize the significance of feature selection. The proposed feature selection approach can be viewed as a practical solution to the high dimensionality problem in neural network design. The findings show that ANN may be used to assess the dynamic security of power systems in real time.

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