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Improvement of Transient Stabilty Using Neuro Fuzzy System

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Abstract: Computational Intelligence combines neural network, fuzzy systems and evolutional computing. Neurofuzzy integrated system utilizes features of both Neural and Fuzzy networks together for better results by which generalization of the unseen data from seen data by forming the fuzzy rules and training. In this project training of the system with training data which usually is 70% of the whole available data, rest 30% data is used for testing. The algorithm used in project is hybrid algorithm. A characteristic inherent to Electric power system is that they operate under the influence of disturbance The analysis required to know whether, the power system will survive the transients and move into stable operation or lead to loss of synchronous operation is subject of primary concern and is referred to as transient stability assessment. Methods of improvement stability try to achieve – Reduction in disturbing influence by minimizing the fault severity and duration. Increase of the restoring synchronizing forces. In Fast Valving it is a technique applicable to thermal units to assist in maintaining power system transient stability. The Application of Artificial neural network to fast valving for transient stability improvement has the input Accelerating power and rotor speed. The output is Fault clearing time. The Neural fuzzy system are stable, efficient, reliable. Here an Adaptive Network based fuzzy system is used. The data with power, speed and fault clearing time is used in order to train network with rule based structure. Then this training data is used to test the output with unseen data and error is obtained then minimization of this error is done in order to obtain an accurate neuro-fuzzy system which can correctly predict the opening and closing of the thermal valve.

Key words: Neurofuzzy System % Transient stability % Artificial neural network % Steady state

INTRODUCTION

During the late 1980s, the number of researchers and engineers interested in neural networks (NNs) and fuzzy logic (FL) increased, dramatically introducing the NN and FL technologies into several application fields. As the two technologies developed at same time, researchers and engineers studied the technologies' similarities and complementarities and began developing a fusion model [1]. Neurofuzzy combines the best features while eliminates the drawbacks of fuzzy logic and neural nets. Neurofuzzy significantly reduces design time, provides more accurate and reliable solution at lower cost [2].

Adaptive Network-Based-Fuzzy Inference System (Anfis): ANFIS are a class of adaptive networks that are which use a hybrid learning algorithm. Given an input-output dataset, the parameters of membership functions in fuzzy variables of antecedents of fuzzy rules are modified using a well-known back-propagation algorithm or hybrid algorithm and least squares estimate [3, 4]. There are two types of fuzzy inference systems: *Mamdani-type* and *Sugeno-type*. Mamdani's fuzzy inference system is the most commonly seen fuzzy methodology. Sugeno or Takagi-Sugeno-Kang, introduced another system of fuzzy inference that is similar to the Mamdani system in many respects [5, 6].

Enhancing Transient Stability Using Neurofuzzy System Working Methodology: A characteristic inherent to electric power system is that they operate under the influence of disturbances. Transient stability is the stability of the power system to maintain synchronism when subjected to a severe transient disturbance such as fault on transmission facilities, loss of generation or loss of large load [7].

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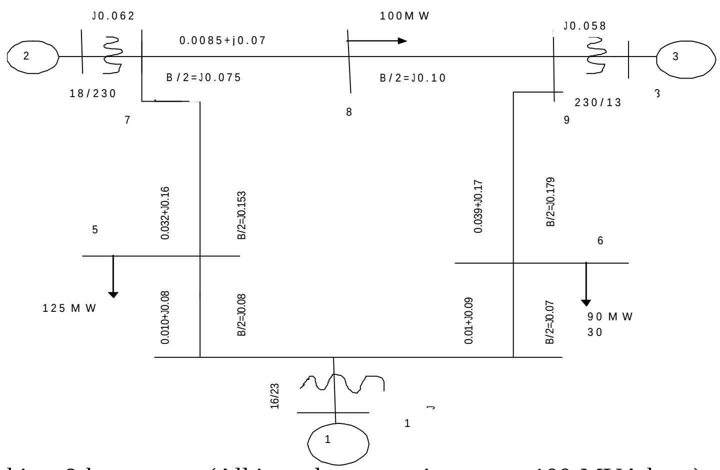

Fig. 2.1: WSCC 3-machine, 9-bus system (All impedances are in pu on a 100-MVA base)

During steady state operation of a power system, there is equilibrium between the mechanical input power of each unit and the sum of losses and electrical power output of that unit. The problem arises when there is a sudden change in the electrical power output due to a severe and sudden disturbance [8]. The severity is measured by drop of this power to a very low or to zero value and a consequential sudden acceleration of the machines govern by the swing equation:

$$\frac{2H}{w}\frac{d^2d}{dt^2} = P_m - P_e = P_a$$

where,

* = Rotor angle, in electrical radian
P_m = Electrical driving power input, in pu,
P_e = Electrical power output, in pu,
H = Inertia constant, in MW-s/MVA,
T = Nominal speed, in electrical radian/sec

A WSCC 3-machine, 9-bus system has been chosen to verify the application of FNN for transient stability enhancement. A three phase fault has been simulated at various buses. The three important input variables chosen for FNN are the value of FCT (fault clearing time) and the accelerating power and rotor speed [9].

A typical 3-generator 9- bus system has been considered for the present study. The line diagram is given in Figure 2.1. Only severe faults are considered presently. Typically the fault locations considered are at points P1, P2 and P3, as indicated in Figure 1. A symmetrical three phase fault on the high tension site of a line transformer is cleared by opening of the corresponding line.

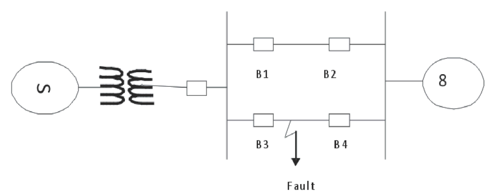

Fig. 2.2: Single machine-infinite bus system

Transient Energy Function Method: The transient energy function method can be considered as a generalization of the conventional equal –area criterion for the first swing stability analysis of machine –infinite bus system. Consider the power system shown. Assume the fault occurs on one of the transmission line. Operating the circuit breakers B3 B4 clears the fault by disconnecting the faulted transmission line.

Single Machine Infinite Bus System: The power angle at the instant if fault clearing is M1. Figure 2.3 illustrates the use of the equal area criterion method, first swing stability [9]. Area A1 is a measure of the energy delivered by the turbine to the machine during the fault. This area may be considered as the kinetic energy stored in the machine. The potential energy between any two transient states is the net area between the post fault power output curve and turbine power line. Area A3 gives the potential energy, with respect to the post fault, stable equilibrium point, accumulated during fault on period. The area (A2+A3) is the difference between the potential energy of the post fault stable equilibrium point and unstable equilibrium point. This is referred to as the Critical energy. If the sum of the total energy at fault is less than the critical energy, the machine will be stable, i.e., A1+A3<A3+A2 for stable systems The above relationship indicates that A1<A2 for stable systems.

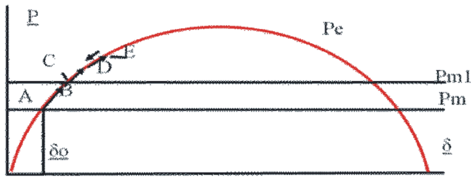

Fig. 2.3: Equal area criteria

Fast Valving: Fast valving as it sometimes referred to is a technique applicable to thermal units to assist in maintaining power system transient stability. It involves rapid closing and opening of the steam valves in a prescribed manner to reduce the generator accelerating power following the recognition of a severe transmission fault [10, 11].

The cost of implementing fast valving is usually small. However, in view of the concerns about possible adverse effects on the turbine and boiler/ steam generator, fast valving should be used only in situations where other less “heroic” measures are not able to maintain system stability [12]. In such situations, often the only other effective means of maintaining system stability is to use generator tripping. Compared to generator tripping, fast valving has the advantage that the unit remains connected the system. As a result, the total system inertia is not reduced and full or partial power output is restored within a few seconds [13, 14].

T1 = Delay between the time of initiation and the time when the valve begins to close.
T2 = Valve closing time
T3 = Time during which the valve remains closed.
T4 = Valve opening time

Generating Fuzzy Rules & Membership Functions: In conventional fuzzy system design, users start with some fuzzy rules and membership functions and they use development system to tune these rules and membership functions [15]. Starting with a good set of rules and membership functions followed by proper tuning is not an easy job and takes lot of time for a reasonably complex system. Neurofuzzy takes a different approach to fuzzy design mainly to eliminate problems associated with conventional fuzzy logic as mentioned above [1, 16].

Hybrid Algorithm: Hybrid genetic algorithms have received significant interest in recent years and are being increasingly used to solve real-world problems [17]. A genetic algorithm is able to incorporate other techniques within its framework to produce a hybrid that reaps the best from the combination. A genetic algorithm is a population-based search and optimization method that mimics the process of natural evolution [18].

The block diagram shown from the view point of designing of neuro-fuzzy network for applying in fast valving for transient stability enhancement. In the process started of improving the transient stability using neuro fuzzy, first there is the need of input and output variables to be selected. In selection of input variable, first input we took as the accelerating power and the second input we took as the speed. The output we took as the fault clearing time. Selection of appropriate membership function is done [15, 19]. Rules are made like if the value of input variable is within some low range, then the variation of output fault clearing time is shown. When the rules are made upto the satisfactions then the rules are viewed by using the rule viewer. Then the data is loaded and it is trained and tested with the error tolerance= 0.01 and Epoch =200. If the tolerance is more than error then rules are modified and the again the process is repeated. Else the final result is obtained and the neural network structure can be viewed [20, 21].

Simulation Results Using Anfis and its Implementation to Improvement of Transient Stability: Here we discuss the main part of an adaptive network based-fuzzy inference system in improvement of transient stability. First we use our data with input output values in order to train our network with a rule-based structure. Accordingly we have selected the membership functions with respect

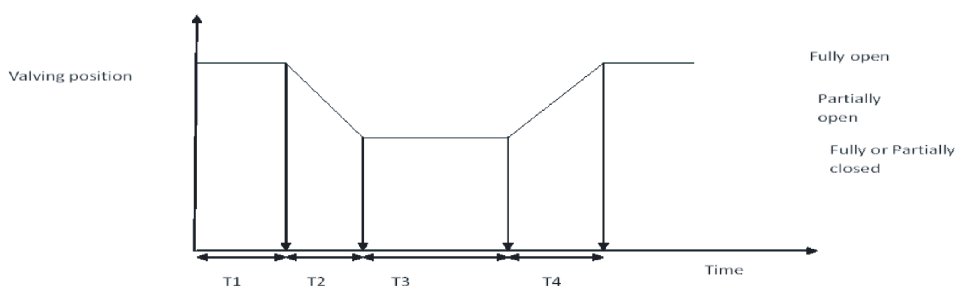

Fig. 2.4: Typical valve closing and opening sequence

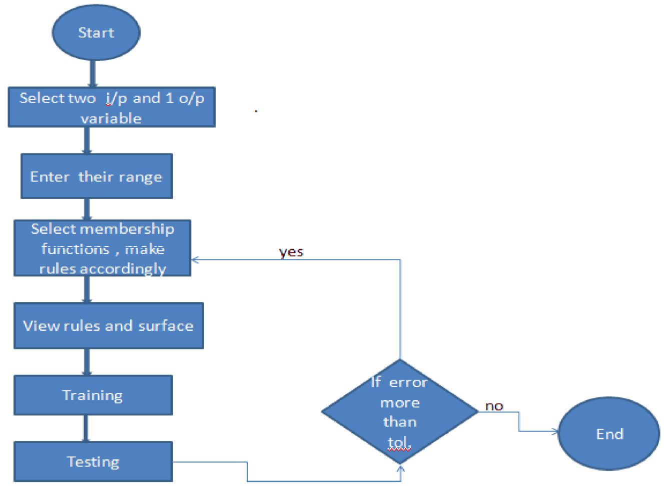

Fig. 2.5: System block diagram for neuro-fuzzy

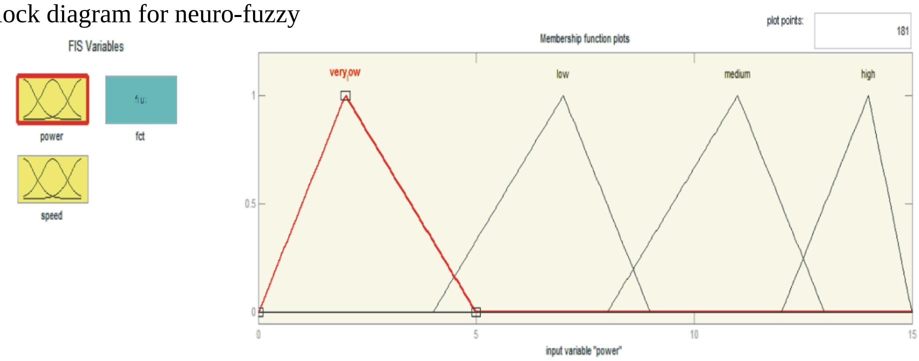

Fig. 3.2: FIS editor showing input variable power

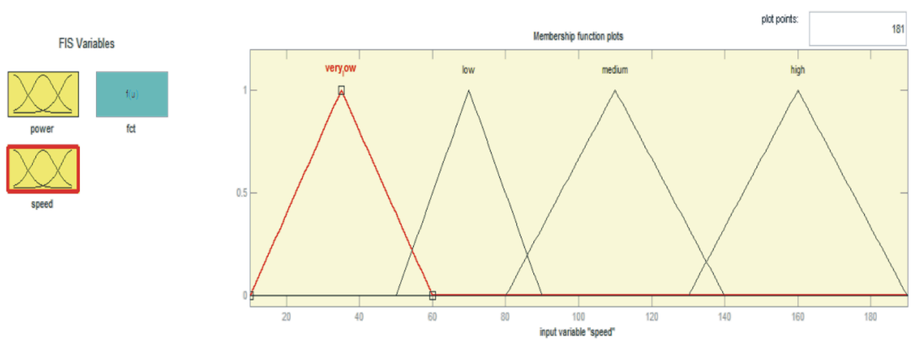

Fig. 3.3: FIS editor showing input variable speed

Fig. 3.4: FIS editor showing fault clearing time.

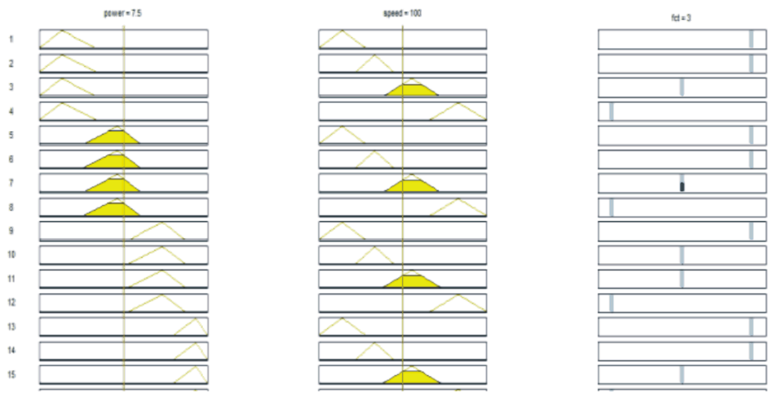

Fig. 3.5: Rule viewer for transient stability improvement

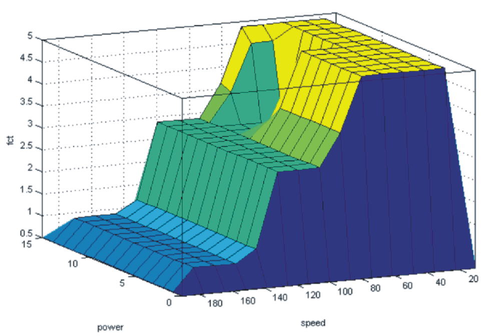

Fig. 3.6: Surface views before training

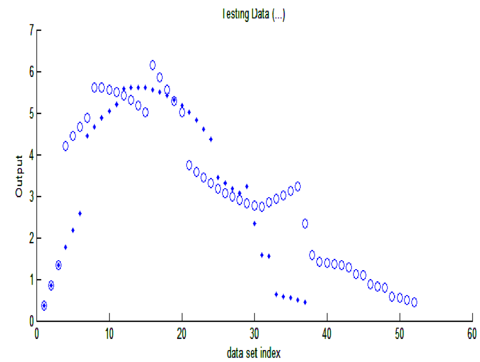

Fig. 3.9: Testing data

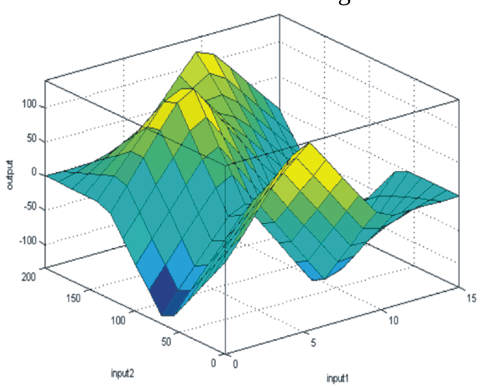

Fig. 3.7: Surface views after training and testing of data and testing of data.

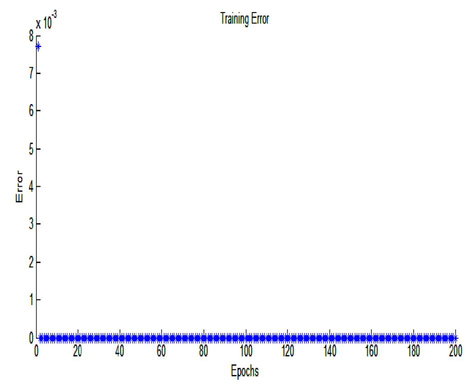

Fig. 3.10: Training error

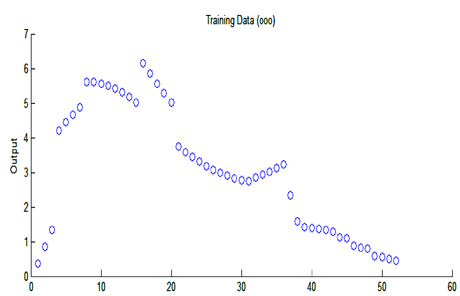

Fig. 3.8: Training data

Fig. 3.11: Testing error

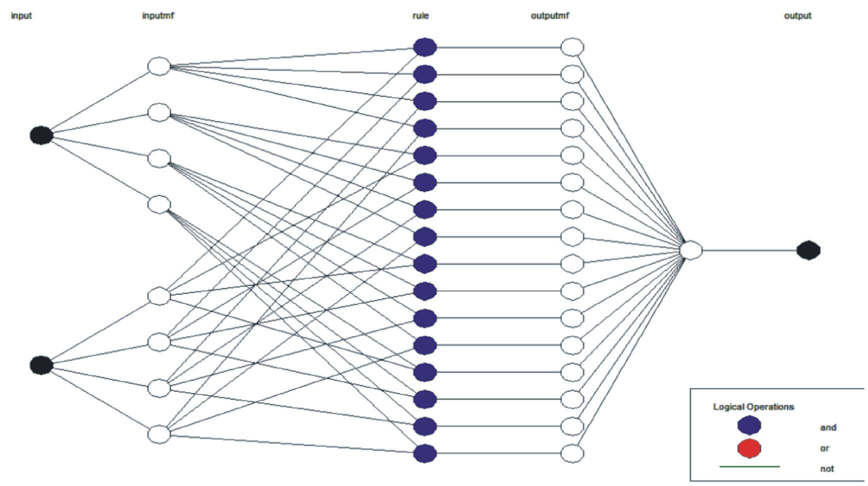

Fig. 3.12: ANFIS Model structure

Table 3.1: Linguistic variables of improvement of transient stability

Variables	Range	Correspondent fuzzy
Accelerating power	0-25	Very low
	20-50	Low
	45-75	Medium
	70-100	High
Speed	10-60	Very low
	50-90	Low
	80-140	Medium
	130-190	High
Fault clearing time	0-2	Low
	2-4	Medium
	3-5	High

A. Fuzzy inference system using sugeno method

to the power, speed and fault clearing time. The rules are made based on the ranges selected. Using data for training procedure will obtain an error so in this network and with the help of following table we will generate the if-then rules and simulate using ANFIS [17].

CONCLUSION

The Neurofuzzy integrated system can be trained by numerical data and linguistic information expressed by fuzzy if-then rules. This feature makes the incorporation of prior knowledge into the design of controllers possible. Another important feature of the neurofuzzy integrated system is that, without any given initial structure, the system can construct itself automatically from numerical training data. This study demonstrates the improvement of transient stability using neuro fuzzy logic.

The *Application* of neurofuzzy system to fast valving for transient stability improvement has the two *inputs* which include Accelerating power and rotor speed. The *output* are signal for fault clearing time. The Neuro fuzzy system is stable, efficient and reliable.

In *future prospects* they can find application in different fields like robotics, artificial intelligence, air traffic control. The proposed research has wide application in many fields, like medical science, noisy speech recognitions, noisy image filtering, nonlinear adaptive control, intelligent agents and performance analysis of dynamical systems.

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