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Enhancement of Power Stabilization System using Artificial Intelligence and its Techniques

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ABSTRACT: This paper focuses on reviewing the traditional and modern control system controllers and proposing a method to overcome it to a certain extent using various Artificial Intelligence techniques such as ANN, Fuzzy Logic, Expert System, Particle Swarm Optimization, Genetic Algorithm, etc. This review justifies that required efforts were taken towards successful performance of Power system stabilizer based on the concept of Artificial Intelligence which will focus on enhancing system stabilities and system performances.

KEYWORDS: Artificial Intelligence, Power System Stabilizer, Fuzzy Logic Application of Artificial Intelligence, Expert System.

I. INTRODUCTION

Artificial Intelligence plays a vital and increasing role in research of management science and operational research areas. Basically, intelligence is considered as the ability to collect knowledge and information and aims to solve complex problems with proper reasoning. In the near future intelligent machines will replace human efforts and capabilities in many areas. Artificial intelligence is the study and developments of intelligent machines and software that can reason, learn, gather knowledge, communicate, manipulate and perceive the objects. It is the study of the computation that makes it possible to perceive reason and act accordingly. Artificial intelligence is different from psychology and computer science because it emphasis on computation and on perception, reasoning and its corresponding actions respectively. Its aims and helps to make machines more powerful, smarter and useful. It works with the help of artificial neurons and scientific theorems. Major areas of Artificial Intelligence are Expert Systems, Natural Language Processing, Speech Understanding, Robotics and Sensory Systems, Computer Vision and Scene Recognition, Intelligent Computer Aided Instruction, Neural Computing. The various techniques applied in artificial intelligence are Neural Networks, Fuzzy Logic, Evolutionary Computing, and also Hybrid Artificial Intelligence. Artificial intelligence is more consistent, permanent and less expensive. Also, it has the ease of duplication and dissemination. Its helps perform the tasks relatively faster and all this factors provides it an edge over natural human intelligence. Power system engineering forms a vast and major portion of electrical engineering studies. It is basically concerned with the production of electrical power and its transmission from the sending end to the receiving end as per consumer requirements making sure minimum amount of losses. Due to the variation of load or basically due to disturbances induced within the length of transmission line the power at the consumer end is often subjected to changes. Due to this the term power system stability is of utmost importance in this field, and is majorly used to define the ability of the of the system to bring back its operation to steady state condition within minimum possible time after having undergone some sort of transience or disturbance in the line. The Automatic Voltage Regulator (AVR) and exciter are the main components of the generator excitation system. The terminal generator voltage is sensed and

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compared with the reference voltage to control the exciter output subsequent to any disturbance the damper and the field winding attempt to damp rotor swing. The damping process repels by the negative damping torques introduced by AVR and due to this power system may expose undesirable oscillations or lose synchronism which is a point of major concern. For this concern, the Power System Stabilizer (PSS) become technologically advanced and expanded to serve for an effective functioning. Introducing an additional signal to provide a damping component that is in the phase with the rotor speed deviation is the main function of the PSS in the excitation system. Thus, this will further enhance the system stability by adding PSS device. Stabilizers that are developed according to classical and modern control theories are based on liberalized machine model. Power system on the other hand is a nonlinear, complex system and is subjected to different kinds of disturbances that yield unresolved issues and uncertain consequences in different power system problems. Furthermore with such limitations, it is difficult to stabilize power system efficiency by these kinds of PSSs. Therefore, other types of modern control techniques like adaptive controller are used to achieve better operating performance as distinguished from conventional stabilizers.

II. POWER STSTEM STABILIZER

2.1 APPLICATION SUPPORT

Excitation systems which have high gain and faster response times is capable of greatly aiding transient stability which can also be called as synchronizing torque but it can also reduce small signal stability which is alternatively known as damping torque. A positive effect is provided by Power system stabilizer (PSS) through damping generator rotor angle swings, which are in a broad range of frequencies in the power system. These frequencies ranges from low frequency intertie modes to local modes to intra-plant modes which typically ranges from 0.1-1.- Hz, 1.0-2.0 Hz, and 2.0-3.0 Hz respectively.

2.2 TUNING MODES

Through normal AVR control, Power System Stabilizer provides modulation of field voltage that damps out power and speed oscillations. The tuning study will help us to determine the optimum PSS settings, based on the particular generator, AVR settings, and also system characteristics. There is a need of special purpose detailed models for this analysis. A specific study was carried by us in order to determine if torsional filters are required and our studies determined the key adjustment of PSS phase compensation.

2.3 TESTING OF POWER SYSTEM STABILIZER CONTROL

Testing of the PSS is normally performed during plant commissioning. The test condition for PSS is at or near base load output of the plant. The testing of modern excitation systems is facilitated by the use of internal data recording and test signals. The basic types of tests usually performed are Step test in AVR Reference, Gain Margin test to determine PSS gain, Step test in AVR Reference.

III. PROPOSED SYSTEM AND METHODOLOGY

3.1 FUZZY LOGIC CONTROLLER

The concept of Fuzzy Logic was introduced in 1963 and is derived from fuzzy set theory. Infinite number of memberships is allowed in Fuzzy Set. A number between 0 and 1 is used to indicate the degree of each membership for each element. Liberalization of nonlinear systems is the basic necessity to design traditional controllers. Furthermore, control laws are derived based on the new model and are used to control the system. Fuzzy logic controllers are nonlinear. Moreover, fuzzy logic controllers do not need a controlled plant model, and not sensitive to plant parameter variations. By using fuzzy logic, the human experience can be used in designing the controller. Fuzzy logic controllers are rule based. A stabilizer covers both heavy and light conditions and can be used to provide better performance than

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conventional PSS. In this study, two linear PSSs were developed based on the conventional frequency domain method to accommodate above conditions. Fuzzy reasoning was formed to find a single stabilize signal in such a way that the signal matches the operating condition optimally. An indirect adaptive fuzzy power system stabilizer was introduced by Hossein-Zadeh and Kalam. The power system was represented by two unknown nonlinear differential equations. Two fuzzy logic systems were built based on these equations and then the stabilizer was designed according to the same. Lyapunov's synthesis methods were applied to adapt the fuzzy logic systems. In order to adapt the stabilizer to different operating conditions, the rule-base was tuned on-line for Single Machine Infinite Bus and multi-machine power systems. Here, the controller parameters are estimated using the variable-structure algorithm. Fuzzy power system stabilizer with a new input signals are tie line connecting two areas and the speed deviation. The approach gave better dynamic performance compared to a conventional PSS and fuzzy PSS with a usual speed deviation and acceleration input signals. The cost and scanning time of the approach were reduced because the same signal can be fed to each of the fuzzy logic PSSs. A new global tuning technique proposed by for fuzzy power-system stabilizers in a multi-machine power system in order to damp the power system oscillations. This technique is based on an iterative adaptive efficient partition algorithm. Numerical results show that this algorithm can find the optimal global solution faster than a conventional Genetic Algorithm. Wide area measurement system can be used to improve large scale power system performances.

3.2 ARTIFICIAL NEURAL NETWORK CONTROLLER

An artificial neural network is a mathematical model or computational model and is based on Biological neural networks. It consists of a number of simple nodes which are alternatively called as neurons connected together to form either a single layer or multiple layers. The connections between neurons are weights that should be necessarily trained. Feedback Connections are the connections from one layer back to a previous layer, and connections between neurons in the same layer. There are different types of Neural Networks and a Neural Network is said to be feed-forwarded network if the input and intermediate signals are always propagated forwards i.e. the information moves from input to output through hidden layers in forward direction without any loops. A recurrent Neural Network is basically a network that has more than one cycle. Artificial Neural Network is an effective tool and is used for many years for identification and control of complex systems. Neural network when sufficiently trained may be used as controller instead of conventional PSS. In order to achieve good performance, the Neural Network must be trained for different operating conditions to tune the parameters of the conventional Power System Stabilizers. The process of learning using the conventional back propagation network under different conditions makes interference. It is important to overcome this drawback and to so it was proposed that a modular Neural Network can be used instead of back propagation network. This model consists of three local expert networks and a single gate network with three layers for each one. The Artificial Neural Network was trained directly from the input and output of the conventional PSS. The simulation results demonstrated that the modular Power System Stabilizer is more effective in damping system oscillations and provides good performances. In order to develop a neural adaptive Power System Stabilizer a feed forward neural network with single hidden layer were used. Furthermore each stabilizer basically comprises of two sub networks and they are Adaptive Neuro- Identifier and Adaptive Neuro- Controller and both this sub networks were trained using a back propagation algorithm. Radial basis function network has three layers and they are input layer, hidden layer and output layer. The hidden layer is trained at first using an unsupervised learning algorithm to find centers and widths of the radial basis functions for individual pattern units. To find the weights between the pattern units and the output units, the output layer is trained using supervised learning algorithm. Recurrent Neural Network stabilization controller was proposed in order to improve the transient stability of power systems under different operating conditions and parametric uncertainties and the proposed supplementary RNN controller was applied for both AVR and the governor. The signal output of first RNN was added to the PSS signal output for excitation control. The signal output of second RNN was used as a stabilizing signal for the governor system. The proposed approach applied to single-machine infinite bus. Its required large training time and also large number of neurons to design intelligent and smart controllers based on Artificial Neural Network due to complexity of large scale power systems. This raised the need to use generalized neurons to make a generalized neuron based adaptive power system stabilizers and the stabilizers was trained for the high range of operating condition and different disturbances. Gain scheduling technique was used to

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design Power system stabilizer in order to enhance the system performance because this type of stabilizers functions better than conventional Power system stabilizer. Further, it was proposed to use neural power system stabilizers which are basically trained using a set of gain scheduling PSS parameters. These parameters were obtained by applying pole-placement technique for different operating conditions.

3.3 OPTIMIZATION BASED INTELLIGENT TECHNIQUES

Different types of intelligent optimization techniques are used in order to search for optimal or maybe near optimal solutions for many power system problems which are bound to be taken in to consideration. The techniques used for this purpose are Genetic Algorithm Technique and Particle Swarm Optimization technique.

3.3.1 GENETIC ALGORITHM TECHNIQUE

Genetic Algorithm is a type of evolutionary algorithms used as a search technique to find an optimal or near optimal solution for many problems. It is categorized as global search heuristics. A Genetic Algorithm is implemented as an iterative procedure in which a population of function inputs which is alternatively called as strings is randomly selected. Then the population is used to create a new population in the string and the process is repeated in the next iterations. The process of creating a new population passes through selection, mating, and mutation operations.

3.3.2 PARTICLE SWARM OPTIMIZATION TECHNIQUE

It is one of the modern heuristic algorithms and also a population based evolutionary algorithm. Particle Swarm Optimization is motivated by the simulation of the social behavior of birds which sounds strange but true. Individual particles in the swarm with a position and velocity fly in a multidimensional search space. The velocity is continually adapted according to the corresponding particle's own experience and also the experience of other accompanying particles. It is expected that the particles will be flying in the course of finding better areas. It was further proposed that PSO technique can be used for tuning parameters of brushless exciter and lead-lag power system stabilizer.

3.4 HYBRID ARTIFICIAL INTELLIGENCE CONTROLLER

As the name implies two or more artificial intelligent techniques are used to produce a hybrid intelligent system. In order to gain the required successful results such techniques are applied in series through cooperative interactions. In the last two decades hybrid systems are applied in engineering applications. Gain-scheduling PID stabilizer is proposed so as to enhance the stability of the power systems. A hybrid conventional Power System Stabilizer, a fuzzy logic based Power System Stabilizer and simple switching criteria was used in 1996. This approach applied was further to a SMIB under various transient disturbances including faults. The parameters of the proposed stabilizer were tuned on-line based on the speed error signal and its derivative. This controller was applied to SMIB and multi-machine power systems. Furthermore an adaptive fuzzy control was presented based on unsupervised learning neural nets for improving the generating unit transient of a hydro power system. By using appropriate means, a linguistic control strategy of optimal state-feedback regulator design was converted to a variable control strategy. The proposed controller contains a set of fuzzy logic based controller modules and a neural net classifier. The relationship between controller inputs and controller output was generated by using unsupervised learning of Neural Network and stored in a matrix called fuzzy associative matrix. The test inputs that are used to generate the input-output pairs in training neural network may not be rich enough to excite all modes of the system and the design of the traditional fuzzy logic controller requires a lot of trial and error and in order to avoid this drawback, Abido and Abdel-Magid proposed a fuzzy basis function network (FBFN) to develop Power System Stabilizer. Genetic Algorithm is applied so as to select and tune the optimal parameters of a neuro fuzzy Power System Stabilizer. Suitable fitness functions were employed to determine the optimal parameters of membership functions during the learning procedure. The proposed stabilizer was tested on SMIB system and the results have shown improving dynamic performances under different operating conditions. In many cases the initial fuzzy rules which are estimated according to the human experiences are tuned using feedback, but with insufficient information about the control system the trial and error may be necessary.

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Recently different techniques employed to avoid this drawback such as TS algorithm, PSO, and Evolutionary Algorithms. These techniques used by many researchers to design fuzzy Power System Stabilizer. The approach applied to SMIB and multi-machine power systems and the results reveal that the proposed fuzzy Power System Stabilizers has robust and adaptive performance under different operating conditions including three phase fault. A comprehensive study was presented to illustrate the possibility of implementing an adapting controller using different approaches. Adaptive Power System Stabilizer was designed based on purely analytic techniques, purely Artificial Intelligence techniques, and combination of the analytical and Artificial Intelligence techniques. These stabilizers are used to enhance the stability and damping oscillation of an electrical generating unit. These systems were implemented and tested in real-time on physical models in the Laboratory. Number of variables is based on the complexity of the power system. In a standard fuzzy system, the number of the rules and the complexity of the problem increase exponentially with the number of variables involved. To introduce linear relation between the number of variables and number of rules, a hierarchical fuzzy system can be used. This idea and innovation further motivated Caner et al. to propose the hierarchical fuzzy Power System Stabilizer. The stability can be enhanced by using this controller for SMIB system with more number of variables and also with appropriate number of rules. The Bacteria Foraging Optimization technique was used by to tune the parameters of both single-input and dual-input Power System Stabilizers. The conventional stabilizer and the three dual-input IEEE Power System Stabilizers were optimally tuned to obtain the optimal transient performances. Sugeno fuzzy logic was used for on-line, off-nominal operating conditions. Simulation results reveal and further proved that the transient performance of dual-input Power System Stabilizer is better than single-input Power System Stabilizers. In addition, the proposed BFO technique provides better transient performance compared to Genetic Algorithm. A robust adaptive fuzzy controller proposed by to design a PSS. Fuzzy logic was used to implement system with both nominal values and adaptive system. A feedback linearization-based control law is implemented using the identified model. The gains of the feedback linearization controller were tuned using a particle swarm optimization technique. The proposed controller was tested on a 4-machine 2-area power system and the results show the ability of the proposed stabilizer in damping inter-area oscillation compared to conventional Power System Stabilizer. It was further proposed a particle swarm optimization technique for tuning of a fuzzy logic power system stabilizer by El-Zonkoly et al. The approach applied to multi-machine power system and simulation carried out. The results show that the stabilizer is successfully working under different loading and fault conditions.

IV. CONCLUSION

The field of artificial intelligence gives the ability to the machines to think analytically, using concepts. Tremendous contribution to the various areas has been made by the Artificial Intelligence techniques from the past many years. Artificial Intelligence will continue to play an increasingly important role in the various fields. This paper is based on the concept of artificial intelligence, areas of artificial intelligence and the artificial intelligence techniques used in the various fields specifically in medical prediction. Artificial Intelligence has several applications like it can be used in gaming, medical application and several others. It can also be used to build smarter products which will add to the benefit of people around. For example the construction of locomotion system for ALS patients requires Artificial Intelligence and it helps ALS patients to attain mobility just by using their thinking capability. Furthermore Artificial Intelligence can replace motion sensor based games as well in future. Our proposed system using the concept of Artificial Intelligence and its several techniques will help to enhance the performance of Power System Stabilizer. The controllers that are designed based on conventional control theory, modern control theory, and adaptive control theory are found to have certain restrictions and by contrast, the advantages of AI techniques convinced and encouraged many researchers to apply these techniques to solve the problems of Power system control and Stabilizers. This review is undertaken to explore and report that fast and accurate controllers developed using the concept of Artificial Intelligence techniques are required to maintain system stability and damping of oscillation and provide high-quality performance. Different types of Artificial Intelligence stabilizers are assessed and compared with other types of stabilizers in this study.

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