GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Subject Code: ME02000771
Subject Name: AI Application in Power Systems

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Basics of Linear Algebra, Fundamental knowledge of Modern Optimization Techniques
Rationale:	As power systems become more complex with the integration of renewable energy, smart grids, and decentralized power generation, traditional methods face limitations in handling dynamic, large-scale data and optimizing system performance. AI provides advanced tools such as artificial neural networks and optimization algorithms to enhance grid stability, predict faults, and optimize energy usage. Incorporating AI allows for real-time decision-making, enabling more efficient management of power distribution and reducing downtime during outages. It also plays a vital role in renewable energy forecasting, demand-side management, and in improving the efficiency of power systems.

Course Outcomes:
After completing the course, students will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Explain the fundamental concepts and applications of artificial intelligence in power systems	7
CO-2	Comprehend and apply fuzzy logic for solving various power system problems	25
CO-3	Analyze neural network and its applications in power systems	25
CO-4	Apply Genetic Algorithms to optimize power system operations such as economic dispatch and power flow	25
CO-5	Explore AI-driven solution for optimization of power systems using Particle Swarm Optimization	18

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Contents:

Sr. No.	Content	Total Hrs	%
1	**Introduction to Artificial Intelligence:** What is AI, The Foundations of Artificial Intelligence, The History of Artificial Intelligence, The State of the Art, Risks and Benefits of AI [1]	3	5
2	**Fuzzy Logic Applications in Power Systems:** Introduction, History and background**,** Applications**,** Pros and Cons of fuzzy logic**,** Linguistic approach, Set theory, Fuzzy set theory, Classical set theory versus fuzzy set theory, Example based on fuzzy logic, Fuzzy system design, Fuzzification, Fuzzy Inference, Mamdani method, Takagi-Sugeno model, Defuzzification, Application example, Load balancing using fuzzy logic, Voltage stability analysis using fuzzy logic, Load profiling and energy consumption modeling using fuzzy logic [2]	10	25
3	**Artificial Neural Networks (ANN) in Power Systems:** Introduction, History and background, Applications, Pros and Cons of ANN, Basic structure of ANN, Structure of a neuron, Transfer functions, Architecture of the ANN, Steps to construct a neural network, Learning Algorithm, The delta rule, Gradient descent, Energy equivalence, The back propagation algorithm, The Hebb rule, Different networks, Perceptron, Multi-layer perceptrons, Back-propagation network, Radial basis function network, Special Issues in NN training, Overfitting, Underfitting, Number of hidden layer units, weight initialization, Scaling of inputs and outputs, Application of NN in Simple ground fault classifier, Advanced ground fault classifier, Advanced load forecasting, Stability analysis [2]	11	25
4	**Genetic Algorithms and Evolutionary Techniques:** Fundamentals of Genetic Algorithms, History of GA, Basic Concepts, Biological background, Creation of offsprings, Search space, Working principle, Encoding, Binary Encoding, Octal encoding, Hexadecimal encoding, Fitness function, Reproduction, Roulette Wheel selection, Tournament selection, Rank Selection, Elitism, Crossover, Single point crossover, Multi-point crossover, Uniform crossover, Mutation operator, Mutation rate, Application of classic economic dispatch by Genetic Algorithm, GA based Economic dispatch solution [3],[4]	11	25
5	**Particle Swarm Optimization and its application in Power systems:** Introduction, Computational implementation of PSO, Improvement to the Particle Swarm Optimization method, Solution of the constrained	10	20

	optimization problem, Finding maximum/minimum of the function using PSO [5], Implementation of PSO for Unit Commitment[4]		
	TOTAL	**45**	**100**

References:

1."Artificial Intelligence, A Modern Approach"by Stuart Russel and Peter Norwig
2."Intelligent Systems and Signal Processing in Power Engineering"by Abhisek Ukil
3."Neural Networks, Fuzzy Logic and Genetic Algorithms"byRajsekaran and Pai
4."Optimization of Power System Operation"by Jizhong Zhu
5."Engineering Optimization – Theory and Practice" by Singiresu S. Rao

Suggested List of practicals:

1. **Simulation of Artificial Neural Networks (ANN) for Load Forecasting**: Implement and train an ANN model for short-term electrical load forecasting using historical data.
2. **Fuzzy Logic Controller Design for feeder load balancing in Power Systems**: Develop a fuzzy logic-based controller to maintain balanced load in all the feeders
3. **Fuzzy Logic Controller Design for Voltage Stability Analysis:** Develop a fuzzy logic-based controller to main voltage stability under varying load conditions
4. **Genetic Algorithm (GA) for Optimal Power Flow**: Use a GA algorithm to optimize power flow in a simple transmission network, minimizing losses and improving system efficiency.
5. **Genetic Algorithm (GA) for Economic Dispatch:** Use a GA algorithm to implement economic dispatch in power systems
6. **Particle Swarm Optimization (PSO) for Unit Commitment**: Implement a PSO algorithm for Unit Commitment
7. **Dynamic Stability Analysis of Power Systems with AI Controllers**: Design an AI-based controller (e.g., reinforcement learning) to stabilize a power system under dynamic load variations.
8. **Real-Time Monitoring of Power Grid using AI for Smart Grids**: Simulate a smart grid scenario where AI is used to predict and respond to grid conditions like demand spikes and outages.
9. **Optimization of Distributed Generation Placement using AI Techniques**: Use an optimization algorithm (e.g., Teaching Learning Based Optimization) to determine the optimal placement of distributed generation units in a power grid.

10. **Simulation of Hybrid AI Techniques (ANN + Fuzzy Logic) for Power System Control**: Combine neural networks and fuzzy logic to create a hybrid control strategy for frequency regulation in microgrids.

Suggested MOOC courses for further study:

https://www.coursera.org/learn/electric-power-systems

https://ocw.mit.edu/courses/6-034-artificial-intelligence-spring-2005/

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