Training Course on Neural Networks in Control and Automation

Professional Development Training Course Outline

Category	Engineering	**Duration**	10 Days
Base Fee	$3,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Introduction

This advanced training course provides a comprehensive deep dive into Neural Networks in Control and Automation, equipping participants with the cutting-edge skills to design, implement, and optimize intelligent control systems. Training Course on Neural Networks in Control and Automation bridges the gap between classical control theory and the transformative power of Artificial Intelligence (AI) and Machine Learning (ML), specifically focusing on the application of various neural network architectures. Attendees will gain hands-on expertise in leveraging feedforward neural networks, recurrent neural networks (RNNs), convolutional neural networks (CNNs), and reinforcement learning (RL) for tasks such as system identification, adaptive control, fault diagnosis, predictive maintenance, and robotic control. This course is essential for control engineers, automation specialists, and researchers seeking to innovate and enhance the performance, autonomy, and robustness of industrial, robotic, and smart infrastructure systems.

The program emphasizes practical implementation and industry best practices, exploring trending topics like Deep Reinforcement Learning (DRL) for complex control tasks, neural network-based predictive control (NNPMC), intelligent fault-tolerant control, and the deployment of neural networks on embedded platforms for real-time automation. Participants will delve into advanced concepts such as transfer learning in control, explainable AI (XAI) for control systems, and the integration of neural networks with traditional control methodologies (e.g., PID controllers). By the end of this course, attendees will possess the expertise to architect and deploy sophisticated neural network-driven control and automation solutions, driving efficiency, adaptability, enhanced safety, and predictive capabilities across diverse applications, from smart manufacturing to autonomous vehicles. This training is indispensable for professionals aiming to be at the forefront of intelligent automation and the next generation of control systems.

Programme Curriculum

Training Course on Neural Networks in Control and Automation

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Course Objectives

1. Understand the foundational concepts of neural networks and their relevance to control and automation.
2. Apply feedforward neural networks for system identification and modeling.
3. Design and implement recurrent neural networks (RNNs) for dynamic system control and time-series prediction.
4. Utilize Convolutional Neural Networks (CNNs) for image-based control tasks and visual servoing.
5. Implement Reinforcement Learning (RL) algorithms to train intelligent agents for optimal control policies.
6. Develop adaptive control strategies using neural networks.
7. Apply neural networks for fault detection, isolation, and diagnosis in automation systems.
8. Design predictive control systems (NNPMC) based on neural network models.
9. Explore neural network applications in robotics, including path planning and manipulation.
10. Optimize and deploy neural network models on embedded platforms for real-time control.
11. Understand and implement transfer learning techniques in control applications.
12. Analyze stability and robustness considerations of neural network-based control systems.
13. Explore Explainable AI (XAI) methods for interpreting neural network decisions in control.

Organizational Benefits

1. Development of highly adaptive and intelligent control systems, improving performance in dynamic environments.
2. Enhanced automation capabilities, leading to increased efficiency and reduced manual intervention.
3. Improved fault detection and diagnostic accuracy, minimizing downtime and maintenance costs.
4. Faster prototyping and deployment of advanced control strategies.
5. Reduced energy consumption through optimized and intelligent control.
6. Increased resilience and robustness of automation systems to disturbances.
7. Competitive advantage by leveraging cutting-edge AI for industrial and robotic applications.
8. Better utilization of operational data for real-time insights and predictive capabilities.
9. Safer operation of complex systems through intelligent monitoring and control.
10. Upskilling of the workforce in the most impactful AI technologies for automation.

Target Participants

- Control Engineers
- Automation Engineers
- Robotics Engineers
- Process Control Engineers
- AI/ML Engineers working in industrial settings
- Researchers in Control Systems and AI
- Electrical and Mechanical Engineers involved in system design and optimization

Course Outline

Module 1: Introduction to AI and Neural Networks in Control

- **Fundamentals of Control Systems:** Open-loop, closed-loop, feedback, feedforward.
- **Challenges in Modern Control:** Non-linearity, uncertainty, adaptability.
- **Neural Network Basics:** Neurons, activation functions, layers, training.
- **Why Neural Networks for Control?** Approximation capabilities, learning from data.
- **Case Study:** Identifying opportunities for neural networks in a conventional PID control loop.

Module 2: System Identification using Neural Networks

- **Modeling Dynamic Systems:** Input-output relationships, state-space models.
- **Feedforward Neural Networks for Static Mapping:** Regression tasks.
- **Dynamic Neural Networks (NARX, NOE):** Modeling time-dependent systems.
- **Data Collection and Preprocessing for System ID:** Noise, sampling rate, feature engineering.
- **Case Study:** Identifying the dynamics of a DC motor using a feedforward neural network from experimental data.

Module 3: Neural Networks for PID and Feedback Control

- **PID Control Review:** Proportional, Integral, Derivative components.
- **Neural Network-based PID Tuning:** Auto-tuning and adaptive PID.

- **Neural Network as a Controller:** Direct and indirect control architectures.
- **Stability Considerations:** Robustness and generalization.
- **Case Study:** Implementing a neural network to adaptively tune PID gains for a temperature control system.

Module 4: Recurrent Neural Networks (RNNs) for Dynamic Control

- **RNN Architecture:** Handling sequential data, memory cells.
- **Long Short-Term Memory (LSTM) Networks:** Overcoming vanishing gradients.
- **Gated Recurrent Units (GRUs):** Simplified LSTMs for sequence modeling.
- **RNNs for Prediction and Estimation:** State estimation, output prediction.
- **Case Study:** Using an LSTM network to predict the future states of a chemical process.

Module 5: Reinforcement Learning (RL) Fundamentals for Control

- **RL Core Concepts:** Agent, environment, state, action, reward, policy.
- **Markov Decision Processes (MDPs):** Formalizing sequential decision-making.
- **Value-Based RL:** Q-Learning, SARSA for discrete actions.
- **Policy-Based RL:** Policy Gradients, Actor-Critic methods.
- **Case Study:** Training a simple RL agent to balance a cart-pole system.

Module 6: Deep Reinforcement Learning (DRL) in Control

- **Deep Q-Networks (DQN):** Combining deep learning with Q-Learning.
- **Policy Optimization Algorithms:** PPO, A2C for continuous control.
- **Model-Based vs. Model-Free RL:** Choosing the right approach.
- **Challenges in DRL for Control:** Sample efficiency, stability, exploration-exploitation.
- **Case Study:** Using DRL to teach a simulated robot arm to reach a target position.

Module 7: Neural Network-based Predictive Control (NNPMC)

- **Model Predictive Control (MPC) Principles:** Receding horizon control.
- **Neural Network as a Predictive Model:** Replacing traditional dynamic models.
- **Online vs. Offline Training of NNPMC:** Adaptability.
- **Optimization Solvers for NNPMC:** Constraints handling.
- **Case Study:** Designing an NNPMC for energy management in a smart building, predicting future energy demands.

Module 8: Fault Detection and Diagnosis with Neural Networks

- **Types of Faults:** Sensor faults, actuator faults, component degradation.
- **Data-Driven Fault Detection:** Supervised and unsupervised approaches.
- **Neural Network Architectures for FDD:** Autoencoders, CNNs for signal/image analysis.
- **Anomaly Detection with NNs:** Identifying deviations from normal operation.
- **Case Study:** Detecting abnormal vibration patterns in industrial machinery using an autoencoder.

Module 9: Neural Networks in Robotics and Autonomous Systems

- **Robot Kinematics and Dynamics:** Review.
- **Neural Networks for Robot Control:** Inverse kinematics, trajectory generation.
- **Visual Servoing and Perception:** CNNs for object recognition and pose estimation.
- **Reinforcement Learning for Robotic Manipulation:** Learning complex motor skills.
- **Case Study:** Developing a CNN-based system for a robot arm to pick and place objects based on camera input.

Module 10: Adaptive and Robust Control with Neural Networks

- **Adaptive Control Concepts:** Handling uncertainties and varying plant dynamics.
- **Neural Network for Parameter Estimation:** Online adaptation.
- **Robustness Analysis:** Ensuring stable operation despite model inaccuracies.
- **Fuzzy-Neural Control:** Combining fuzzy logic with neural networks.
- **Case Study:** Designing an adaptive neural network controller for a system with unknown or changing parameters.

Module 11: Real-Time Implementation and Embedded Deployment

- **Hardware for Neural Network Inference:** GPUs, NPUs, dedicated AI accelerators.
- **Model Quantization and Pruning:** Optimizing models for resource-constrained devices.
- **Embedded Deep Learning Frameworks:** TensorFlow Lite Micro, ONNX Runtime.
- **Real-Time Operating Systems (RTOS) and NNs:** Integration challenges.
- **Case Study:** Deploying a trained neural network for real-time control on an embedded microcontroller or edge device.

Module 12: Stability, Safety, and Verification of NN-Based Control

- **Challenges of Neural Network Control:** Lack of formal guarantees, black-box nature.
- **Verification Techniques:** Reachability analysis, formal methods (basics).
- **Safety Critical Applications:** Considerations for autonomous vehicles, medical devices.
- **Explainable AI (XAI) in Control:** Interpreting decisions for trust and debugging.
- **Case Study:** Discussing the safety implications of a neural network controller in an autonomous driving scenario.

Module 13: Hybrid Control Systems with Neural Networks

- **Combining NN with Classical Control:** PID-NN fusion, gain scheduling.
- **Supervisory Control with NNs:** Switching between controllers.
- **Hierarchical Control Architectures:** High-level planning, low-level execution.
- **Event-Triggered Control with NNs:** Energy efficiency.
- **Case Study:** Designing a hybrid control system where a neural network provides adaptive feedforward compensation to a classical feedback controller.

Module 14: Neural Networks for Process Optimization

- **Process Modeling and Prediction:** Using NNs to predict process outputs.
- **Optimization of Process Parameters:** Using NNs to find optimal setpoints.
- **Soft Sensors:** Using NNs to estimate unmeasured process variables.
- **Batch Process Optimization:** Learning optimal recipes.
- **Upcoming Scheduled Sessions**

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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