Training Course on Neuromorphic Computing and Circuits

Professional Development Training Course Outline

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

Course Introduction

Introduction

Unlock the future of Artificial Intelligence with our intensive training course on Neuromorphic Computing and Circuits. Training Course on Neuromorphic Computing and Circuits delves into the revolutionary paradigm of brain-inspired computing, offering a profound understanding of how silicon architectures can emulate the human brain's unparalleled energy efficiency, parallel processing, and adaptive learning capabilities. Participants will explore the fundamental principles, cutting-edge hardware, and innovative algorithms that are driving the next generation of AI, enabling real-time processing and edge AI solutions for diverse applications.

This comprehensive course is designed to equip engineers, researchers, and technical professionals with the essential knowledge and practical skills to design, develop, and deploy neuromorphic systems. We will cover everything from the biological inspiration behind spiking neural networks (SNNs) to the intricacies of neuromorphic hardware (e.g., Intel Loihi, IBM TrueNorth, SpiNNaker) and their integration into real-world applications. Join us to be at the forefront of this transformative technology, pushing the boundaries of sustainable AI and intelligent systems.

Programme Curriculum

Training Course on Neuromorphic Computing and Circuits

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Course Objectives

1. Comprehend the foundational biological principles inspiring neuromorphic computing and brain-inspired AI.
2. Differentiate between traditional Von Neumann architectures and neuromorphic architectures in terms of efficiency and processing paradigms.
3. Master the theory and implementation of Spiking Neural Networks (SNNs), including various neuron models and learning rules.
4. Analyze and compare different neuromorphic hardware platforms (e.g., Intel Loihi, IBM TrueNorth, SpiNNaker) and their respective strengths.
5. Design and develop energy-efficient algorithms for neuromorphic systems, focusing on low-power AI.
6. Apply neuromorphic computing principles to edge AI applications, enabling real-time data processing in IoT and embedded devices.
7. Evaluate the environmental impact of AI systems and identify how neuromorphic computing contributes to sustainable AI.
8. Utilize industry-standard neuromorphic software development kits (SDKs) and simulation tools for model implementation and testing.
9. Explore advanced concepts in neuromorphic sensors and their integration with brain-inspired processing units.
10. Implement practical case studies involving pattern recognition, anomaly detection, and adaptive learning using neuromorphic approaches.
11. Identify and mitigate challenges in neuromorphic system deployment, including programming complexities and standardization.
12. Discuss emerging trends and future directions in neuromorphic research, including quantum neuromorphic computing and novel materials.
13. Contribute to the development of next-generation intelligent autonomous systems and human-computer interaction through neuromorphic innovation.

Organizational Benefits

1. Enhanced Competitive Advantage.
2. Optimized Energy Efficiency.
3. Accelerated Real-time Processing.

4. Improved Edge Computing Capabilities.
5. Increased Innovation Capacity.
6. Sustainable AI Development.
7. Talent Retention and Upskilling.
8. Reduced Hardware Costs (Long-term.
9. Strategic R&D Alignment.
10. Enhanced Problem-Solving.

Target Participants

- Hardware Engineers
- Software Developers
- AI/ML Engineers and Researchers
- Robotics Engineers
- IoT Device Developers
- Data Scientists

Course Outline

Module 1: Introduction to Neuromorphic Computing: A Paradigm Shift

- **Defining Neuromorphic Computing:** What it is and how it differs from traditional Von Neumann architectures.
- **Historical Context & Evolution:** Tracing the journey from early concepts to modern brain-inspired systems.
- **The Need for Neuromorphic AI:** Addressing energy consumption, latency, and scalability challenges in modern AI.
- **Key Characteristics:** Event-driven processing, parallelism, memory-in-compute.
- **Case Study:** Overview of early successes in pattern recognition.

Module 2: Biological Inspiration: The Brain as a Blueprint

- **Fundamentals of Neurons & Synapses:** Understanding the building blocks of biological intelligence.
- **Neural Plasticity & Learning Mechanisms:** How the brain adapts and learns (STDP, Hebbian learning).
- **Sensory Processing in Biology:** Emulating biological sensory pathways for efficient data interpretation.
- **From Biology to Silicon:** Translating neurobiology into hardware and software designs.
- **Case Study:** Biological vision systems inspiring neuromorphic cameras.

Module 3: Spiking Neural Networks (SNNs): The Core of Neuromorphic AI

- **SNN vs. ANN:** Key differences and advantages of spiking over traditional artificial neural networks.
- **Neuron Models:** Leaky Integrate-and-Fire (LIF), Hodgkin-Huxley, and their applications.
- **Synaptic Plasticity Rules:** Implementing learning in SNNs (STDP, anti-STDP).
- **Encoding Schemes:** Rate coding, temporal coding, and their implications for data representation.
- **Case Study:** SNNs for real-time auditory processing.

Module 4: Neuromorphic Hardware Architectures: The Brain in Silicon

- **Digital Neuromorphic Chips:** Deep dive into architectures like Intel Loihi.
- **Analog/Mixed-Signal Neuromorphic Chips:** Exploring designs like IBM TrueNorth and BrainScaleS.
- **Massively Parallel Platforms:** Understanding the SpiNNaker architecture.
- **Emerging Memory Technologies:** Resistive RAM (RRAM), Phase-Change Memory (PCM) for in-memory computing.
- **Case Study:** Comparative analysis of energy consumption across different neuromorphic platforms.

Module 5: Neuromorphic Software Development & Simulation Tools

- **Introduction to Neuromorphic SDKs:** Programming models and frameworks for different hardware.
- **Simulation Environments:** NEST, Brian2 for simulating SNNs.
- **Toolchain and Workflow:** From model design to deployment on neuromorphic hardware.
- **Debugging and Optimization:** Techniques for efficient neuromorphic algorithm development.
- **Case Study:** Building and simulating a simple SNN for classification using a chosen SDK.

Module 6: Energy Efficiency & Sustainable AI with Neuromorphic Computing

- **Measuring AI's Carbon Footprint:** Understanding the energy demands of traditional AI.
- **Power Consumption Analysis:** Comparing neuromorphic systems with GPUs/TPUs.
- **Event-Driven Processing for Efficiency:** How sparsity reduces energy use.
- **Strategies for Green AI:** Leveraging neuromorphic principles for sustainable solutions.
- **Case Study:** Developing an ultra-low power anomaly detection system for industrial IoT.

Module 7: Edge AI and Real-time Applications

- **Fundamentals of Edge AI:** Why processing at the edge is crucial.
- **Neuromorphic Computing at the Edge:** Advantages for low-latency and autonomous operations.
- **Sensor Integration:** Connecting neuromorphic chips with various sensor modalities.
- **Real-time Processing Challenges:** Addressing constraints in embedded systems.
- **Case Study:** Implementing a neuromorphic solution for real-time object tracking in robotics.

Module 8: Neuromorphic Computing in Robotics & Autonomous Systems

- **Bio-inspired Control:** Applying neuromorphic principles to robotic motor control.
- **Perception & Navigation:** Real-time environmental understanding for autonomous vehicles.
- **Learning & Adaptation:** Robots that learn on the fly with minimal supervision.
- **Swarm Robotics:** Distributed intelligence with neuromorphic agents.
- **Case Study:** Designing a neuromorphic controller for a miniature autonomous drone.

Module 9: Neuromorphic Sensing & Signal Processing

- **Event-Based Cameras:** Dynamic Vision Sensors (DVS) and their integration with neuromorphic chips.
- **Auditory Sensors & Speech Recognition:** Neuromorphic approaches to sound processing.
- **Olfactory & Tactile Sensing:** Emulating biological senses for advanced perception.
- **Bio-signal Processing:** Applications in medical diagnostics and brain-computer interfaces.

- **Case Study:** Building a neuromorphic system for real-time gesture recognition using DVS data.

Module 10: Advanced SNN Architectures & Learning

- **Deep Spiking Neural Networks:** Architectures for complex pattern recognition.
- **Unsupervised Learning in SNNs:** Self-organizing maps and clustering.
- **Reinforcement Learning with SNNs:** Training agents for decision-making.
- **Spike-Timing Dependent Plasticity (STDP) Variations:** Exploring different STDP rules.
- **Case Study:** Implementing a deep SNN for complex image classification.

Module 11: Neuromorphic Computing for Data Analytics & Anomaly Detection

- **Pattern Recognition in Large Datasets:** Leveraging SNNs for efficient data analysis.
- **Real-time Anomaly Detection:** Identifying outliers in streaming data.
- **Graph Neural Networks (GNNs) on Neuromorphic Hardware:** Processing relational data.
- **Data Compression & Feature Extraction:** In-hardware processing for reduced data movement.
- **Case Study:** Neuromorphic fraud detection in financial transactions.

Module 12: Challenges and Opportunities in Neuromorphic Development

- **Programming Model Complexity:** Bridging the gap between software and novel hardware.
- **Lack of Standardization:** The need for common frameworks and interfaces.
- **Scalability & Integration:** Challenges in building large-scale neuromorphic systems.
- **Benchmarking & Performance Evaluation:** Metrics for comparing neuromorphic with traditional AI.
- **Case Study:** Overcoming development hurdles in a multi-platform neuromorphic project.

Module 13: Emerging Trends & Future Directions

- **Quantum Neuromorphic Computing:** Intersection of quantum mechanics and brain-inspired AI.
- **Memristors & Novel Devices:** Advancements in resistive memory technologies.
- **Photonic Neuromorphic Computing:** Using light for ultra-fast processing.
- **Beyond AI: Neuromorphic for General-Purpose Computing:** Expanding applications.
- **Case Study:** Research spotlight on a cutting-edge neuromorphic innovation.

Module 14: Ethical Considerations & Societal Impact

- **Bias in Neuromorphic AI:** Addressing fairness and transparency.
- **Privacy and Security:** Safeguarding data in brain-inspired systems.
- **Human-AI Collaboration:** The future of intelligent machines and human interaction.
- **Regulatory Landscape:** Policy implications for emerging AI technologies.
- **Case Study:** Ethical review of a neuromorphic application in healthcare.

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
21 Sep 2026	02 Oct 2026	Online	$2,000

Start Date	End Date	Location	Price
21 Sep 2026	02 Oct 2026	Physical	$3,000
21 Sep 2026	02 Oct 2026	Physical	$0
21 Sep 2026	02 Oct 2026	Physical	$0
21 Sep 2026	02 Oct 2026	Physical	$0
21 Sep 2026	02 Oct 2026	Physical	$0
21 Sep 2026	02 Oct 2026	Physical	$0
21 Sep 2026	02 Oct 2026	Physical	$0

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