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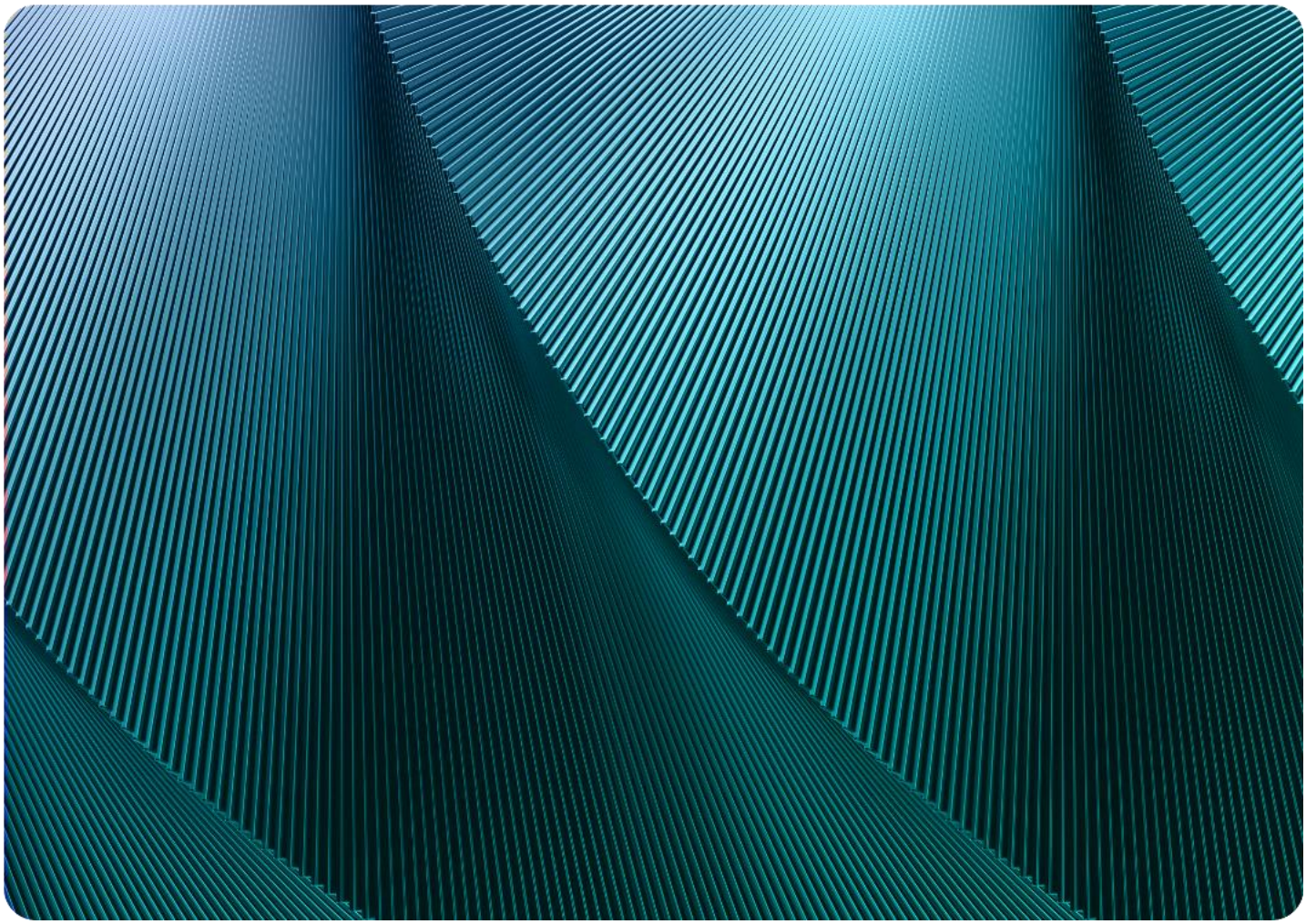
Course Outline Details

Deep Learning in AI

This intermediate course delves into deep learning, the driving force behind transformative breakthroughs in artificial intelligence.



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Course Outline

Week starting on / Module	Module Topic
Week 1	Mod 01: Introduction to Deep Learning and Its Applications Mod 02: Environments and Tools
Week 2	Mod 03: Neural Network Optimization and Training Deep Networks
Week 3	Mod 04: Convolutional Neural Networks (CNNs) for Computer Vision
Week 4	Mod 05: Sequence Modeling and Natural Language Processing with RNNs
Week 5	Mod 06: Transformers and Attention Mechanisms for NLP and Beyond
Week 6	Mod 07: Variational Autoencoders (VAEs)
Week 7	Mod 08: Generative Adversarial Networks (GANs)
Week 8	Mod 09: Diffusion Models and Advanced Generative Techniques
Week 9	Mod 10: Deep Reinforcement Learning and AI Agents
Week 10	Mod 11: Reasoning Models and RAG
Week 11	Mod 12: Agent Planning and Orchestration
Week 12	Mod 13: LangChain and Agent Architectures
Week 13	Mod 14: Advanced Agent Systems and Applications
Week 14	Mod 15: Future Trends and Course Review
Week 15	Mod 16: Course Wrap-Up
Week 16	Finals week / Capstone Projects

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Course Outline Details

Module 01: Introduction to Deep Learning

- Course overview and expectations
- Definition and significance of deep learning
- Historical milestones and evolution
- Core components of neural networks
- Impact and applications in modern AI
- **Lab: Setting up a deep learning environment and building a simple neural network for a classification task.**

Module 02: Tools and Environments for Deep Learning

- Programming languages for deep learning
- Development environments (e.g., Jupyter Notebook, VS Code, cloud-based platforms)
- Computing options: cloud vs. local
- Libraries and frameworks for model development
- Repositories and learning platforms
- AI-assisted coding tools
- **Lab: Configuring a development environment and using a deep learning framework to create a basic model.**

Module 03: Foundations of Neural Networks

- Neural network architectures: MLPs vs. deep networks
- Weights, biases, and activation functions
- Training methods: backpropagation, loss functions, dropout, early stopping, hyperparameter tuning
- Optimization techniques: SGD, adaptive methods (e.g., Adam), gradient challenges
- **Lab: Training a deep neural network on a dataset (e.g., Fashion MNIST) and experimenting with optimization strategies.**

Module 04: Convolutional Neural Networks (CNNs)

- CNN fundamentals: convolutional layers, filters, pooling
- Key CNN architectures and their evolution
- Advanced CNN designs and techniques
- Transfer learning for efficient model development
- **Lab : Building a CNN for image classification (e.g., CIFAR-10) and applying transfer learning with a pre-trained model.**

Module 05: Sequence Modeling with Recurrent Neural Networks (RNNs)

- Text preprocessing and embeddings
- RNNs for sequential and time-series data
- Gradient challenges in RNNs
- Advanced RNN variants: LSTMs and GRUs
- **Lab: Developing an RNN or LSTM model for tasks like sentiment analysis or time-series prediction.**

Module 06: Transformers and Attention Mechanisms

- Transformer architecture and attention principles
- Pre-trained models and fine-tuning approaches
- Applications in language and vision tasks
- Transformers for non-language domains
- **Lab: Fine-tuning a transformer model for text classification and experimenting with vision transformers.**

Module 07: Variational Autoencoders (VAEs)

- Autoencoder principles and structure
- VAE architecture and mathematical foundations
- Loss functions and training strategies
- Applications and limitations of VAEs
- **Lab: Implementing a VAE for image generation (e.g., MNIST) and exploring latent space properties.**

Module 08: Generative Adversarial Networks (GANs)

- GAN architecture: generator and discriminator
- Adversarial training dynamics
- Challenges: mode collapse, instability
- Applications in generative tasks
- **Lab: Building a GAN for image generation (e.g., MNIST) and testing different loss functions.**

Module 09: Diffusion Models and Advanced Generative Methods

- Diffusion models and their principles
- Applications in high-quality generation
- Other generative approaches: VQ-VAEs, autoregressive models
- Multimodal learning techniques
- **No Lab, Midterm assigned: Implementing a diffusion model for image generation and exploring multimodal generative tasks.**

Module 10: Reinforcement Learning and AI Agents

- Fundamentals of reinforcement learning
- Deep reinforcement learning methods
- AI agent architectures
- Integration with language models
- Multi-agent systems
- **Lab: Training a reinforcement learning agent (e.g., DQN) for a game and implementing an Actor-Critic model.**

Module 11: Reasoning Models and Retrieval-Augmented Generation (RAG)

- Advanced agent architectures for reasoning
- Reasoning strategies: chain-of-thought, tree-of-thought
- RAG systems: retrieval and generation integration
- Role of feedback in agent improvement
- **Lab: Building a RAG system for knowledge-enhanced generation and testing reasoning patterns.**

Module 12: Agent Planning and Orchestration

- Planning techniques: task decomposition, hierarchical planning
- Orchestration: workflows, decision trees, state machines
- Behavior trees for agent control
- Memory management in agents
- **Lab: Developing a planning-focused agent with execution monitoring and recovery mechanisms.**

Module 13: Agent Frameworks and Architectures

- Agent framework components and design
- Memory and context management
- Tool and API integration
- Building scalable agent systems
- **Lab: Creating an agent system with integrated tools and memory management using a framework.**

Module 14: Advanced Agent Systems and Applications

- Multi-agent architectures and collaboration
- Orchestration with human-in-the-loop
- Agent performance evaluation
- Domain-specific agent applications
- Deployment and scalability considerations
- **Lab: Designing a multi-agent system for a specific domain (e.g., research or business).**

Module 15: Future Trends in Deep Learning

- Emerging models and learning paradigms
- Applications in critical and creative domains
- Synthesis of course concepts
- Trends shaping the future of AI
- **Lab: Exploring an emerging model for a novel application (e.g., healthcare or sustainability).**

Module 16: Course Wrap-Up and Capstone Project

- Review of key learnings
- Capstone project development and presentation
- Final portfolio compilation

Teaching Methods and Strategies

- Total Course Duration: 96 contact hours; 16 weeks
- Weekly Contact Time: 6 hours
- Weekly Structure:
    - Lecture: 2-3 hours
    - Lab: 3-4 hours