Deep Learning Specialization

Module 1: Introduction to Deep Learning

- What is Deep Learning?
- Neural Networks vs Traditional ML
- Biological vs Artificial Neurons
- Deep Learning Workflow
- Activation Functions (ReLU, Sigmoid, Tanh)
- Cost Functions and Optimization
- Forward and Backward Propagation
- Overfitting and Underfitting
- Regularization (L1, L2, Dropout)

Module 2: Neural Networks in Practice

- Setting up Deep Learning Environment (Colab, Jupyter)
- Vectorization with NumPy
- Initializing Parameters
- Mini-Batch Gradient Descent
- Learning Rate Scheduling
- Hyperparameter Tuning
- Building Models with TensorFlow/Keras
- Case Studies: Binary and Multi-class Classification

Module 3: Structuring Machine Learning Projects

- ML Project Lifecycle
- Orthogonalization and Error Analysis
- Bias-Variance Trade-off in Practice
- Choosing the Right Evaluation Metric
- Data Mismatch and Distribution Shift
- Transfer Learning Basics
- Multi-task Learning
- End-to-End Deep Learning Systems

Module 4: Convolutional Neural Networks (CNNs)

- Why CNNs? Real-life Examples
- Convolution Operation & Filters
- Padding, Stride, Pooling (Max/Average)
- CNN Architectures: LeNet, AlexNet, VGG, ResNet
- Batch Normalization
- Transfer Learning with CNNs
- Image Classification, Object Detection, Image Segmentation
- Using Pretrained Models (MobileNet, ResNet50)

Module 5: Recurrent Neural Networks (RNNs) and Sequence Models

- Time-Series Data & Sequence Processing
- Recurrent Neural Networks (RNNs)
- Vanishing Gradients and Exploding Gradients
- Long Short-Term Memory (LSTM) Networks
- Gated Recurrent Units (GRUs)
- Bidirectional RNNs
- Attention Mechanisms (Intro)
- Applications: Sentiment Analysis, Machine Translation, Chatbots

Module 6: Natural Language Processing (NLP) & Transformers

- Text Preprocessing (Tokenization, Lemmatization)
- Word Embeddings (Word2Vec, GloVe, FastText)
- Sequence-to-Sequence Models
- Introduction to Transformers
- Self-Attention and Positional Encoding
- BERT, GPT Family (GPT-2, GPT-3, GPT-4)
- Fine-tuning Pretrained LLMs
- Practical NLP Applications (QA, Summarization, Chatbots)

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