

Deep Learning Syllabus

Module 1: Introduction to Deep Learning

- History and motivation
- Machine Learning vs. Deep Learning
- Perceptron model
- Biological vs Artificial Neurons
- Linear vs Non-linear models

Practical: Implement a single-layer perceptron in Python

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Module 2: Neural Networks

- Multi-Layer Perceptrons (MLP)
- Forward and Backward Propagation
- Activation Functions (ReLU, Sigmoid, Tanh, Softmax)
- Loss Functions (MSE, Cross-Entropy)
- Optimization Algorithms (SGD, Adam, RMSProp)

Practical: Build a fully-connected NN using TensorFlow or PyTorch

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Module 3: Convolutional Neural Networks (CNNs)

- CNN architecture and layers (Conv, Pooling, Flatten)
- Feature extraction and hierarchical representation
- Regularization (Dropout, BatchNorm)
- Object detection intro (YOLO, SSD overview)

Practical: Image classification using CNN on CIFAR-10/MNIST

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Module 4: Recurrent Neural Networks (RNNs)

- Sequential data modeling
- RNN, LSTM, GRU architectures
- Vanishing gradient problem
- Applications: Text generation, time-series prediction

Practical: Text classification or sequence prediction using LSTM

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Module 5: Autoencoders & Representation Learning

- Undercomplete and Overcomplete Autoencoders
- Denoising Autoencoders
- Variational Autoencoders (VAE)
- Applications: Compression, Denoising, Anomaly Detection

Practical: Implement Autoencoder for image reconstruction

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Module 6: Generative Models

- Introduction to Generative Models
- GANs: Generator and Discriminator
- DCGAN, CycleGAN, Conditional GANs
- Evaluation: Inception Score, FID

Practical: Train a DCGAN on CelebA dataset

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Module 7: Deep Learning for Natural Language Processing

- Word Embeddings (Word2Vec, GloVe)
- Sequence-to-sequence models
- Attention Mechanism
- Transformers and BERT

Practical: Text summarization or sentiment analysis using BERT

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Module 8: Transformers & Vision Transformers

- Self-attention and Multi-head Attention
- Positional Encoding
- Transformer Encoder-Decoder architecture
- Vision Transformer (ViT), DETR

Practical: Fine-tune ViT for image classification

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Module 9: Transfer Learning & Fine-Tuning

- Pre-trained models (ResNet, EfficientNet, VGG)
- Feature extraction vs. fine-tuning
- Domain adaptation

Practical: Transfer learning for medical image classification

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Module 10: Applications & Case Studies

- Medical Imaging
- Speech Recognition
- Autonomous Driving
- Video Surveillance (Anomaly Detection)

Project: Choose one application for a final mini-project

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Module 11: Model Evaluation & Deployment

- Metrics: Accuracy, F1-Score, AUC, Confusion Matrix
- Hyperparameter Tuning (Grid Search, Bayesian Optimization)
- Model Interpretability (Grad-CAM, SHAP, LIME)
- Model Deployment (Flask, TensorFlow Serving, ONNX)

Practical: Deploy a trained model using Flask or Streamlit