Course Outline: Time Series Analysis

Introduction to Time Series Analysis

- What time series is and why it is important
- Types of Time Series Data: Univariate vs Multivariate
- Time Series vs Cross-Sectional Data
- Components of Time Series: Trend, Seasonality, Cyclicity, Noise
- Basic Descriptive Techniques
- Handling Missing Values and Outliers

Time Series Decomposition and Smoothing

- How to decompose trend, seasonality, and residuals
- Smoothing Techniques: Rolling Mean, Exponential Smoothing
- Stationarity and Differencing
- ADF and KPSS Tests
- Resampling and Frequency Conversion

Time Series Models

- Autocorrelation and Partial Autocorrelation (ACF & PACF)
- AR, MA, ARMA, ARIMA Models
- Seasonal ARIMA (SARIMA)
- Exponential Smoothing (Holt-Winters)
- Introduction to Prophet (by Meta)
- Machine Learning Models: Random Forest, XGBoost for Time Series

Model Selection and Evaluation

- Model Selection Using AIC/BIC
- Model Diagnostics and Residual Analysis
- Model Evaluation Metrics: MAE, RMSE, MAPE
- Cross-Validation for Time Series (TimeSeriesSplit)
- Model Comparison and Selection

Advanced Techniques and Applications

- Time Series Applications in Oil and Gas
- Types of Models: Additive, Multiplicative, Pseudo-Additive
- Time Series Forecasting with Python
- Anomaly Detection Using Control Charts
- Introduction and Use Case for Kalman Filters
- Signal Transformations
- Techniques such as Fourier Transformations, Filters, and Window Functions
- Deep Learning with Time Series

Course Outline: Deep Learning & Computer Vision

Foundations of Deep Learning

Introduction to Deep Learning

- Overview and Key Concepts
- Deep Learning Fundamentals
- Neuron & Perceptron, Artificial Neural Network Basics
- From Neuron to Neural Network
- Perceptron, Feed Forward Neural Networks
- Neural Network Architecture, Fully Connected Layers
- Non-Linearity in Neural Networks
- Activation Functions, Bias Node
- Matrix Representation (Vectorization)
- Basics of Forward Propagation and Backpropagation

- Forward Propagation & Backpropagation
- Inference in Neural Networks

Loss Functions and Optimization

- Understanding Objective/Loss/Cost Functions
- Optimizers, Learning Rate, Parameters
- Optimization & Regularization
- Dropout, L1 and L2 Regularization
- Monitoring Training
- Overfitting & Underfitting, Strategies to Combat Them

Neural Network Types and Training

Types of Neural Networks

- Perceptron, Feed Forward NN
- Radial Basis NN (RBF), Deep Feed Forward (DFF)

Model Training

- Definition, Hyperparameters, Examples

Deep Learning Frameworks

PyTorch and Model Building

- Overview, PyTorch Basics
- DataLoaders & Datasets, Model Architecture

Convolutional Neural Networks (CNNs)

CNN Fundamentals

- Brain's Organization, Why Convolutional Layer?
- Convolution: Stride, Visualization of Feature Maps

- CNN Layers and Operations
- Spatial Convolution, Edge Detectors, Border Effects
- Dimension Reduction, Pooling (Max/Average)
- Building a CNN
- The Whole CNN, Feature Maps to FC Layers
- Global Average Pooling (GAP), Last FC Layer

Modern Architectures and Advanced Models

Modern CNN Architectures

- Overview: LeNet, AlexNet, VGG, NiN, GoogLeNet, ResNet
- Residual Connections, Batch Normalization

Recurrent Neural Networks (RNNs)

- Sequence Model, Feed-forward vs Recurrent Network
- RNN with LSTM/GRU, Gate Concept
- Applications of LSTM/RNN
- Neural Machine Translation, Chat Models, Image Caption Generation

Autoencoders

- Autoencoders

Advanced Computer Vision Topics

Object Detection

- Object Detection
- YOLOv5, Faster R-CNN
- Bounding boxes, IoU, NMS

Image Segmentation

- Segmentation

- Semantic vs. instance segmentation
- U-Net, Mask R-CNN

Vision Transformers and Foundation Models

- Vision Transformers
- Foundation Models in Vision
- Segment Anything Model (SAM)
- CLIP and DINO

Generative AI in Vision

- Generative AI for Synthetic Data
- GANs and diffusion models
- Synthetic seismic data generation for training augmentation