Task : 8/6/2025

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1. Graph Neural Networks (GNNs) for Molecular Property Prediction

- **Description**: Represent molecules as graphs (atoms = nodes, bonds = edges) and predict properties like solubility or toxicity.
- **Key Techniques**:
    - Message Passing Neural Networks (MPNN)
    - Graph Convolutional Networks (GCN) / Graph Attention Networks (GAT)
    - Benchmark with MoleculeNet (e.g., ESOL, FreeSolv datasets)
- **What You'll Learn**: graph data preprocessing, custom GNN layers in PyTorch Geometric or DGL, transfer learning on small datasets.

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2. Generative Adversarial Networks (GANs) for Image-to-Image Translation

- **Description**: Train a GAN to convert images from one domain to another—e.g., turning sketches into photos, day to night scenes, or summer to winter landscapes.
- **Key Techniques**:
    - Conditional GANs (cGAN), Pix2Pix, CycleGAN
    - Adversarial loss + cycle consistency loss
    - Image augmentation & training stability tricks (label smoothing, spectral normalization)
- **Datasets**: CMP Facades, Cityscapes, Horse2Zebra.
- **What You'll Learn**: advanced generator/discriminator architectures, balancing multi-term loss functions, high-resolution training.

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3. Transformer-Based Time Series Forecasting

- **Description**: Use Transformer architectures (originally for NLP) to model long-range dependencies in time series—e.g., stock prices, energy consumption, multivariate weather data.
- **Key Techniques**:
    - Self-attention over temporal windows
    - Positional encodings for time steps
    - Encoder–decoder forecasting setup
- **Datasets**: ElectricityLoadDiagrams, M4 Forecasting Competition data.
- **What You'll Learn**: adapting Transformers beyond text, efficient attention for long sequences, multi-horizon forecasting.

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4. Deep Reinforcement Learning (DRL) for Continuous Control

- **Description**: Train agents to perform tasks in continuous action spaces—e.g., robotic arm manipulation, autonomous driving simulators.
- **Key Techniques**:
    - Actor-Critic methods (DDPG, TD3, SAC)
    - Reward shaping and exploration strategies
    - Sim2Real considerations if you move to physical robots
- **Environments**: OpenAI Gym's "Pendulum-v0", "MuJoCo" tasks (HalfCheetah, Ant).
- **What You'll Learn**: stability of policy gradient methods, continuous action discretization, environment interfacing.

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5. Self-Supervised Learning on Vision Transformers (ViT)

- **Description**: Pre-train a Vision Transformer on unlabeled images using contrastive or masked-patch objectives, then fine-tune on classification tasks.
- **Key Techniques**:
    - DINO, MAE (Masked Autoencoders), SimCLR-style losses
    - Patch embedding and positional encoding for images
    - Large-scale pretraining pipelines
- **Datasets**: ImageNet-1k for fine-tuning; use a large unlabelled set (e.g. uncurated Flickr images) for pretraining.
- **What You'll Learn**: transformer internals on vision data, designing pretext tasks, scaling compute.

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6. Neural Architecture Search (NAS) for Custom Model Design

- **Description**: Automate discovery of high-performance model architectures for a given task/dataset rather than hand-crafting layers.
- **Key Techniques**:
    - Reinforcement Learning or Evolutionary Algorithms to propose architectures
    - Weight-sharing one-shot NAS (e.g., DARTS) for efficiency
    - Search space definition and constraints
- **Use Case**: CIFAR-10 or CIFAR-100 architecture search; then transfer to your own image or signal domain.
- **What You'll Learn**: meta-optimization loops, resource-aware search, trade-offs between search cost and accuracy.

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7. Federated Learning with Differential Privacy

- **Description**: Train a global model across multiple client devices (e.g., phones) without sharing raw data, and guarantee user privacy.
- **Key Techniques**:
    - Federated Averaging (FedAvg)
    - Per-client gradient clipping and noise addition for DP
    - Communication efficiency (quantization, sparsification)
- **Simulated Dataset**: Split MNIST or CIFAR into non-IID shards to mimic client heterogeneity.
- **What You'll Learn**: privacy-preserving ML, cross-device coordination, handling non-IID data distributions.

Aslo do Frontend UI for all Proper way