WEEK 4: MODEL BUILDING AND DEEP LEARNING

DAY 19 (17/07/2025)

Deep Learning & Transfer Learning:

Today, we explored Deep Learning (DL) and Transfer Learning (TL) - two foundational concepts that make modern image-based AI so powerful.

1. Deep Learning (DL)

Definition:
Deep Learning is a subset of Machine Learning that uses **Neural Networks with multiple hidden layers**. The "deep" in Deep Learning comes from these stacked layers that allow the model to learn complex representations from raw data.

Why It Matters:

- Traditional ML requires manual feature extraction.
- DL learns features automatically, from simple to complex, layer by layer.

How Layers Work:

1. **Early Layers:** Detect basic patterns like edges, lines, and corners.
2. **Middle Layers:** Combine these simple features to identify more complex patterns like shapes or textures.
3. **Final Layers:** Recognize high-level features and classify the entire object (like a cat, dog, or car).

2. Convolutional Neural Networks (CNNs)

Purpose: CNNs are specialized neural networks for images, designed to efficiently extract spatial hierarchies of features.

Key Concept – Convolution:

- Uses a small matrix called a filter that slides over the image.
- Detects local patterns such as edges, corners, or textures.
- Produces feature maps that highlight where patterns occur in the image.

Other Important Components:

- **Pooling Layers:** Reduce feature map size while keeping important information.
- **Fully Connected Layers:** Combine all features to make the final prediction.

3. Transfer Learning (TL)

Problem with Training from Scratch:

- Training a deep CNN from scratch requires millions of images and massive computational resources.
- Small datasets often lead to overfitting when trained from scratch.

Solution – Transfer Learning:

- Use a **pre-trained model** trained on a large dataset like ImageNet.
- **Freeze** the pre-trained layers (to keep learned features).

- **Replace the output layer** with a new layer matching your specific task (e.g., 2 classes for Cats vs Dogs).

- Train only the new layer (or fine-tune a few top layers) on your smaller dataset.

Advantages of Transfer Learning:

1. **Saves Time:** No need to train millions of parameters from scratch.

2. **Improved Accuracy:** Leverages rich features already learned from a large, general dataset.

3. **Works with Small Datasets:** High performance even with limited data.

Reflection:

- Deep Learning is about automatic hierarchical feature learning.

- CNNs are the go-to architecture for images, detecting patterns at multiple scales.

- Transfer Learning is a shortcut that leverages existing knowledge, making high-performing models achievable even with limited data.

Deep Learning + CNNs give your model the power to understand complex image patterns, while Transfer Learning **accelerates training and improves accuracy** without the massive dataset requirements.