WEEK 4: MODEL BUILDING AND DEEP LEARNING

DAY 17 (15/07/2025)

The Neural Network Blueprint:

Today, I began my deep dive into **Neural Networks (NNs)**, which are the foundation of modern deep learning projects like image classification. Understanding neural networks is crucial because they allow machines to **learn patterns from data in a way inspired by the human brain**.

Biological Inspiration

Neural Networks are inspired by the **human brain**, which is made up of billions of interconnected neurons.

- Each neuron receives information, processes it, and passes it forward to other neurons.

- Similarly, in artificial neural networks, the “neurons” (or nodes) receive input data, process it mathematically, and send outputs to the next layer.

- This architecture allows networks to **learn complex patterns**, just like the brain learns from experience.

The Neuron (Node)

The **neuron** is the fundamental building block of a neural network. Each neuron performs a simple computation, but when many neurons work together, they can handle very complex tasks.

Components of a Neuron:

1. **Inputs:**

    - Each neuron receives several inputs, which are the **features of the data**.

    - In image classification, the inputs are the pixel values of the image.
      For a 160×160 RGB image, there are 160×160 pixels, and each pixel has 3 color channels (Red, Green, Blue). This results in a total of **160 × 160 × 3 = 76,800 input values**, with each neuron corresponding to one of these values.

    - These inputs are then passed forward to the next layer, where the network processes them using weights, biases, and activation functions.

2. **Weights (W):**

    - Each input has an associated **weight**, which determines how important that input is for the neuron's output.

    - During training, the network **learns the optimal weight values** to make accurate predictions.

3. **Bias (b):**

    - The bias is an additional parameter that allows the neuron to **adjust its output independently** of the input values.

    - This helps the network shift the decision boundary to better separate classes.

4. **Activation Function:**

    - Introduces **non-linearity** into the network so it can learn complex patterns.

    - Without activation functions, the network would only learn linear relationships, which are insufficient for tasks like image recognition.

- Common activation functions include ReLU, Sigmoid.

The Layers of a Neural Network

A neural network is organized into **layers**, each with a specific role in processing data.

1. **Input Layer:**
    - Receives the raw data features.
    - This layer does **not perform any computation**; it just passes the data forward.
2. **Hidden Layers:**
    - These are the **processing layers** where the network learns patterns in the data.
    - Multiple hidden layers allow the network to learn **hierarchical features**:
        - Early layers detect simple patterns (edges, colors).
        - Middle layers combine these patterns into more complex features (shapes, textures).
        - Later layers recognize high-level concepts (a cat's face, a dog's ears).
    - Each neuron in hidden layers uses weights, bias, and activation functions to process information.
3. **Output Layer:**

- The output layer is the final layer of the neural network, responsible for producing the model's prediction.

- Each neuron in this layer represents a possible output. For example:
    - In binary classification, there is usually one neuron that outputs a probability between 0 and 1.
    - In multi-class classification, there is one neuron per class, and the network predicts the class with the highest probability.
- The output layer typically uses an activation function to convert raw numbers into meaningful predictions:
    - Sigmoid for binary classification (outputs a probability)
    - Softmax for multi-class classification (outputs probabilities for each class)
- The network's learning process aims to make this output as close as possible to the true label for given inputs.

Reflection:

- Neural networks are like a team of interconnected experts. Each expert (neuron) contributes a small piece of knowledge, and the network combines all contributions to make a final prediction.
- The more complex the task (like classifying images vs. numbers), the deeper the network may need to be, with more hidden layers and neurons.