

CNN Homework

Network Architecture:

1. Input Layer:

- Image Size: 16×16

2. Convolutional Layer 1:

- 8 feature maps
- 5×5 kernel size
- Stride = 1, No padding

3. Max Pooling Layer:

- 2×2 receptive fields
- No overlap
- No trainable weights

4. Convolutional Layer 2:

- 10 feature maps
- 3×3 kernel size
- Stride = 1, No padding
- Fully connected to all maps in the previous layer

5. Fully Connected MLP:

- 20 hidden nodes

6. Output Layer:

- 3 nodes (for 3 classes)
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Layer-wise Details

1. Input Layer

- a) Map Size:

16×16

- b) Unique Trainable Weights:

0

- c) Total Connections:

0

2. Convolutional Layer 1

- a) Map Size:

$$\left(\frac{16 - 5}{1} + 1 \right) \times \left(\frac{16 - 5}{1} + 1 \right) = 12 \times 12$$

- b) Unique Trainable Weights:

Each filter has:

$$5 \times 5 \text{ (kernel)} + 1 \text{ (bias)} = 26 \text{ weights}$$

Total for 8 feature maps:

$$26 \times 8 = 208$$

- c) Total Connections:

$$5 \times 5 \times 1 \times 8 = 200$$

3. Max Pooling Layer

- a) Map Size:

$$\frac{12}{2} \times \frac{12}{2} = 6 \times 6$$

- b) Unique Trainable Weights:

0

- c) Total Connections:

0

4. Convolutional Layer 2

- a) Map Size:

$$\left(\frac{6-3}{1} + 1\right) \times \left(\frac{6-3}{1} + 1\right) = 4 \times 4$$

- **b) Unique Trainable Weights:**

Each filter has:

$$3 \times 3 \times 8 \text{ (input feature maps)} + 1 \text{ (bias)} = 73 \text{ weights}$$

Total for 10 feature maps:

$$73 \times 10 = 730$$

- **c) Total Connections:**

$$3 \times 3 \times 8 \times 10 = 720$$

5. Fully Connected MLP

- **a) Input Size:**

$$4 \times 4 \times 10 = 160$$

- **b) Unique Trainable Weights:**

$$160 \times 20 \text{ (hidden nodes)} + 20 \text{ (bias)} = 3,220$$

- **c) Total Connections:**

$$160 \times 20 = 3,200$$

6. Output Layer

- **a) Map Size:**

$$3 \text{ nodes}$$

- **b) Unique Trainable Weights:**

$$20 \times 3 \text{ (output nodes)} + 3 \text{ (bias)} = 63$$

- **c) Total Connections:**

$$20 \times 3 = 60$$

Summary

Layer	Map Size	Trainable Weights	Total Connections
Input	16×16	0	0
Conv Layer 1	12×12	208	200
Max Pooling	6×6	0	0
Conv Layer 2	4×4	730	720
Fully Connected (MLP)	-	3,220	3,200
Output Layer	3 nodes	63	60

Total Trainable Weights:

$$208 + 730 + 3,220 + 63 = 4,221$$

Total Connections:

$$200 + 720 + 3,200 + 60 = 4,180$$

Explanation:

- **Map Size Calculations:** For convolutional layers, the output size is determined by:

$$\text{Output size} = \frac{\text{Input size} - \text{Kernel size}}{\text{Stride}} + 1$$

- **Trainable Weights:** Calculated as:

$$\text{Weights per filter} = (\text{Kernel height} \times \text{Kernel width} \times \text{Input channels}) + \text{Bias}$$

$$\text{Total weights} = \text{Weights per filter} \times \text{Number of filters}$$

- **Total Connections:** Represents the number of weights excluding biases:

$$\text{Connections} = \text{Kernel height} \times \text{Kernel width} \times \text{Input channels} \times \text{Number of filters}$$

- **Fully Connected Layers:**

- **Weights:**

$$\text{Input neurons} \times \text{Hidden neurons} + \text{Biases}$$

- **Connections:**

Input neurons \times Hidden neurons