Class Activation Mapping (CAM) in CNN - Forward Propagation

Step 1: Forward Propagation in a CNN

Forward propagation refers to the process where the input (an image) is passed through the various layers of the neural network,
and the output (predictions) is computed.

1. Input Image: A grayscale image of size 3x3 is provided as input to the CNN.
2. Convolutional Layer: The image passes through a convolutional filter, which extracts features.
3. Activation Layer: A ReLU activation function is applied after convolution to introduce non-linearity.
4. Fully Connected Layer: The output of the convolutional layer is flattened and passed through fully connected layers for classification.

In this example, we compute the score for each class using the feature map generated from the convolutional layer.

Input Image (3x3):

The input image is represented as a 3x3 matrix:

[[0.4, 0.6, 0.3],
 [0.1, 0.5, 0.2],
 [0.7, 0.6, 0.9]]

After passing through the convolution and ReLU activation layers, the feature map (A) is as follows:

[[0.4, 0.6, 0.3],
 [0.1, 0.5, 0.2],
 [0.7, 0.6, 0.9]]

Weights for Classes and Score Calculation:

The model uses learned weights for each class:

- Weight for Class 1 (w1) = 0.5

- Weight for Class 2 (w2) = 0.7

The prediction scores for each class are calculated using the following formula:

score_c = sum(A * w_c) for all pixels

For Class 1:

score_1 = 0.5 * (0.4 + 0.6 + 0.3 + 0.1 + 0.5 + 0.2 + 0.7 + 0.6 + 0.9) = 2.15

For Class 2:

score_2 = 0.7 * (0.4 + 0.6 + 0.3 + 0.1 + 0.5 + 0.2 + 0.7 + 0.6 + 0.9) = 3.01

Step 2: Class Activation Mapping (CAM)

CAM helps to visualize which parts of the input image are contributing most to the model's prediction for each class.

The CAM for each class is computed by multiplying the feature map values by the learned weights.

For Class 1 (weight = 0.5):

CAM_1 = [[0.2, 0.3, 0.15],

[0.05, 0.25, 0.1],

[0.35, 0.3, 0.45]]

For Class 2 (weight = 0.7):

CAM_2 = [[0.28, 0.42, 0.21],

[0.07, 0.35, 0.14],

[0.49, 0.42, 0.63]]

These CAMs show which regions of the input image are most important for each class prediction.