6CS012 - Artificial Intelligence and Machine Learning. Practical Aspects of Training a CNN.

Prepared By: Siman Giri {Module Leader - 6CS012}

March 30, 2025

Tutorial - 6.

1 Instructions

This sheet contains exercises for various operations performed in Convolutional Neural Networks, accompanying the tutorial slides

- Please Complete all the exercise with Pen and On Paper.

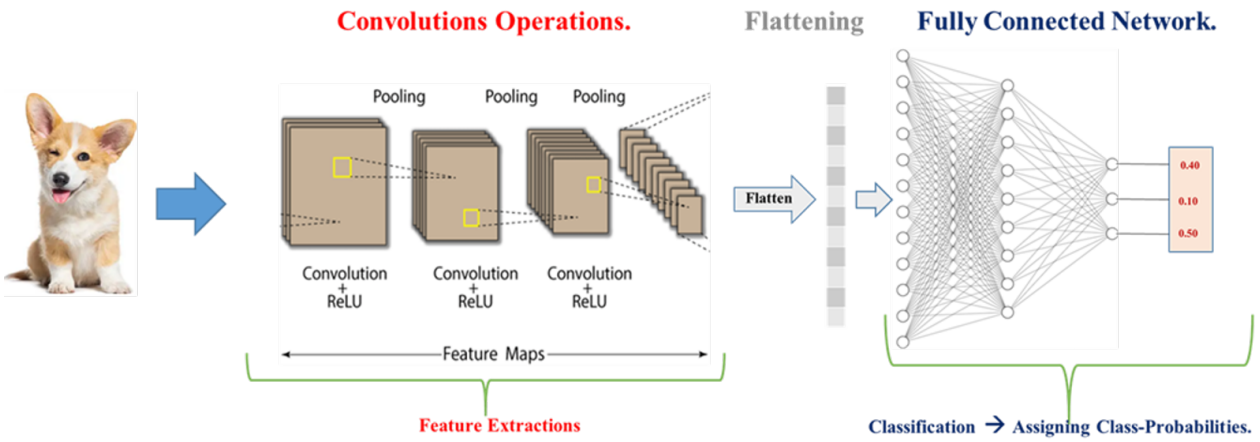

Figure 1: An example of Convolutional Neural Network.

2 Exercise - 1:

Convolutional Layer and Pooling Operations:

1. Consider the following input image:

$$I = \begin{bmatrix} 20 & 35 & 35 & 35 & 35 & 20 \\ 29 & 46 & 44 & 42 & 42 & 27 \\ 16 & 25 & 21 & 19 & 19 & 12 \\ 66 & 120 & 116 & 154 & 114 & 62 \\ 74 & 216 & 174 & 252 & 172 & 112 \\ 70 & 210 & 170 & 250 & 170 & 110 \end{bmatrix}$$

   What is the output provided by a convolution layer with the following properties:

   - **Stride of 1**.
   - **Filter is given by:**

$$K = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

2. Take the output from 1. and apply a max pooling layer with the following properties:

   - Stride - $[2, 2]$.
   - Window Shape - $[2, 2]$
   - **{Hint: First Compute the Output Dimension.}**

3. For the following Feature Map of 4×4 apply the 2×2 pooling operation with stride 2:

$$I = \begin{bmatrix} 5, & 12, & 8, & 1 \\ 3, & 7, & 6, & 14 \\ 9, & 4, & 2, & 11 \\ 15, & 10, & 13, & 16 \end{bmatrix}$$

4. For the following Feature Map apply a 2×2 average pooling with stride 2.

$$X = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \\ 13 & 14 & 15 & 16 \end{bmatrix}$$

3 Exercise - 2:

Model Architecture and Parameter Count.

1. Given is a CNN Architecture, Count the number of Parameters.

   - Given CNN Architecture:
     (a) **CONV2D Layer 1:**
       – Filters: 16 Filters each of size 3×3.
       – Input Size: $32 \times 32 \times 3$ i.e. (Height, Width Channels).
     (b) **BatchNormalization Layer - 2:**
       – This layer normalizes each of the 16 Feature maps (Channels).
     (c) **MaxPooling:**
       – Window of 2×2 with strides of 2.
       – No Parameters to count.
     (d) **CONV2D Layer 2:**
       – Filters: 32 Filters each of size 3×3.
       – Input Size: $16 \times 16 \times 16$ after maxpooling which halves the size.
     (e) **BatchNormalization Layer - 2:**
       – This layer normalizes each of the 32 feature maps.
     (f) **MaxPooling Layer - 2:**
       – Window of 2×2 with strides of 2.
       – No Parameters to count.
     (g) **Flattening:**
       – Flattens $8 \times 8 \times 32$ to 1D Vector.
     (h) **Dense layer 1:**
       – Input Dimensions : From Flatten $8 \times 8 \times 32$
       – Neurons: 128
     (i) **Dense Layer 2 - Output Layer:**
       – Input size: 128 from Dense Layer 1.
       – Neurons: 10 (assume your dataset has 10 classes).

A Sample Computations for CONV2D Layer 1:

- CONV2D Layer 1:
  – Input Dimensions $32 \times 32 \times 3$.
  – Filter Size 3×3.
  – Number of filters 16.
- To calculate the number of parameters:
  –

$$\texttt{Weight Parameters} = F_H \times F_W \times \texttt{input channels} \times \texttt{Output Channels}$$

$$\texttt{Weight Parameters} = 3 \times 3 \times 3 \times 16 = 432$$

–

$$\texttt{Bias Parameters} = \texttt{Output Channels} \text{ i.e. one bias per filter.}$$

$$\texttt{Bias Parameters} = 16 \text{one per filter.}$$

– **Total Parameters for CONV2D Layer 1**:

$$432 + 16 = 448.$$

——————— Good Luck. ———————-