

## DSE 3151 DEEP LEARNING

### SOLUTION FOR MISAC-1 : SET1

DATE: 31-08-2023

DURATION: 20 MINS

MAX. MARKS: 5

1. Consider a Convolutional Neural Network (CNN) applied to gridded weather data. The input consists of 7-channels (corresponding to the value of 7 atmospheric variables) of size 16 x 16 corresponding to spatial grids in the region of interest. Answer the following questions:
  - a. Compute the size of the feature map obtained as a result of applying a convolution operation on the input data. To perform the convolution, eight filters each of size 3 x 5 is used. The stride length is 1 in the horizontal direction, and 2 in the vertical direction, and no padding is applied. [1 mark]
  - b. Compute the number of parameters and the total number of connections (including the bias) between the input layer and the convolution layer (whose details are same as described in 1.a). [1.5 marks]

**CO2 APPLICATION**

#### Answer:

##### 1.a.

$$W2 = ((W1 - F + 2P)/S) + 1 \Rightarrow W2 = ((16 - 3 + 0)/1) + 1 = 13 + 1 = 14$$

$$H2 = ((H1 - F + 2P)/S) + 1 \Rightarrow H2 = ((16 - 5 + 0)/2) + 1 = \text{floor}(5.5) + 1 = 6$$

$$D2 = 8$$

**Feature map size: 14 x 6 x 8**

##### 1.b.

$$\text{Number of parameters} = ((3 * 5 * 7) + 1) * 8 = 848$$

Do the following to calculate the no. of connections:

--Each neuron of one plane of the feature map (in the convolution layer) is connected to

$$(3*5*7) + 1 = 106 \text{ neurons in the input layer.}$$

$$\text{--Total connections for 1 plane of feature map in the convolution layer} = 14*6*106 = 8904$$

$$\text{--Total connections for 8 planes of feature maps in the convolution layer} = 8904*8 = 71232$$

$$\text{Total no. of connections} = ((3*5*7) + 1) * (14*6) * 8 = 71232$$

2. For the following Neural Network:

a. Consider a training instance [1,0,1,1]. Compute the Output at F after feed of the training instance to the neural network.

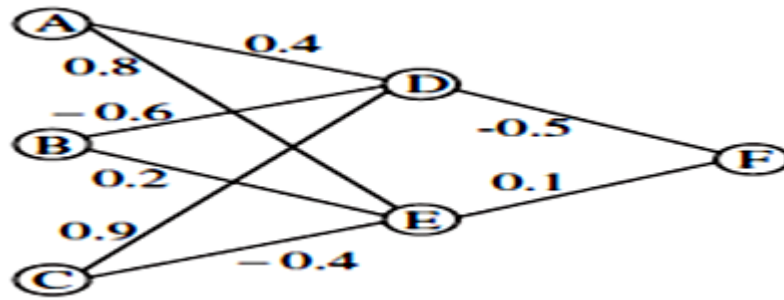
b. After 1 instance of the training, compute the loss.

[1 mark]

c. Compute the change in weights of the Neural Network using back propagation. (Assume learning rate of 0.7)

[1.5 marks]

CO2 APPLICATION



Q) 
$$\text{Sigmoid} = \frac{1}{1 + e^{-x}}$$

○ / Bias assumed to be 0

i) Net Input & Output Calculations

| Unit | Input  | Output (Sigmoid)                |
|------|--|---------------------------------|
| D    | $0.4 + 0 + 0.9 = 1.3$                                | $1 / (1 + e^{-1.3}) = 0.786$    |
| E    | $0.8 + 0 + (-0.4) = 0.4$                             | $1 / (1 + e^{-0.4}) = 0.599$    |
| F    | $(0.786 \times -0.5) + (0.599 \times 0.1) = -0.3362$ | $1 / (1 + e^{-0.3362}) = 0.417$ |

ii) Calc Error at each node

| UNIT | Error  |
|------|--|
| F    | $0.417(1 - 0.417)(1 - 0.417) = 0.142$                |
| E    | $0.599(1 - 0.599)(0.142)(0.1) = 3.41 \times 10^{-3}$ |
| D    | $0.786(1 - 0.786)(0.142)(-0.5) = -0.012$             |

ii) Weights adjust & updation  $Lx = 0.7$

$$\Delta w_{ij} = (Lx) Err_j \cdot a_i - o_i$$
$$w_{ij} = w_{ij} + \Delta w_{ij}$$

$$w_{DF} = (-0.5) + ((0.7)(0.147)(0.786))$$
$$= -0.422$$

$$w_{EF} = (0.1) + ((0.7)(0.147)(0.599))$$
$$= 0.16$$

$$w_{AD} = (0.4) + ((0.7)(-0.012)(1))$$
$$= 0.4$$

$$w_{AE} = (0.8) + ((0.7)(3.41 \times 10^{-3}) \times 1)$$
$$= 0.802$$

$$w_{BD} = -0.6 \quad \left. \vphantom{w_{BD}} \right\} \text{ since } o_i = 0$$

$$w_{BE} = 0.2$$

$$w_{CD} = (0.9) + ((0.7)(-0.012)(1))$$
$$= 0.89$$

$$w_{CE} = (-0.4) + ((0.7)(3.41 \times 10^{-3})(1))$$
$$= -0.397$$

## DSE 3151 DEEP LEARNING

### SOLUTION FOR MISAC-1: SET2

DATE: 31-08-2023

DURATION: 20 MINS

MAX. MARKS: 5

1. Consider a Convolutional Neural Network (CNN) applied to gridded weather data. The input consists of 5-channels (corresponding to the value of 5 atmospheric variables) of size  $8 \times 16$  corresponding to spatial grids in the region of interest. Answer the following questions:
  - a. Compute the size of the feature map obtained as a result of applying a convolution operation on the input data. To perform the convolution, eight filters each of size  $3 \times 3$  is used. The stride length is 2 in the horizontal direction, and 1 in the vertical direction, and no padding is applied. [1 mark]
  - b. Compute the number of parameters and the total number of connections (including the bias) between the input layer and the convolution layer (whose details are same as described in 1.a). [1.5 marks]

CO2 APPLICATION

#### Answer:

##### 1.a.

$$W2 = ((W1 - F + 2P)/S) + 1 \Rightarrow W2 = ((8 - 3 + 0)/2) + 1 = \text{floor}(2.5) + 1 = 3$$

$$H2 = ((H1 - F + 2P)/S) + 1 \Rightarrow H2 = ((16 - 3 + 0)/1) + 1 = 13 + 1 = 14$$

$$D2 = 8$$

**Feature map size:  $3 \times 14 \times 8$**

##### 1.b.

$$\text{Number of parameters} = ((3 * 3 * 5) + 1) * 8 = 368$$

Do the following to calculate the no. of connections:

--Each neuron of one plane of the feature map (in the convolution layer) is connected to

$$(3*3*5) + 1 = 46 \text{ neurons in the input layer.}$$

$$\text{--Total connections for 1 plane of feature map in the convolution layer} = 3*14*46 = 1932$$

$$\text{--Total connections for 8 planes of feature maps in the convolution layer} = 1932*8 = 15456$$

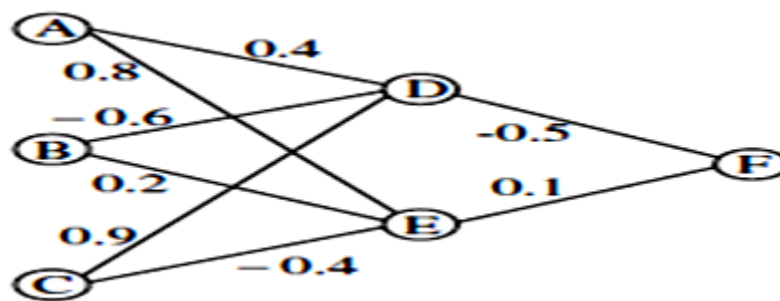
$$\text{Total no. of connections} = ((3*3*5) + 1) * (3*14) * 8 = 15456$$

2. For the following Neural Network:

- d. Consider a training instance [1,1,0,1]. Compute the Output at F after feeding the training instance to the neural network.
- e. After 1 instance of the training, compute the loss. [1 mark]
- f. Compute the change in weights of the Neural Network using back propagation. (Assume learning rate of 0.5)

[1.5 marks]

CO2 APPLICATION



Input = 1 1 0      Output = 1

$$\text{Input}_D = 1 \times 0.4 + 1 \times (-0.6) + 0 \times 0.9 = -0.2$$

$$\text{Input}_E = 1 \times 0.8 + 1 \times 0.2 + 0 \times (-0.4) = 1$$

Assuming Sigmoid Activation

$$\text{Output}_D = 0.4501 \quad \text{Output}_E = 0.7310$$

$$\text{Input}_F = 0.4501 \times (-0.5) + 0.7310 \times 0.1 = -0.22505 + 0.0731 = -0.15195$$

$$\text{Output}_F \text{ (Sigmoid)} = 0.46208$$

$$\text{Error}_F = \text{Output}_F (1 - \text{Output}_F) (\text{Actual} - \text{Output}_F)$$

$$= 0.46208 (1 - 0.46208) (1 - 0.46208)$$

$$= 0.46208 \times 0.53792 \times 0.53792 = 0.1337$$

$$\text{Error}_D = \text{Output}_D (1 - \text{Output}_D) (\text{Error}_F \times W_{DF})$$

$$= 0.4501 (0.5499) (0.1337 \times (-0.5)) = -0.0165$$

$$\text{Error}_E = \text{Output}_E (1 - \text{Output}_E) (\text{Error}_F \times W_{EF})$$

$$= 0.7310 (0.269) (0.1337 \times 0.1) = 0.002629$$

$$W_{AD} = 0.4 + 0.5 (-0.0165) (1) = 0.39173$$

$$W_{AE} = 0.8 + 0.5 (0.002629) (1) = 0.80131$$

$$W_{BD} = -0.6 + 0.5 (-0.0165) (1) = -0.60825$$

$$W_{BE} = 0.2 + 0.5 (0.002629) (1) = 0.20131$$

$$W_{CD} = 0.9 + 0.5 (-0.0165) (1) = 0.9$$

$$W_{CE} = -0.4 + 0.5 (0.002629) (1) = -0.39737$$

$$W_{DF} = -0.5 + 0.5 (0.1337) (0.4501) = -0.46901$$

$$W_{EF} = 0.1 + 0.5 (0.1337) (0.46208) = 0.1318$$