CSC 412 Machine Learning and Knowledge Discovery

Exercise II

1. (12 points) Deep Neural Network



Here is a graph representing a fully connected network. All the hidden layers use the Sigmoid function, and the output layer uses the Softmax function. We use a data batch size of 32 as an input.

- (a) What is the shape of $a^{[1]}$?
- (b) What is the shape of X?
- (c) What is the shape of $\boldsymbol{W}^{[2]}$?
- (d) Let $A^{[1]} = \sigma(XW^{[1]} + b^{[1]})$. What is the shape of $A^{[1]}$?
- (e) What is $a_2^{[2]}$?
- (f) What is $oldsymbol{W}_3^{[3]}$?
- (g) How many parameters are there in this network?
- (h) What could this network be used for? (Choose one)
 - (i) Predicting if Donald Trump wins or loses
 - (ii) Predicting a stock's price

- (iii) Predicting a student's final grade
- (i) Complete the code of this network:

```
model = keras.models.Sequential([
    keras.layers.Flatten(input_shape=[2, 2]),
    keras.layers.Dense(3, activation="sigmoid"),
```

(j) What does the sgd mean in the previous code?

(k) Let

$$\boldsymbol{a}^{[3]} = \begin{bmatrix} 1\\1\\0\\1 \end{bmatrix}$$
, $\boldsymbol{W}^{[4]} = \begin{bmatrix} 1 & 1 & 0\\1 & 0 & 1\\0 & 1 & 0\\1 & 1 & 0 \end{bmatrix}$, and $\boldsymbol{b}^{[4]} = \begin{bmatrix} 0\\0\\1 \end{bmatrix}$. What is $\boldsymbol{a}^{[4]}_3$?

Answer:

(a) 3×1 (b) 32×4 (c) 3×5 (d) 32×3 (g) $(4 \times 3 + 3) + (3 \times 5 + 5) + (5 \times 4 + 4) + (4 \times 3 + 3)$ (h) (iii) (i) keras.layers.Dense(5, activation="sigmoid"), keras.layers.Dense(4, activation="sigmoid"), keras.layers.Dense(3, activation="softmax") (j) Stochastic Gradient Descent (k)

$$\boldsymbol{z}^{[4]^{\mathsf{T}}} = \boldsymbol{a}^{[3]^{\mathsf{T}}} \cdot \boldsymbol{W}^{[4]} + \boldsymbol{b}^{[4]^{\mathsf{T}}} = \begin{bmatrix} 1 & 1 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 1 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 3 & 2 & 2 \end{bmatrix}$$
$$\boldsymbol{a}^{[4]}_{3} = \frac{e^{2}}{e^{3} + e^{2} + e^{2}}$$