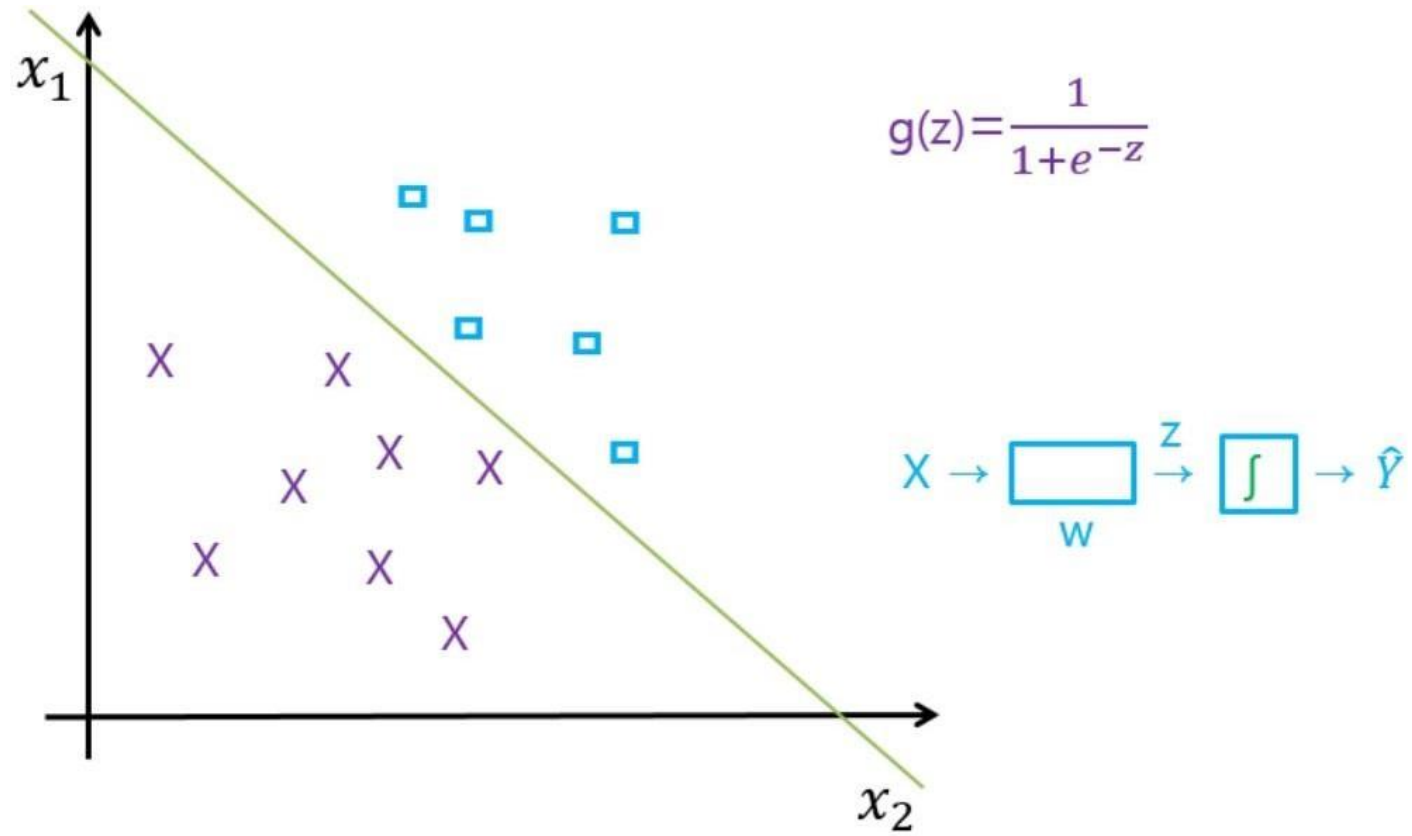




DEEP LEARNING

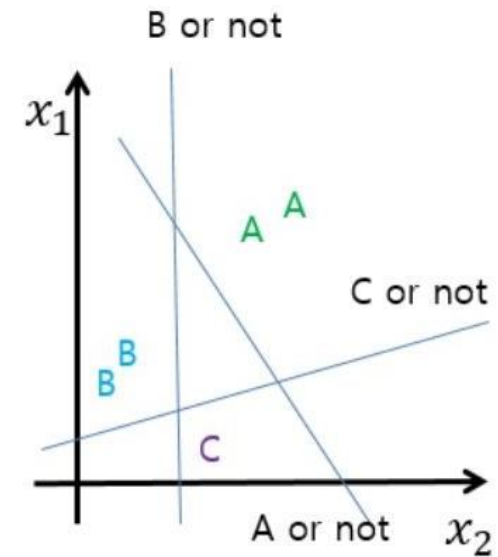
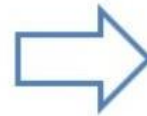
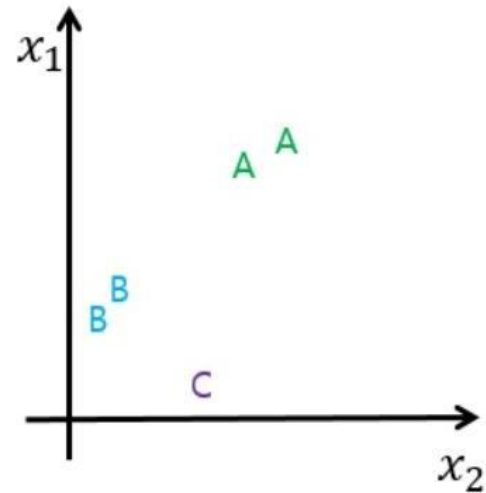
CROSS-ENTROPY

LOGISTIC REGRESSION

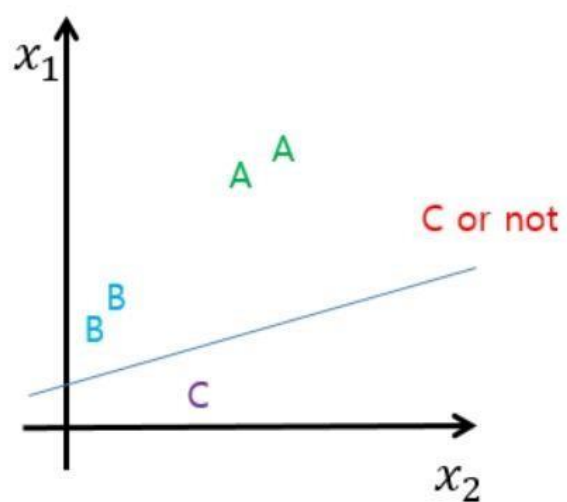


MULTINOMIAL CLASSIFICATION

x1 (hours)	x2 (attendance)	y (grade)
10	5	A
9	5	A
3	2	B
2	4	B
11	1	C

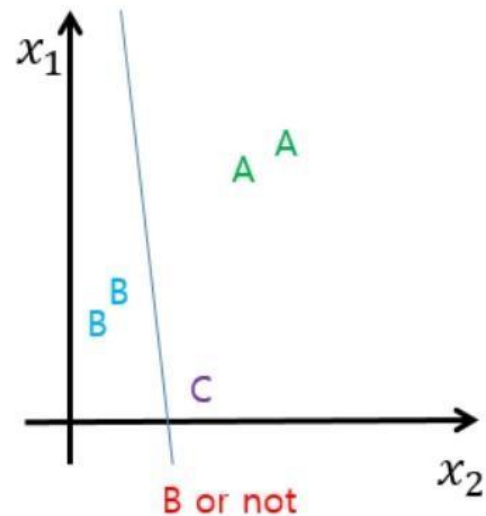


MULTINOMIAL CLASSIFICATION



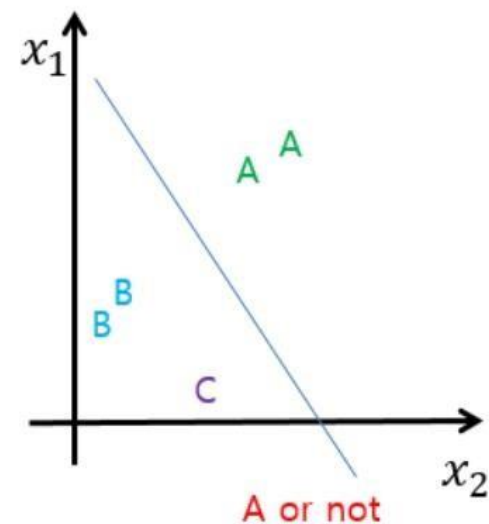
$$X \rightarrow \boxed{} \rightarrow \hat{Y}$$

A



$$X \rightarrow \boxed{} \rightarrow \hat{Y}$$

B



$$X \rightarrow \boxed{} \rightarrow \hat{Y}$$

C

MULTINOMIAL CLASSIFICATION

$$[w_1 \ w_2 \ w_3] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = [w_1 x_1 + w_2 x_2 + w_3 x_3]$$

$$X \rightarrow \boxed{} \xrightarrow{Z} \boxed{\int} \rightarrow \hat{Y}$$

W

$$[w_1 \ w_2 \ w_3] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = [w_1 x_1 + w_2 x_2 + w_3 x_3]$$

$$X \rightarrow \boxed{} \xrightarrow{Z} \boxed{\int} \rightarrow \hat{Y}$$

W

$$[w_1 \ w_2 \ w_3] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = [w_1 x_1 + w_2 x_2 + w_3 x_3]$$

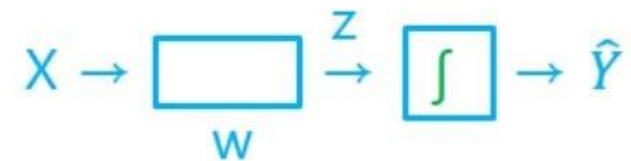
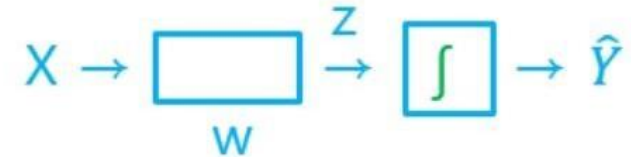
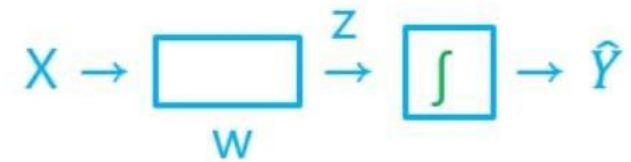
$$X \rightarrow \boxed{} \xrightarrow{Z} \boxed{\int} \rightarrow \hat{Y}$$

W

MULTINOMIAL CLASSIFICATION

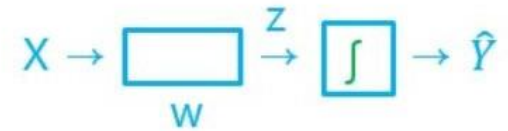
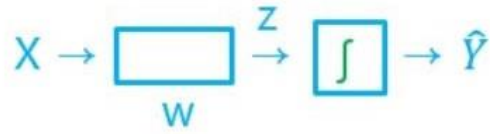
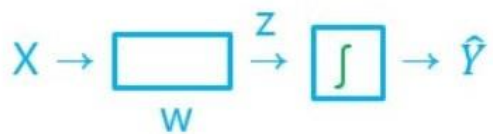
$$[w_1 \ w_2 \ w_3] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = [w_1 x_1 + w_2 x_2 + w_3 x_3]$$

$$\begin{bmatrix} w_{A1} & w_{A2} & w_{A3} \\ w_{B1} & w_{B2} & w_{B3} \\ w_{C1} & w_{C2} & w_{C3} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = ?$$



MULTINOMIAL CLASSIFICATION

$$\begin{bmatrix} w_{A1} & w_{A2} & w_{A3} \\ w_{B1} & w_{B2} & w_{B3} \\ w_{C1} & w_{C2} & w_{C3} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} w_{A1}x_1 + w_{A2}x_2 + w_{A3}x_3 \\ w_{B1}x_1 + w_{B2}x_2 + w_{B3}x_3 \\ w_{C1}x_1 + w_{C2}x_2 + w_{C3}x_3 \end{bmatrix} = \begin{bmatrix} \hat{y}_A \\ \hat{y}_B \\ \hat{y}_C \end{bmatrix}$$



WHERE IS SIGMOID?

$$\begin{bmatrix} w_{A1} & w_{A2} & w_{A3} \\ w_{B1} & w_{B2} & w_{B3} \\ w_{C1} & w_{C2} & w_{C3} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} w_{A1}x_1 + w_{A2}x_2 + w_{A3}x_3 \\ w_{B1}x_1 + w_{B2}x_2 + w_{B3}x_3 \\ w_{C1}x_1 + w_{C2}x_2 + w_{C3}x_3 \end{bmatrix} = \begin{bmatrix} \hat{Y}_A \\ \hat{Y}_B \\ \hat{Y}_C \end{bmatrix} \begin{bmatrix} 2.0 \\ 1.0 \\ 0.1 \end{bmatrix}$$



SIGMOID?

LOGISTIC
CLASSIFIER

$$WX = Y \quad \begin{bmatrix} 2.0 \\ 1.0 \\ 0.1 \end{bmatrix}$$

$$p = 0.7$$



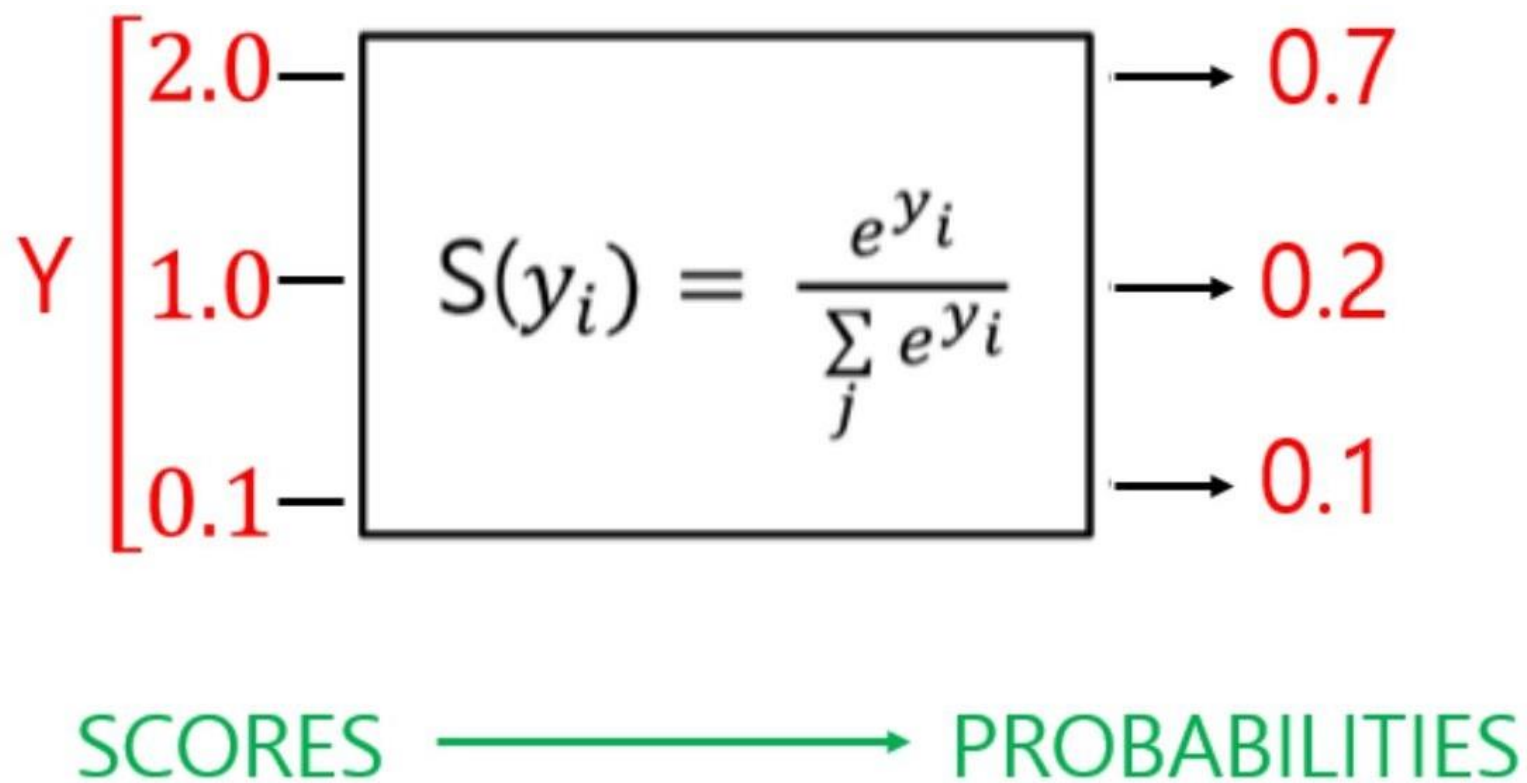
$$p = 0.2$$



$$p = 0.1$$

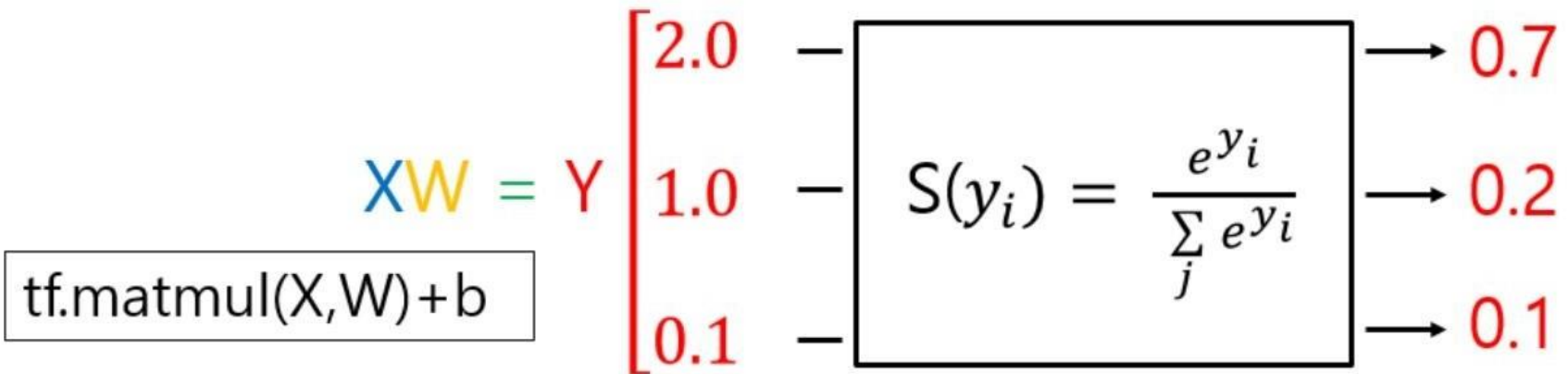


SOFTMAX



SOFTMAX

```
hypothesis = tf.nn.softmax(tf.matmul(X,W)+b)
```



SOFTMAX_CROSS_ENTROPY_WITH_LOGI

```
logits = tf.matmul(X, W) + b  
hypothesis = tf.nn.softmax(logits)
```

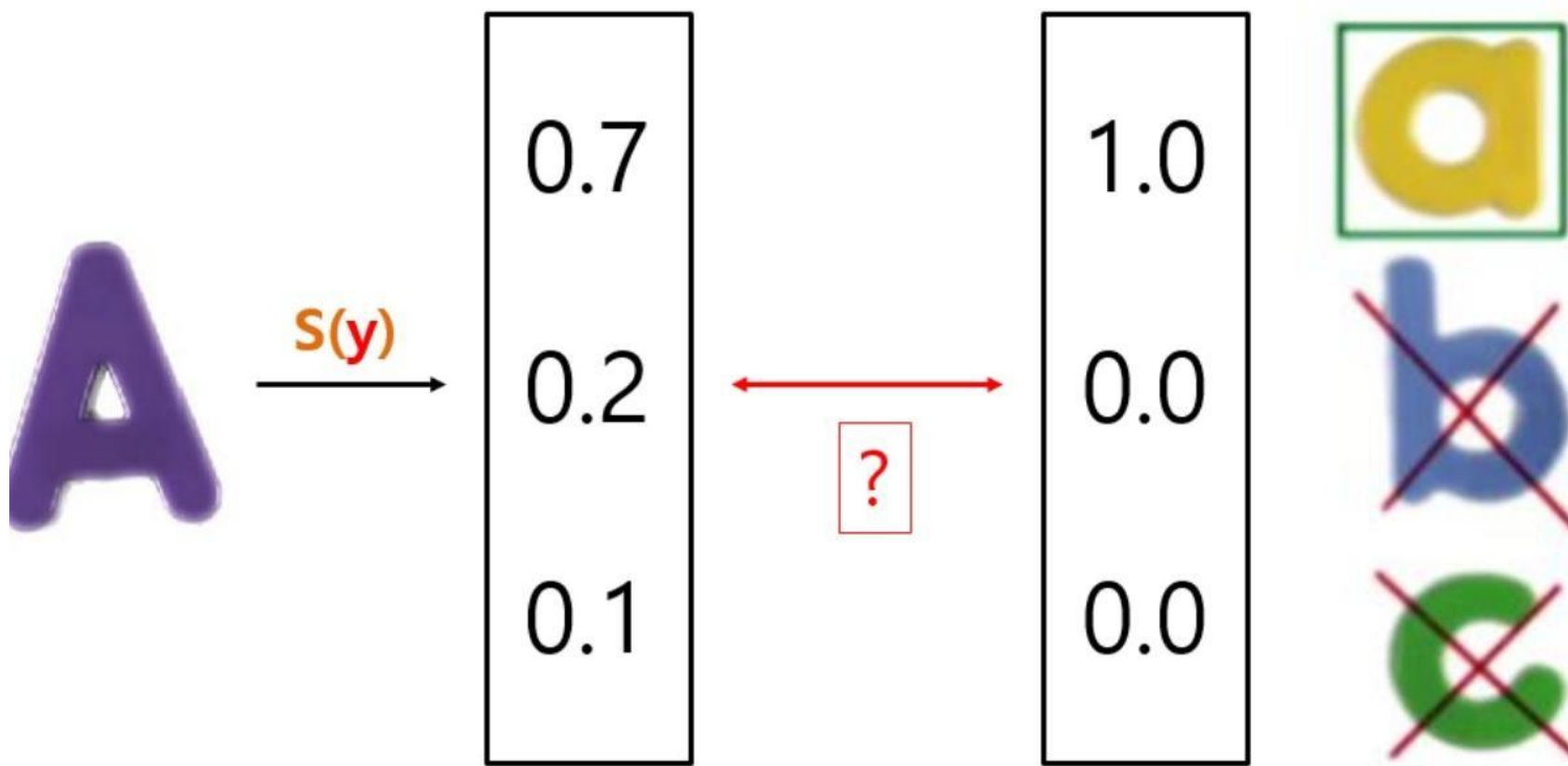
1

```
# Cross entropy cost/loss  
cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))
```

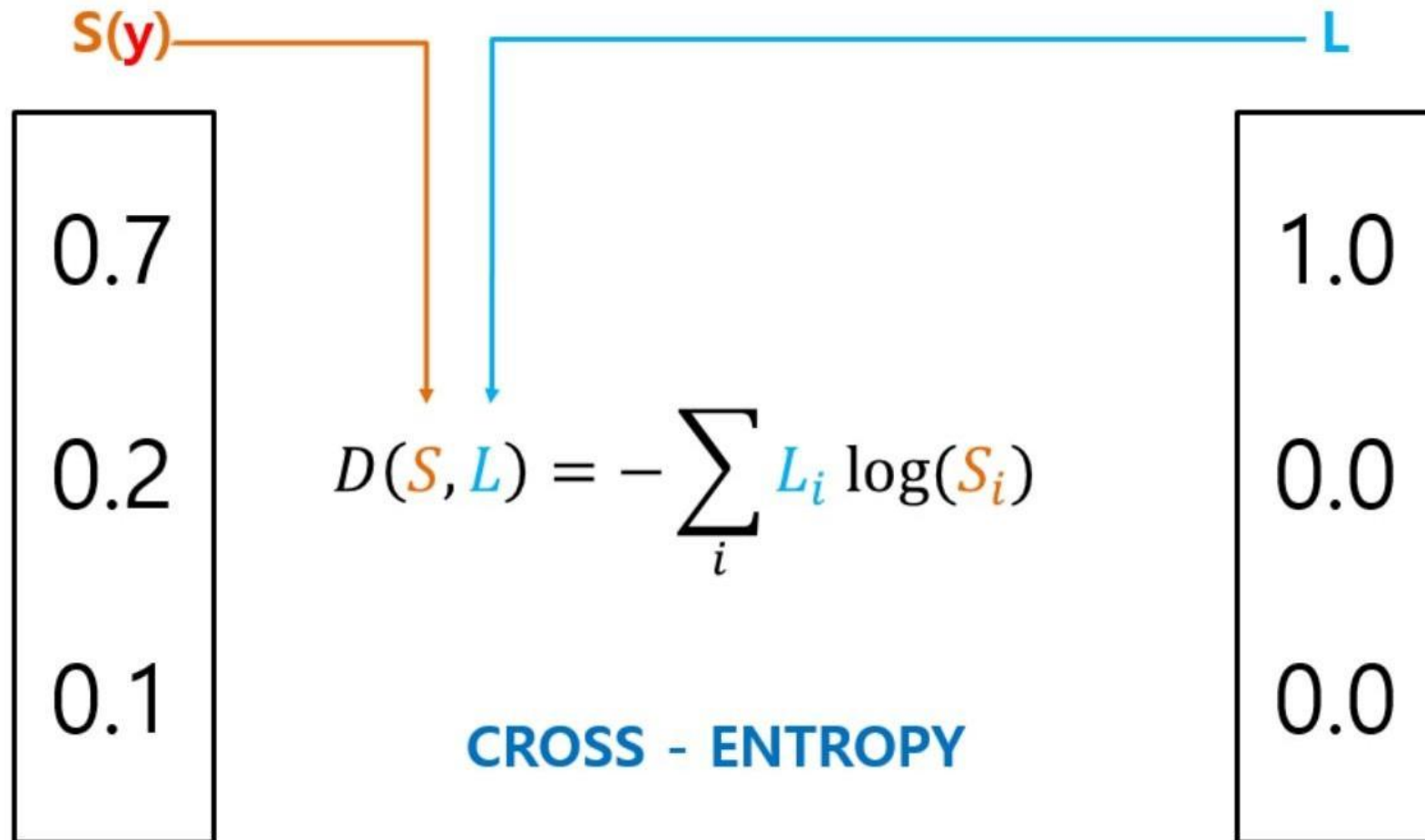
2

```
# Cross entropy cost/loss  
cost_i = tf.nn.softmax_cross_entropy_with_logits(logits=logits,  
                                                  labels=Y_one_hot)  
cost = tf.reduce_mean(cost_i)
```

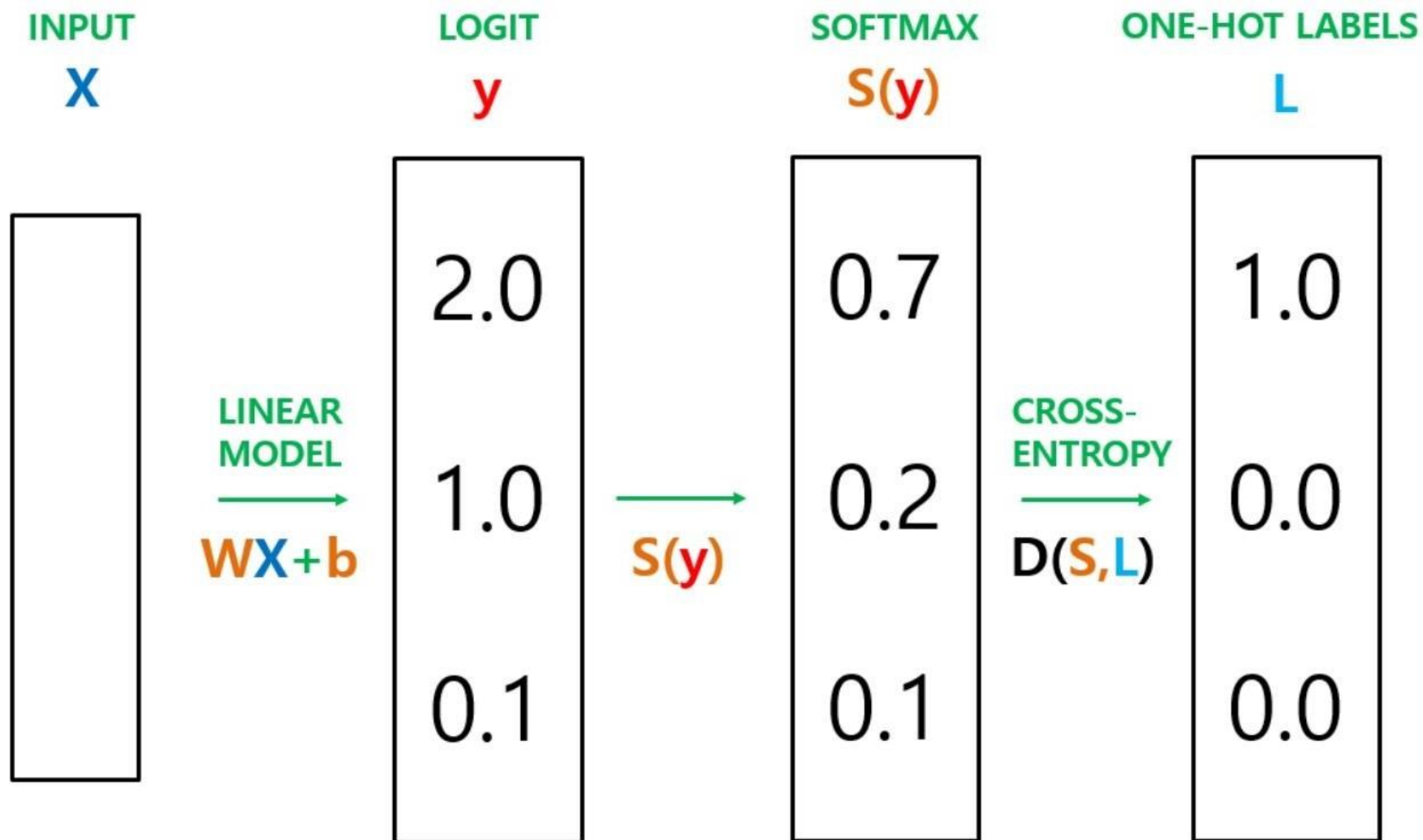
ONE-HOT ENCODING



COST FUNCTION

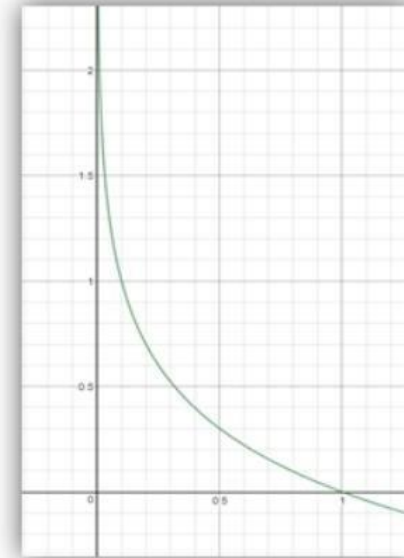


COST FUNCTION



CROSS-ENTROPY COST FUNCTION

$$-\sum_i L_i \log(S_i) \rightarrow -\sum_i L_i \log(\hat{y}_i) \rightarrow \sum_i L_i * -\log(\hat{y}_i)$$



$$L = \begin{matrix} A \\ B \end{matrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} = B$$

$$\hat{Y} = \begin{matrix} A \\ B \end{matrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} = B(0), \quad \begin{bmatrix} 0 \\ 1 \end{bmatrix} * -\log \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} * \begin{bmatrix} \infty \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} = 0$$

$$\hat{Y} = \begin{matrix} A \\ B \end{matrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = A(X), \quad \begin{bmatrix} 0 \\ 1 \end{bmatrix} * -\log \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} * \begin{bmatrix} 0 \\ \infty \end{bmatrix} = \begin{bmatrix} 0 \\ \infty \end{bmatrix} = \infty$$

LOGISTIC COST VS. CROSS ENTROPY

$$C(H(x), y) = -y \log(H(x)) - (1 - y) \log(1 - H(x))$$

$$D(\textcolor{brown}{S}, \textcolor{teal}{L}) = - \sum_i \textcolor{teal}{L}_i \log(\textcolor{brown}{S}_i)$$

COST FUNCTION : CROSS ENTROPY

$$\text{LOSS } L = \frac{1}{N} \sum_i D(S(WX_i + b), L_i)$$

























































TRAINING SET

```
# Cross entropy cost/loss
cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))

optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)
```

ANIMAL CLASSIFICATION

with `softmax_cross_entropy_with_logits`

Birds	Insect	Fishes	Amphibians	Reptiles	Mammals
					 
					 
					 
					 
					 
					 
					 
					 
					 
					 
					 
					 
					 

1	0	0	1	0	0	0	1	1	1	0	0	4	1	0	1	0
0	0	1	0	0	1	1	1	1	0	0	1	0	1	0	0	3
1	0	0	1	0	0	1	1	1	1	0	0	4	0	0	1	0
1	0	0	1	0	0	1	1	1	1	0	0	4	1	0	1	0
1	0	0	1	0	0	1	1	1	1	0	0	4	1	0	1	0
1	0	0	1	0	0	1	1	1	1	0	0	4	1	1	1	0
0	0	1	0	0	1	0	1	1	0	0	1	0	1	1	0	3
0	0	1	0	0	1	1	1	1	0	0	1	0	1	0	0	3
1	0	0	1	0	0	0	1	1	1	0	0	4	0	1	0	0
1	0	0	1	0	0	1	1	1	1	0	0	4	1	0	1	0
0	1	1	0	1	0	0	0	1	1	0	0	2	1	1	0	1
0	0	1	0	0	1	1	1	1	0	0	1	0	1	0	0	3
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	6
0	0	1	0	0	1	1	0	0	0	0	0	4	0	0	0	6
0	0	1	0	0	1	1	0	0	0	0	0	6	0	0	0	6
0	1	1	0	1	0	1	0	1	1	0	0	2	1	0	0	1
1	0	0	1	0	0	0	1	1	1	0	0	4	1	0	1	0