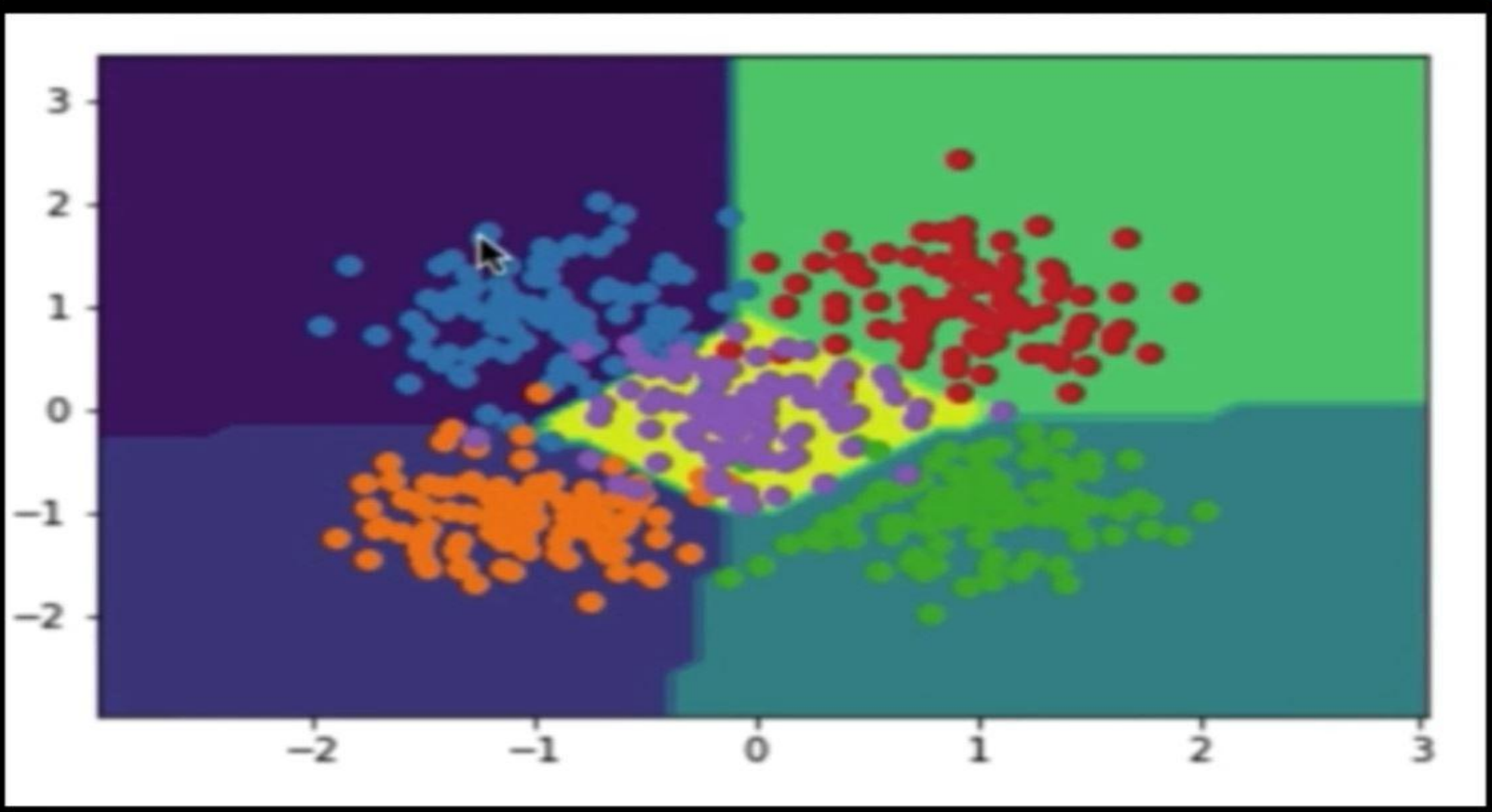
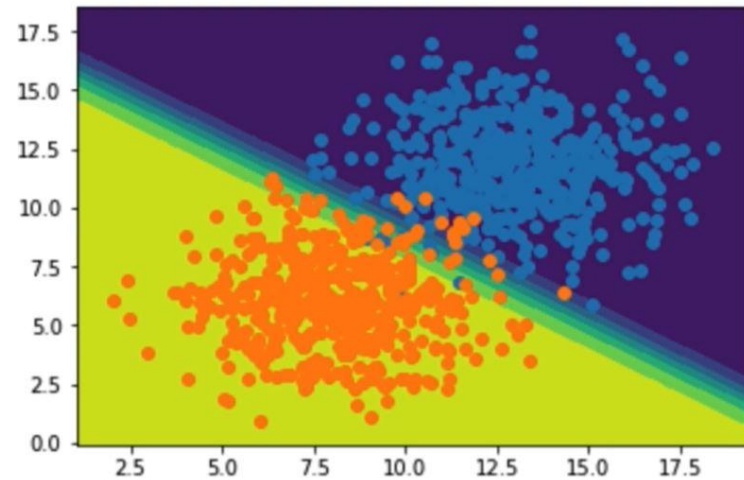
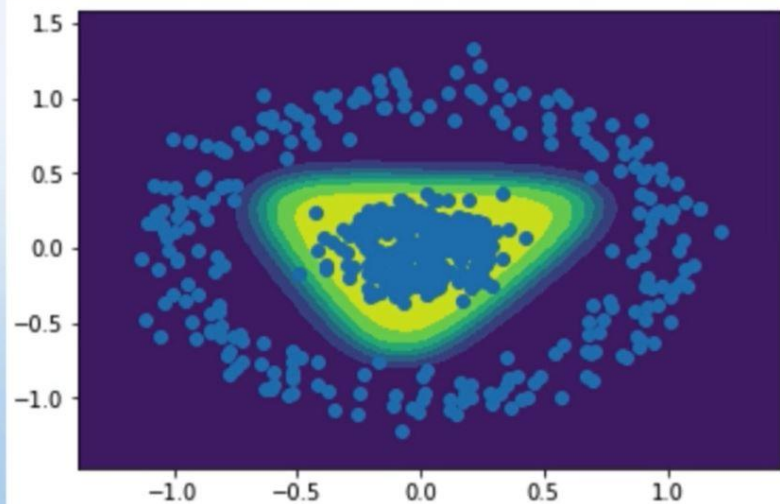


Deep Learning

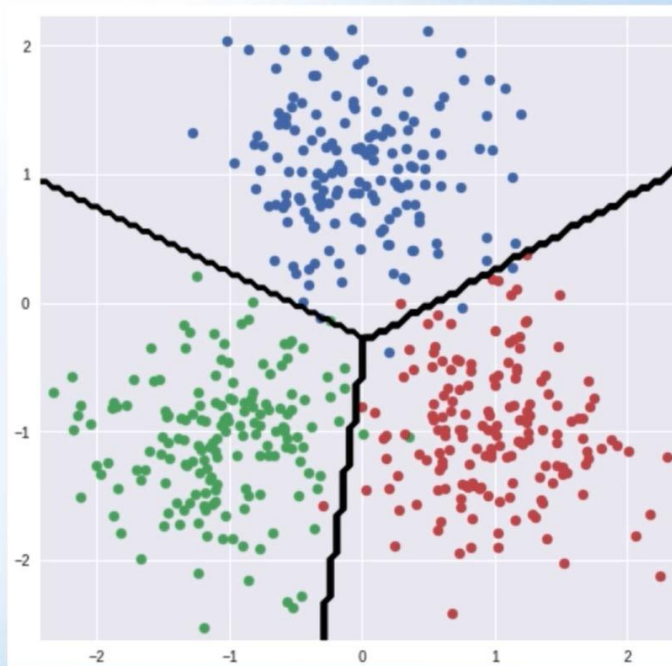




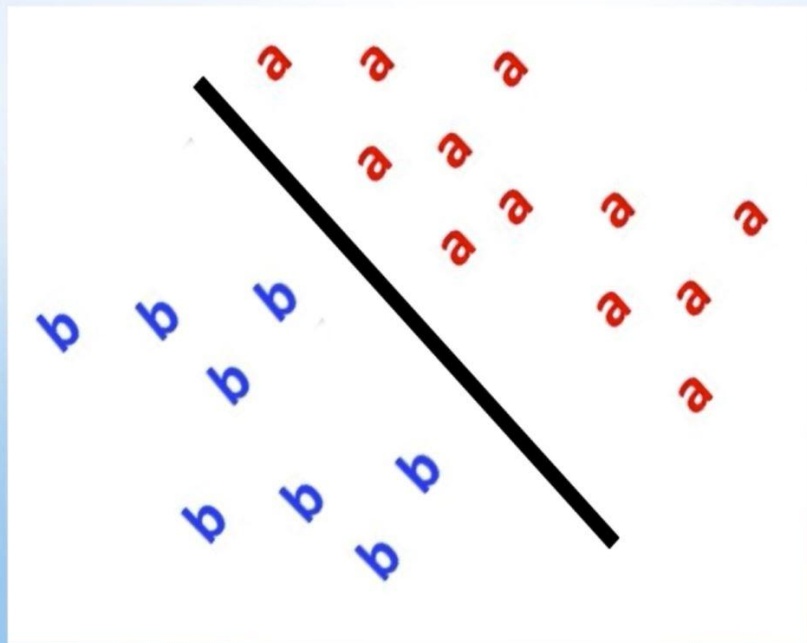
Softmax



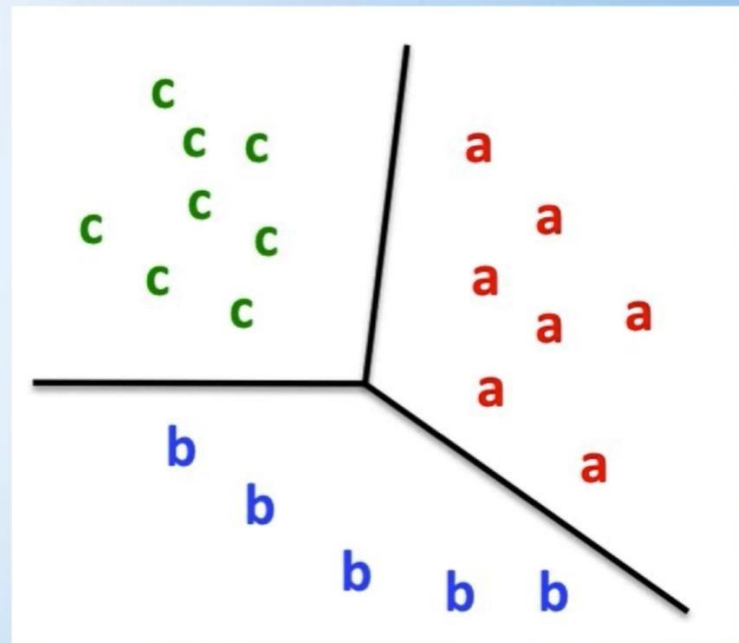
Softmax

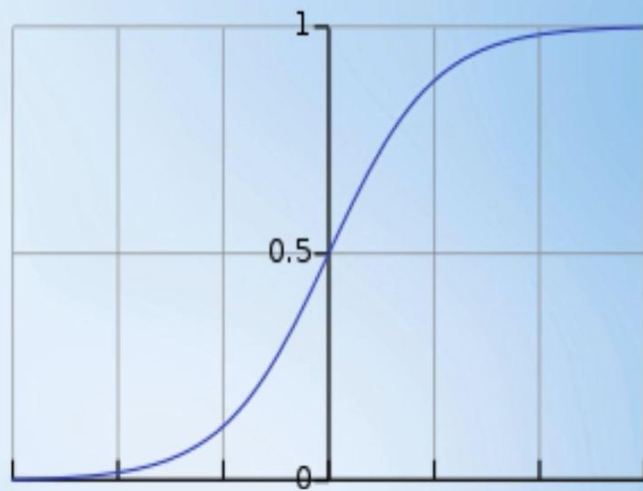
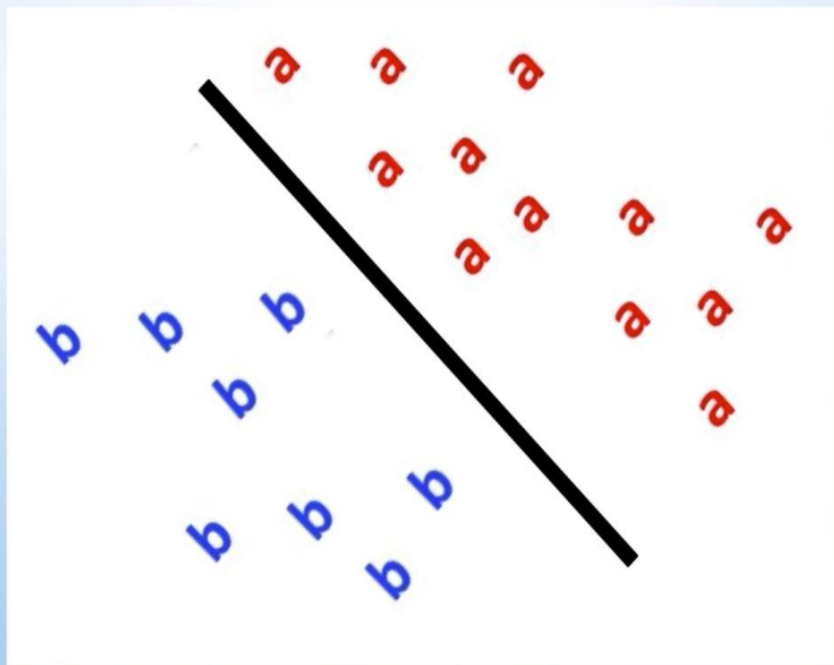


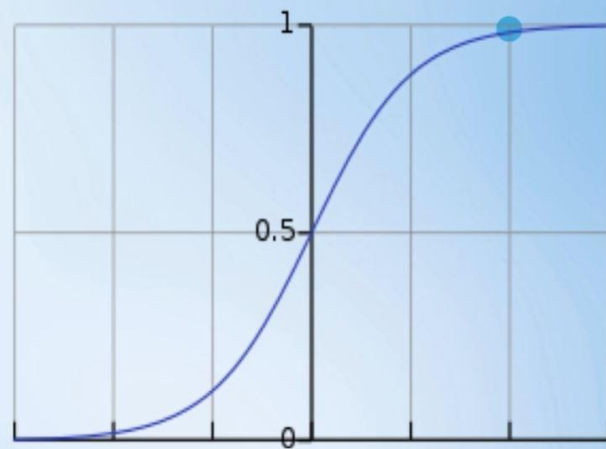
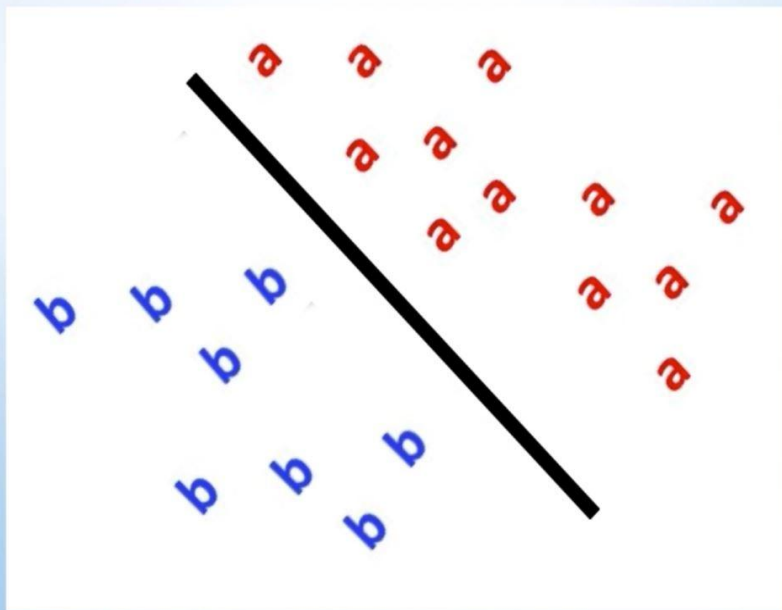
Binary



Multiclass

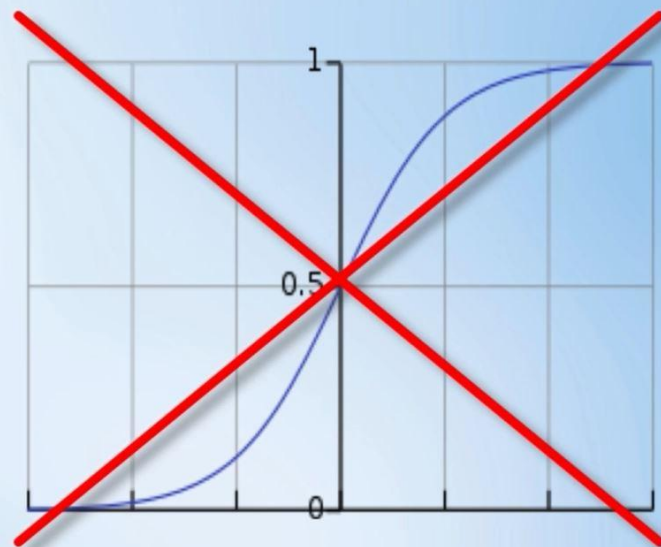
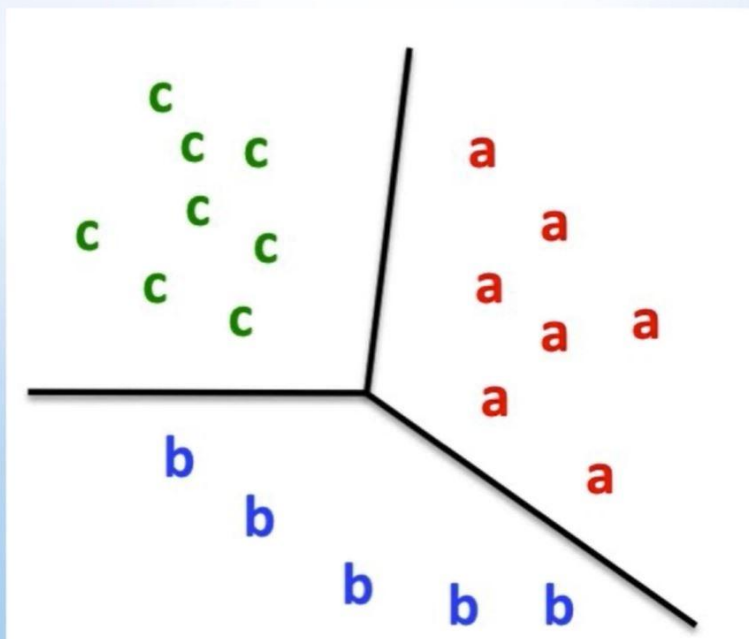




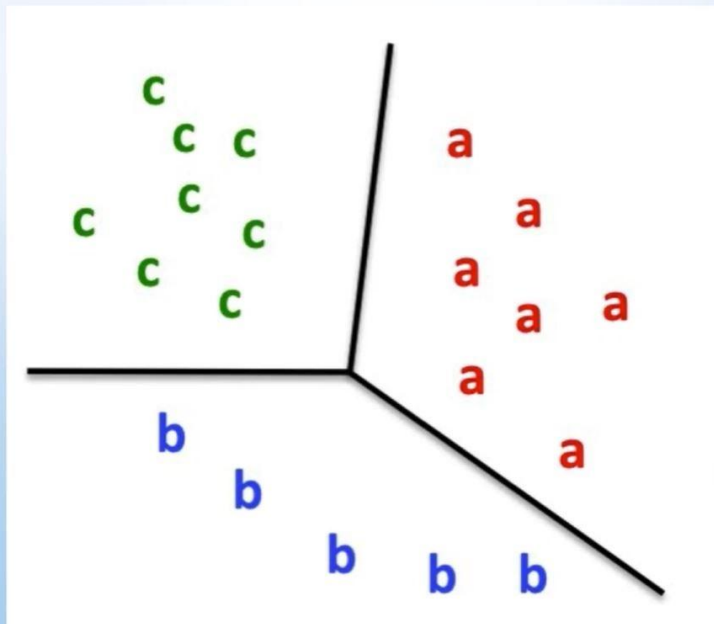


$$S(x) = \frac{e^x}{1 + e^x}$$

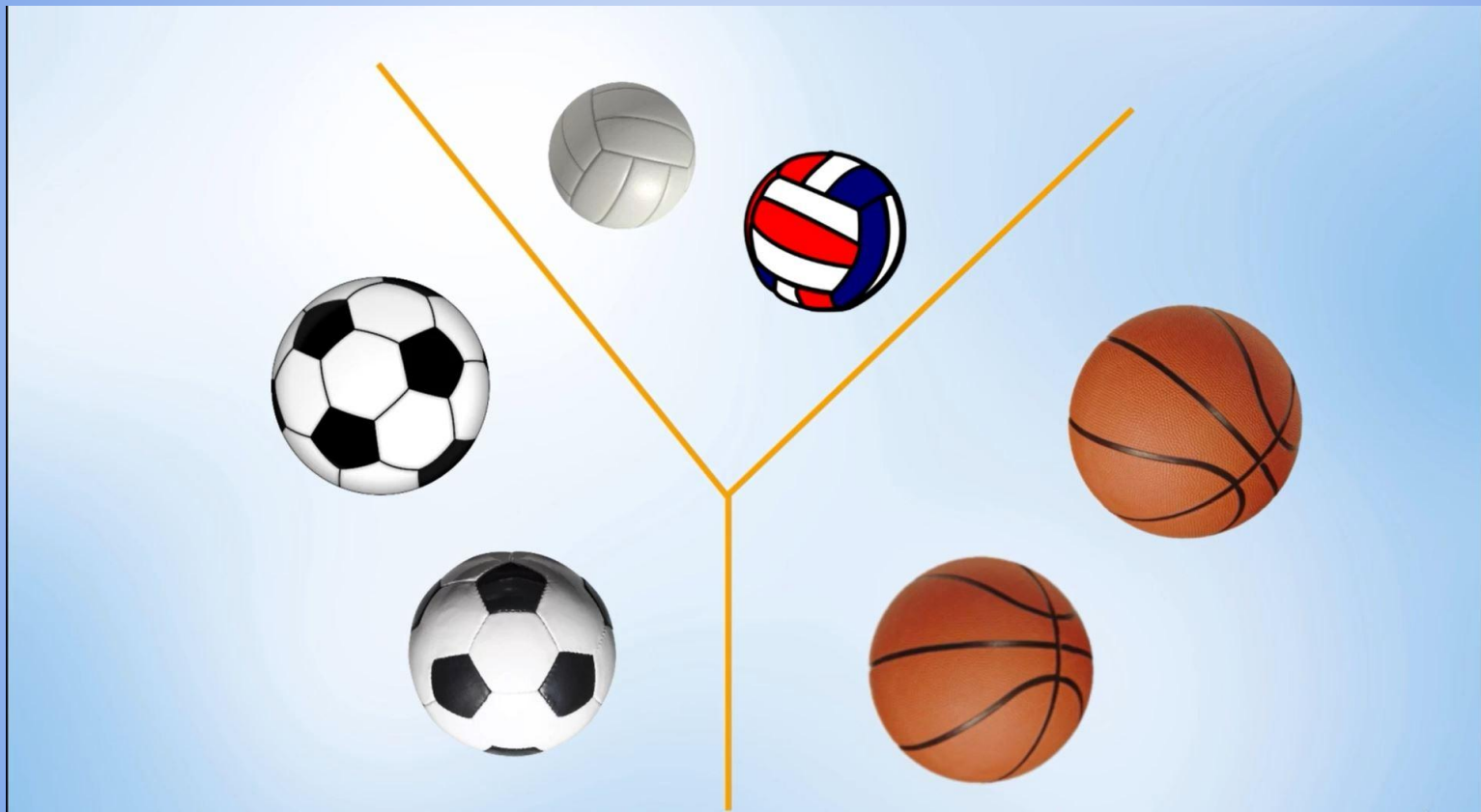
Multiclass

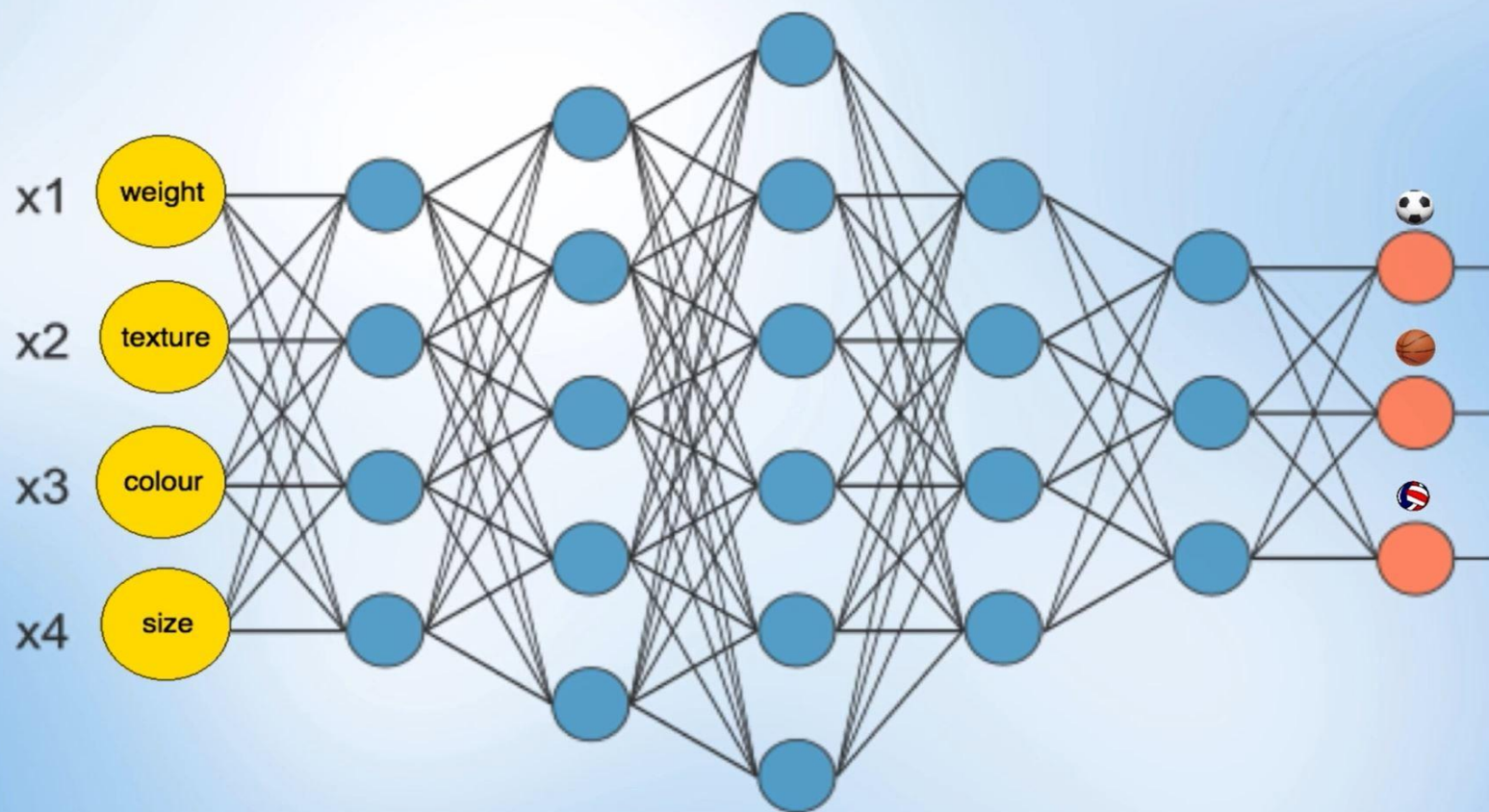


Multiclass



Softmax







2



1



0



2

>



1

>



0



2



1



0

1. Relative magnitudes must be maintained

2. All Probabilities must add up to 1

$$P(\text{score } m) = e^m / \sum_{i=1}^n e^i$$



2



1



0

$$P(\text{score } m) = e^m / \sum_{i=1}^n e^i$$



2



1



0

$$\frac{e^m}{e^2 + e^1 + e^0}$$

$$P(\text{score } m) = e^m / \sum_{i=1}^n e^i$$



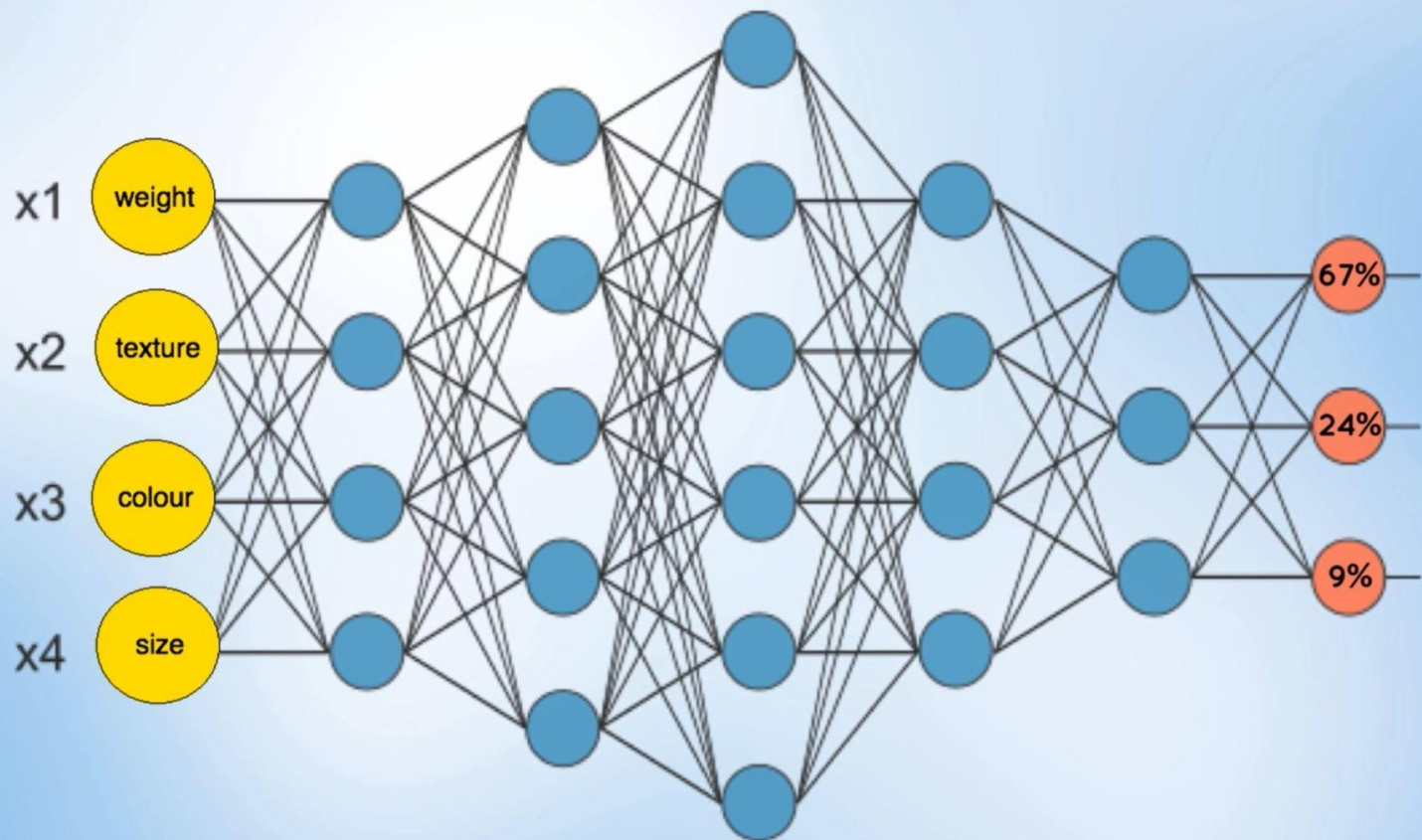
67%



24%



0.09



0

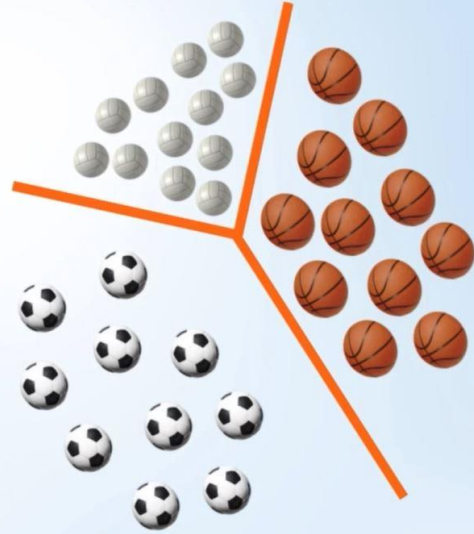


1

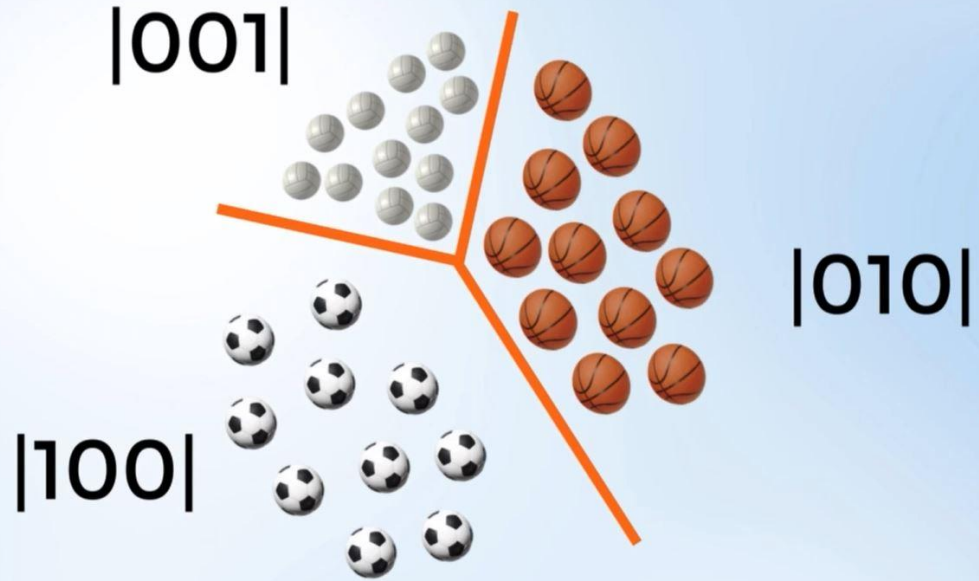


2





Ball Type	Value	Value	Value
Soccer Ball	1	0	0
Basketball	0	1	0
Volleyball	0	0	1



Ball Type	Value	Value	Value
Soccer Ball	1	0	0
Basketball	0	1	0
Volleyball	0	0	1

Cross Entropy

$$\text{Cross Entropy} = - \sum_{i=1}^m y_i \ln(p_i) + (1 - y_i) \ln(1 - p_i)$$



Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	0.4	0.3	0.5
Basketball	0.2	0.6	0.3
Volleyball	0.4	0.1	0.2



Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	0.4	0.3	0.5
Basketball	0.2	0.6	0.3
Volleyball	0.4	0.1	0.2

$$-(\ln(0.4) + \ln(0.6) + \ln(0.2)) = 3.04$$

Binary Cross Entropy

$$\text{Cross Entropy} = - \sum_{i=1}^m y_i \ln(p_i) + (1 - y_i) \ln(1 - p_i)$$

Categorical Cross Entropy

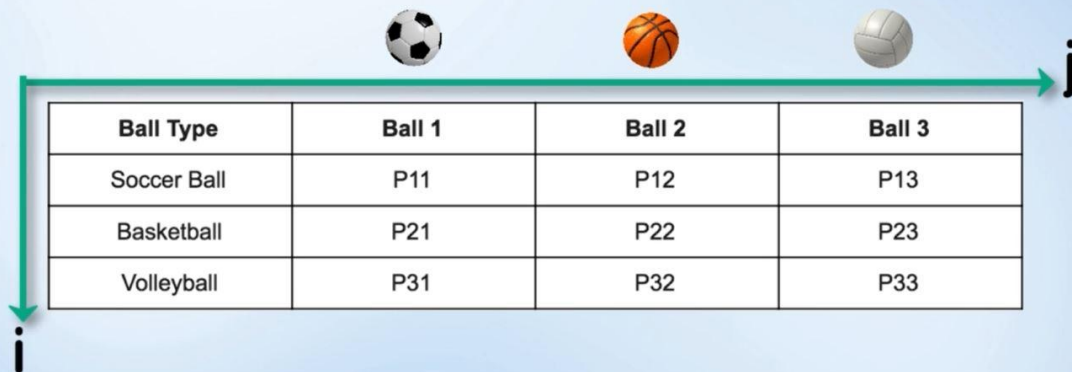


Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	0.4	0.3	0.5
Basketball	0.2	0.6	0.3
Volleyball	0.4	0.1	0.2

Binary Cross Entropy

$$\text{Cross Entropy} = - \sum_{i=1}^m y_i \ln(p_i) + (1 - y_i) \ln(1 - p_i)$$

Categorical Cross Entropy



The diagram illustrates Categorical Cross Entropy. It features a table with 3 rows and 4 columns. Above the table, there are three ball icons: a soccer ball, a basketball, and a volleyball. A green arrow points from the soccer ball icon to the first column of the table. Another green arrow points from the basketball icon to the second column. A third green arrow points from the volleyball icon to the third column. The fourth column is labeled 'j' at the top right. The first row is labeled 'Ball Type' and the first column is labeled 'i' at the bottom left. The table contains probability values for each combination of ball type and column.

Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	P11	P12	P13
Basketball	P21	P22	P23
Volleyball	P31	P32	P33

Binary Cross Entropy

$$\text{Cross Entropy} = - \sum_{i=1}^m y_i \ln(p_i) + (1 - y_i) \ln(1 - p_i)$$

Categorical Cross Entropy

The diagram illustrates Categorical Cross Entropy using two tables and a formula. The first table shows predicted probabilities (P) for three ball types (Soccer Ball, Basketball, Volleyball) across three balls (Ball 1, Ball 2, Ball 3). The second table shows the corresponding ground truth labels (y) for the same data. A green arrow labeled 'j' points from the first table to the second, indicating the transition from predicted probabilities to ground truth labels. A yellow box highlights the first column of both tables, corresponding to Ball 1. Below the tables, the formula for Categorical Cross Entropy is shown, with the terms for Ball 1 highlighted and the terms for Ball 2 and Ball 3 crossed out.

Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	P11	P12	P13
Basketball	P21	P22	P23
Volleyball	P31	P32	P33

Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	1	0	0
Basketball	0	1	0
Volleyball	0	0	1

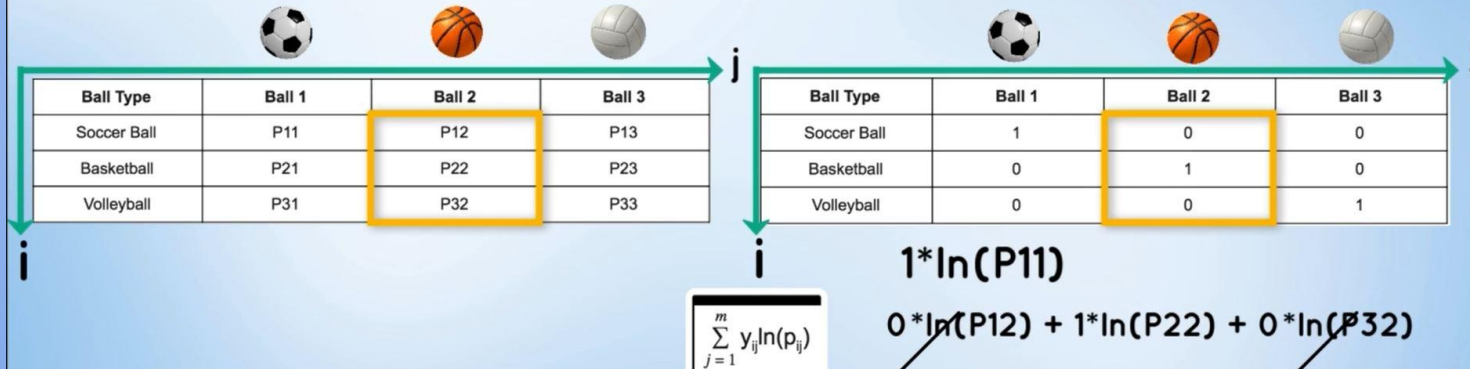
$1 * \ln(P11) + 0 * \ln(P21) + 0 * \ln(P31)$

$\sum_{j=1}^m y_{ij} \ln(p_{ij})$

Binary Cross Entropy

$$\text{Cross Entropy} = - \sum_{i=1}^m y_i \ln(p_i) + (1 - y_i) \ln(1 - p_i)$$

Categorical Cross Entropy



Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	P11	P12	P13
Basketball	P21	P22	P23
Volleyball	P31	P32	P33

Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	1	0	0
Basketball	0	1	0
Volleyball	0	0	1

$$\sum_{j=1}^m y_{ij} \ln(p_{ij})$$




$$1 * \ln(P11)$$

$$0 * \ln(P12) + 1 * \ln(P22) + 0 * \ln(P32)$$




Binary Cross Entropy

$$\text{Cross Entropy} = - \sum_{i=1}^m y_i \ln(p_i) + (1 - y_i) \ln(1 - p_i)$$

Categorical Cross Entropy

Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	P11	P12	P13
Basketball	P21	P22	P23
Volleyball	P31	P32	P33

Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	1	0	0
Basketball	0	1	0
Volleyball	0	0	1

$$1 \cdot \ln(P11) + 1 \cdot \ln(P22) + 1 \cdot \ln(P33)$$

$$\sum_{i=1}^n \sum_{j=1}^m m_{ij} \ln(p_{ij})$$

Binary Cross Entropy

$$\text{Cross Entropy} = - \sum_{i=1}^m y_i \ln(p_i) + (1 - y_i) \ln(1 - p_i)$$

Categorical Cross Entropy



j



j

Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	P11	P12	P13
Basketball	P21	P22	P23
Volleyball	P31	P32	P33

Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	1	0	0
Basketball	0	1	0
Volleyball	0	0	1

i

i

Ball Type	Ball 1	Ball 2	Ball 3
Soccer Ball	0.4	0.3	0.5
Basketball	0.2	0.6	0.3
Volleyball	0.4	0.1	0.2

$$- \sum_{i=1}^n \sum_{j=1}^m \ln(p_{ij})$$

$$-(1 * \ln(0.4) + 1 * \ln(0.6) + 1 * \ln(0.2)) = 3.04$$

Autoencoder

