TRƯỜNG ĐẠI HỌC CÔNG NGHỆ THÔNG TIN

KHOA KHOA HỌC MÁY TÍNH

CS231. Nhập môn Thị giác máy tính

Machine Learning Image Classification: Linear classifiers

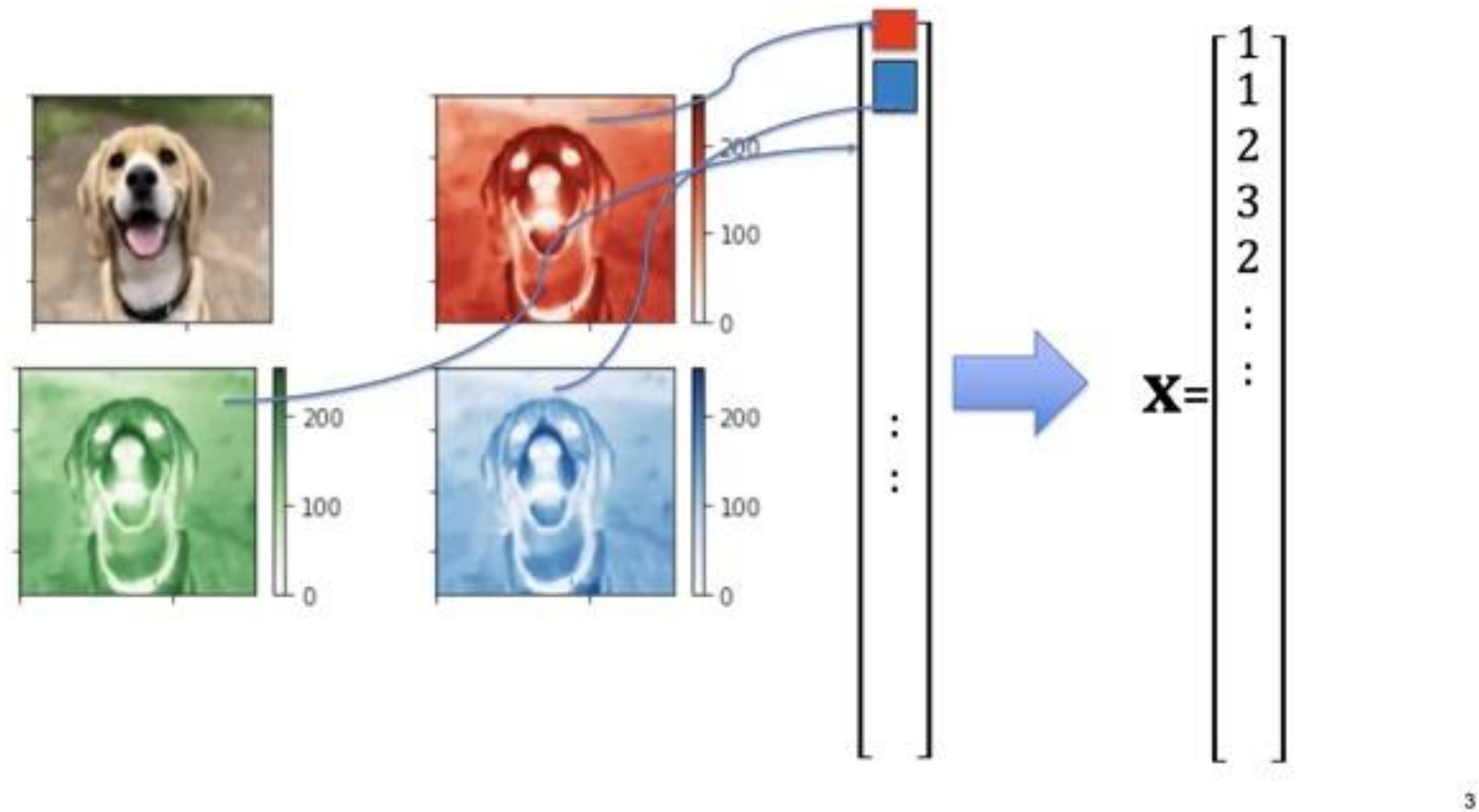
Mai Tiến Dũng

Targets :

Targets :

$y = 0$

$y = 1$



200
100
0
200
100
0
200
100
0
X=
1
1
2
3
2
:
:
3

Function:

$\mathbf{x}$

$\hat{y} = f($  $)$

Function:

$\mathbf{x}$

$\hat{y} = f($  $) = 1$

Function:

Probability this image is a dog

$$p\Big(\quad$$  $$\Big) = 0.92$$

Linear Classifier

- Learnable Parameters

$$z = wx + b$$

Linear Classifier

- Learnable Parameters

$$z = w\mathrm{x} + \mathrm{b}$$

$$z = w_1 x_1 + .. + w_d x_d + \mathrm{b}$$

Linear Classifier

- Learnable Parameters

$$z = w\mathrm{x} + \mathrm{b}$$

$$z = w_1 x_1 + .. + w_d x_d + \mathrm{b}$$

$$z = \boldsymbol{w}\mathbf{x} + \mathrm{b}$$

Linear Classifier

$$z = \boldsymbol{w}\boldsymbol{x} + \mathrm{b}$$

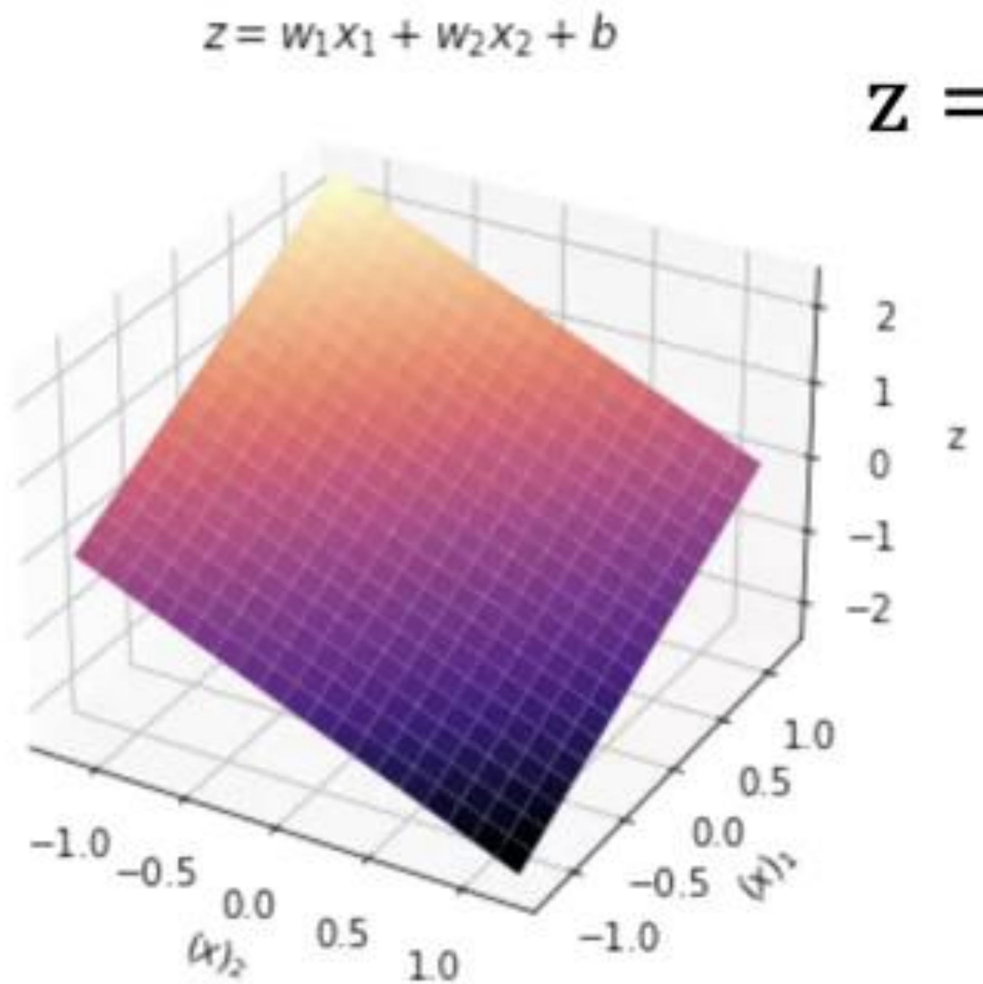
$$z = w_1 x_1 + w_2 x_2 + \mathrm{b}$$

Linear Classifier

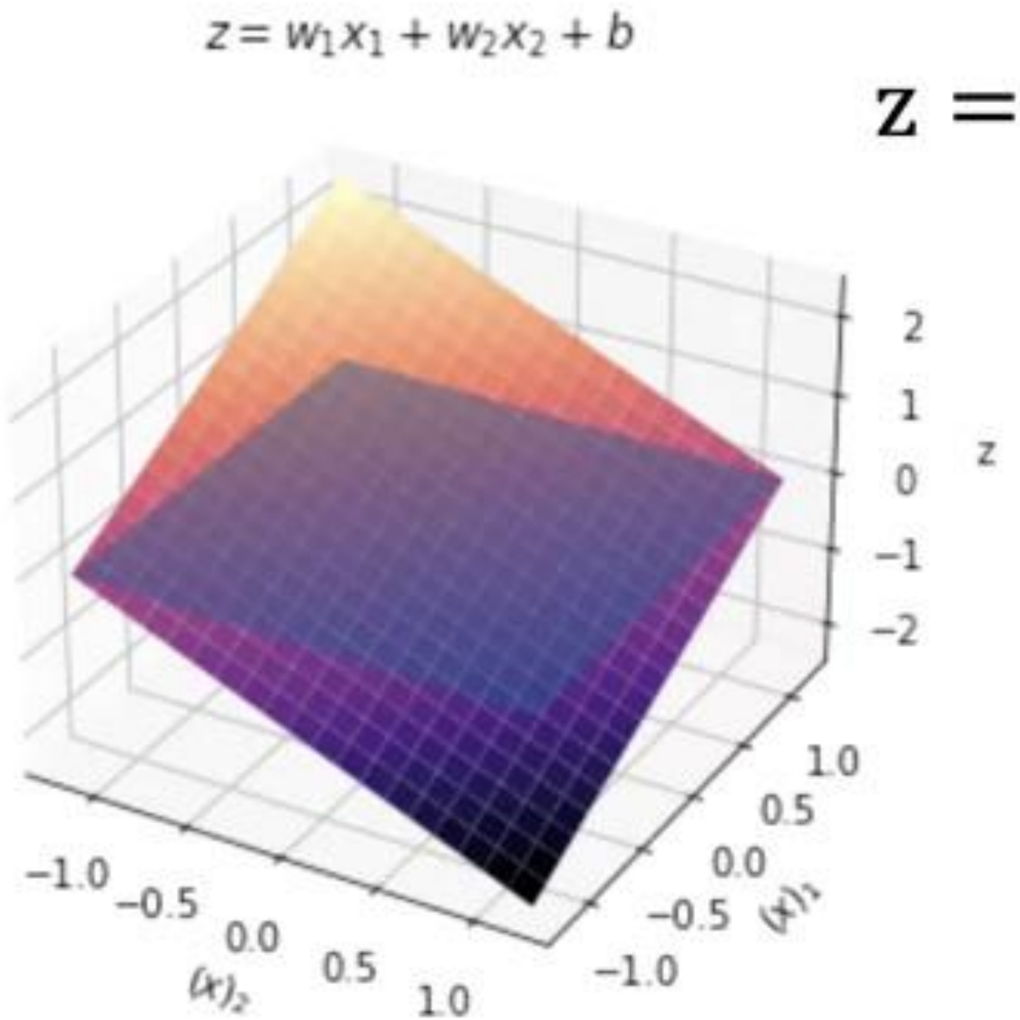
$$z = \boldsymbol{w}\boldsymbol{x} + \mathrm{b}$$

$$z = w_1 x_1 + w_2 x_2 + \mathrm{b}$$

$$z = 1x_1 - 1x_2 + 1$$

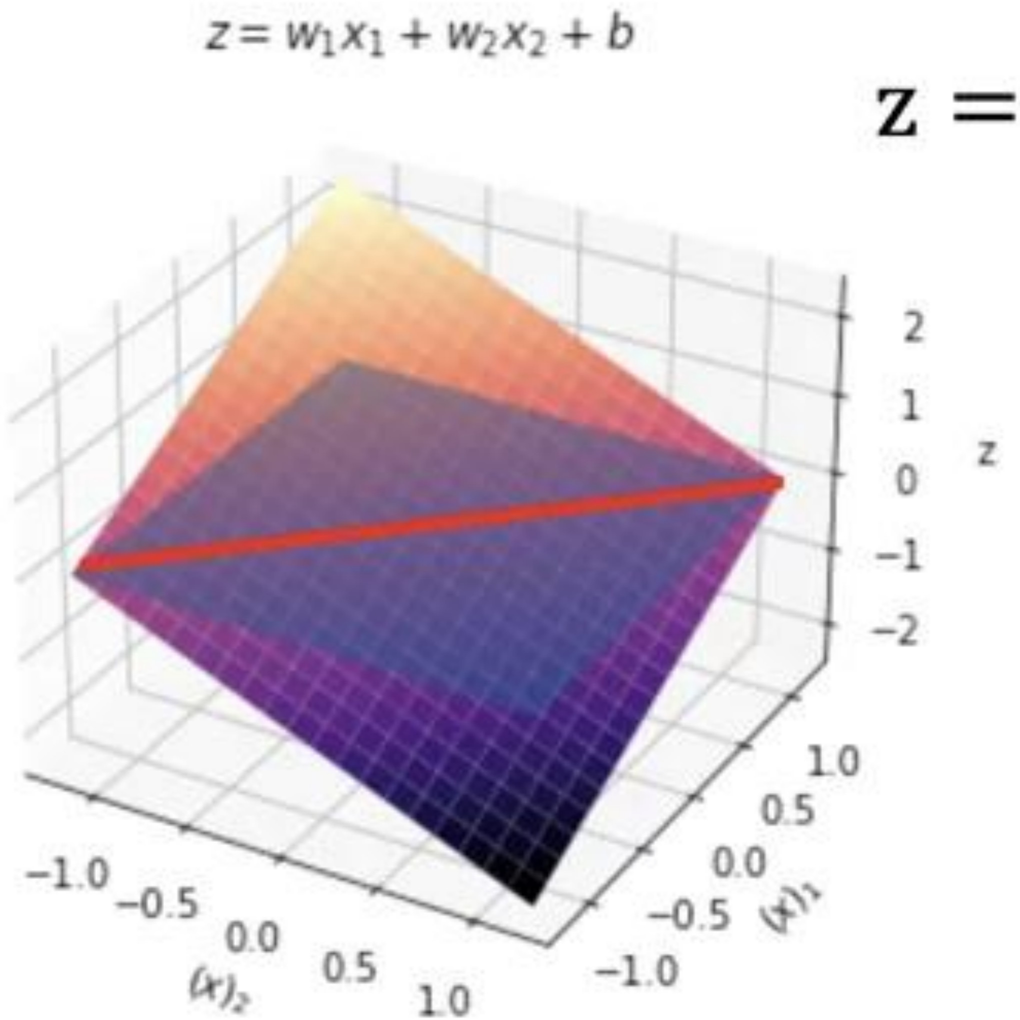


$$\mathbf{z} = \boldsymbol{w}\mathbf{x} + \mathrm{b}$$



$$\mathbf{z} = \boldsymbol{w}\mathbf{x} + \mathrm{b}$$

8

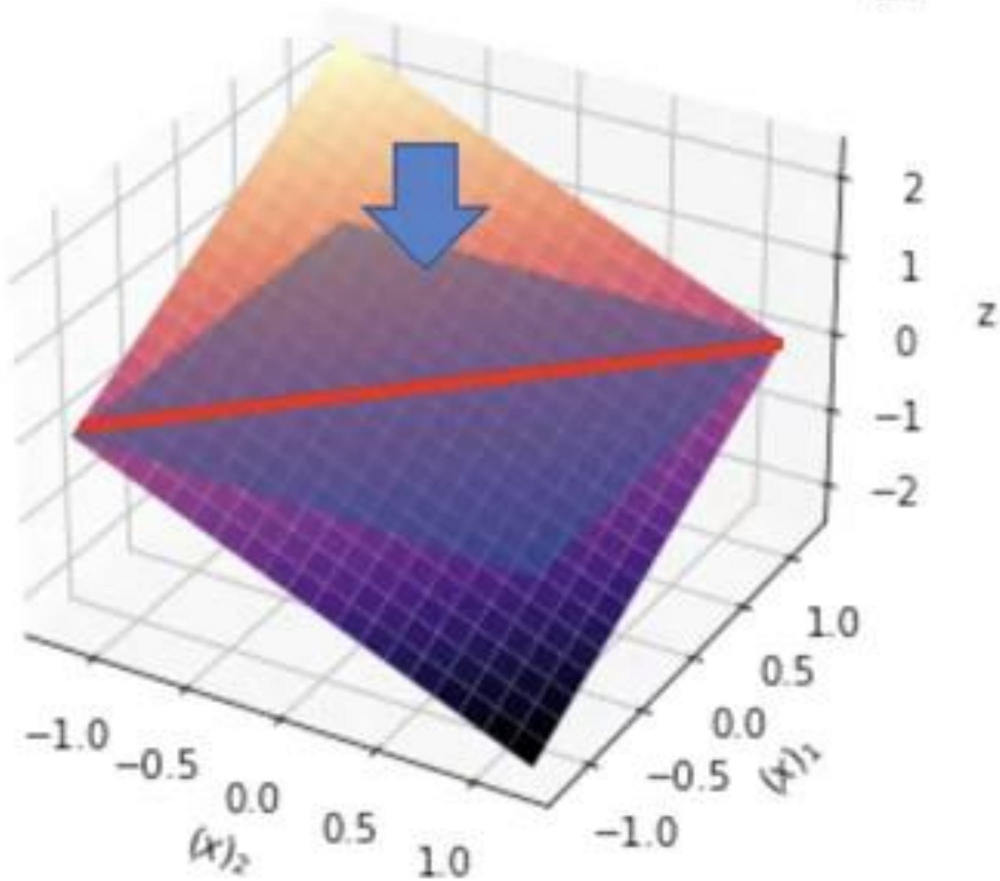


$$\mathbf{z} = \boldsymbol{w}\mathbf{x} + \mathrm{b}$$

8

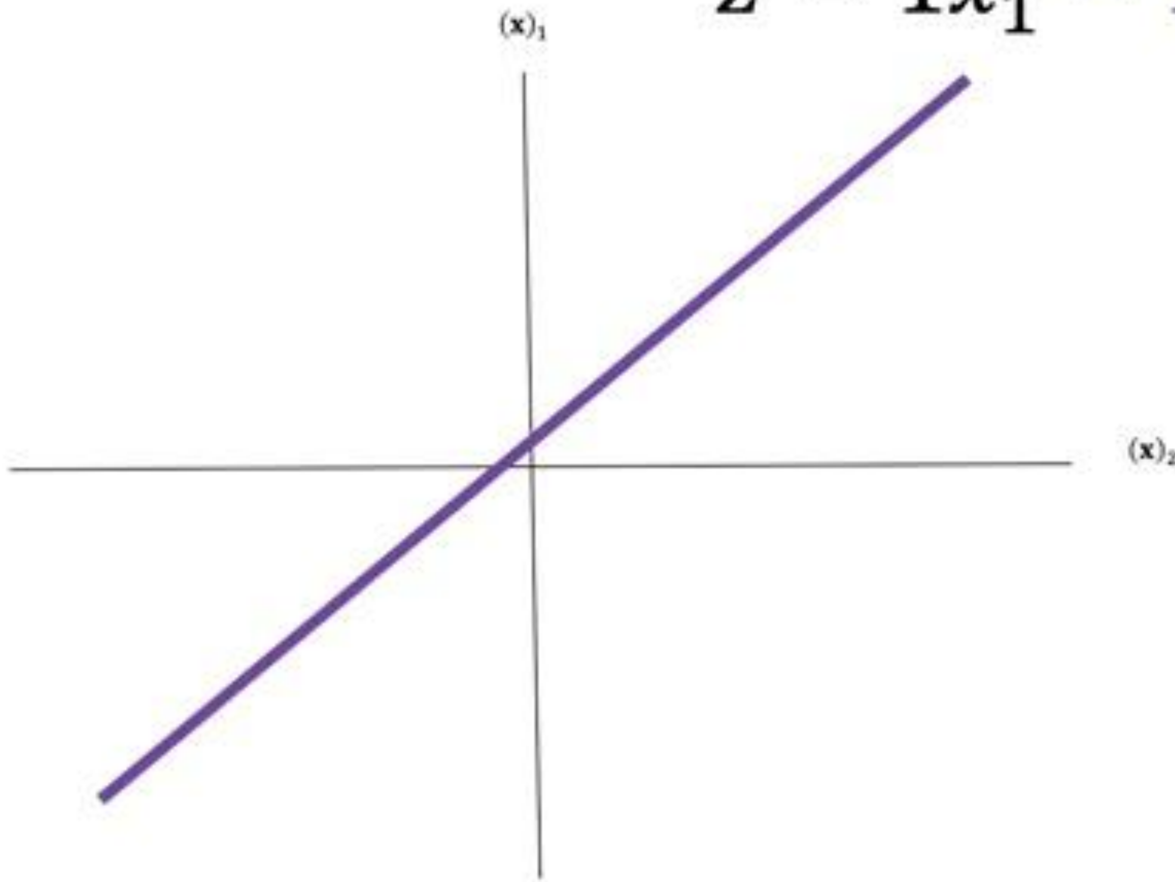
$$z = w_1x_1 + w_2x_2 + b$$

$$\mathbf{z} = \boldsymbol{w}\mathbf{x} + \mathrm{b}$$



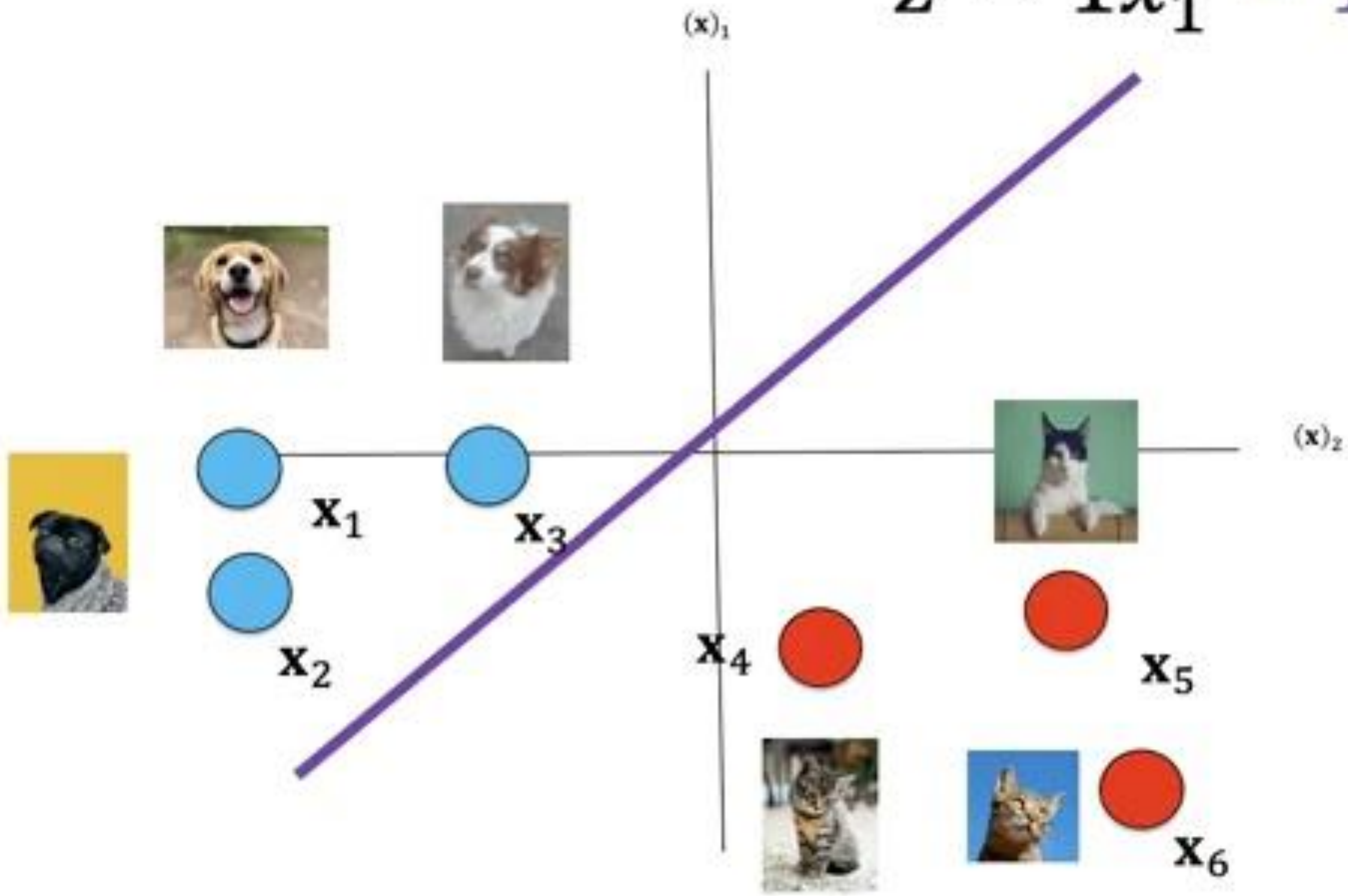
8

$$z = 1x_1 - 1x_2 + 1 = 0$$

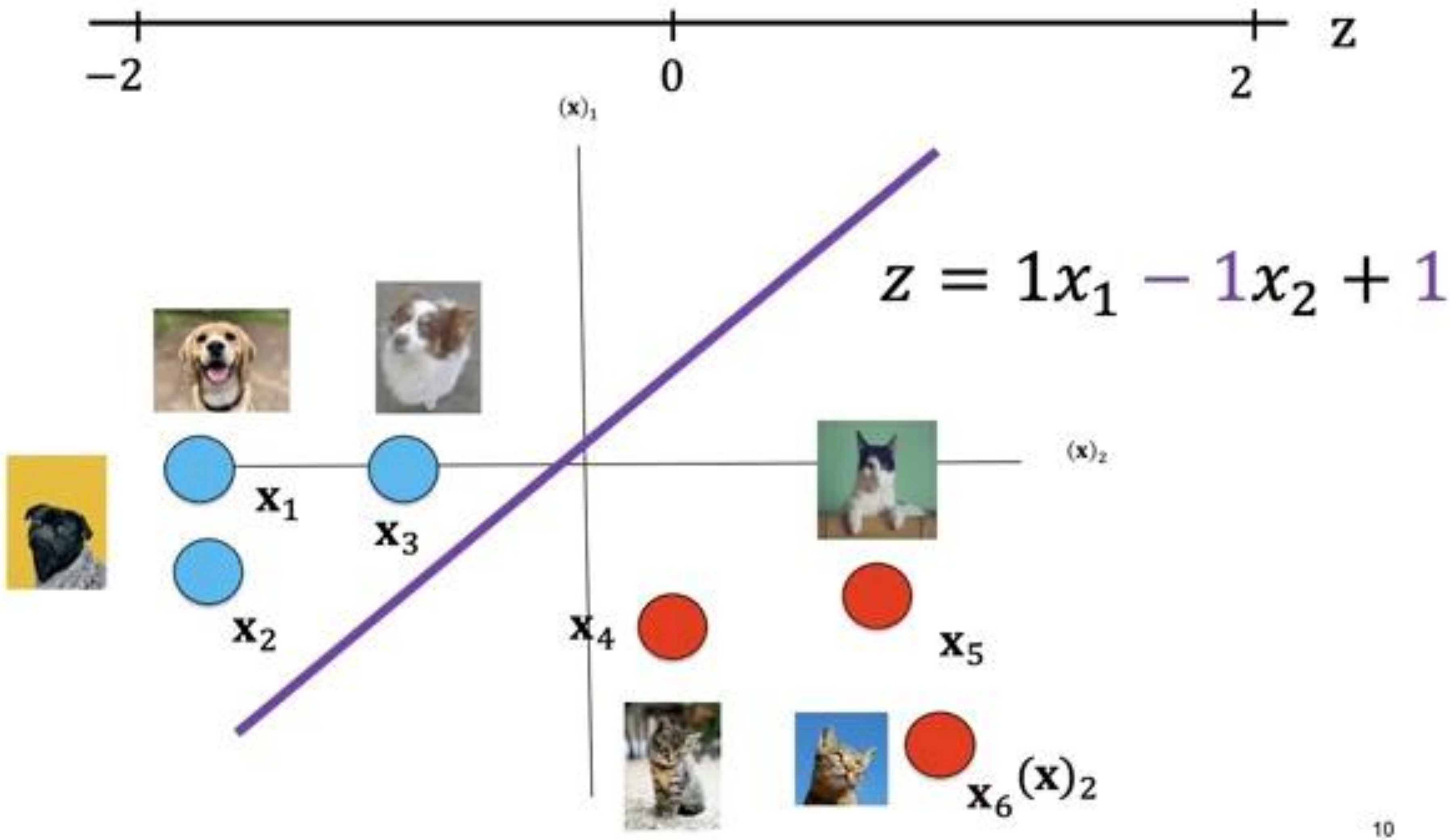


9

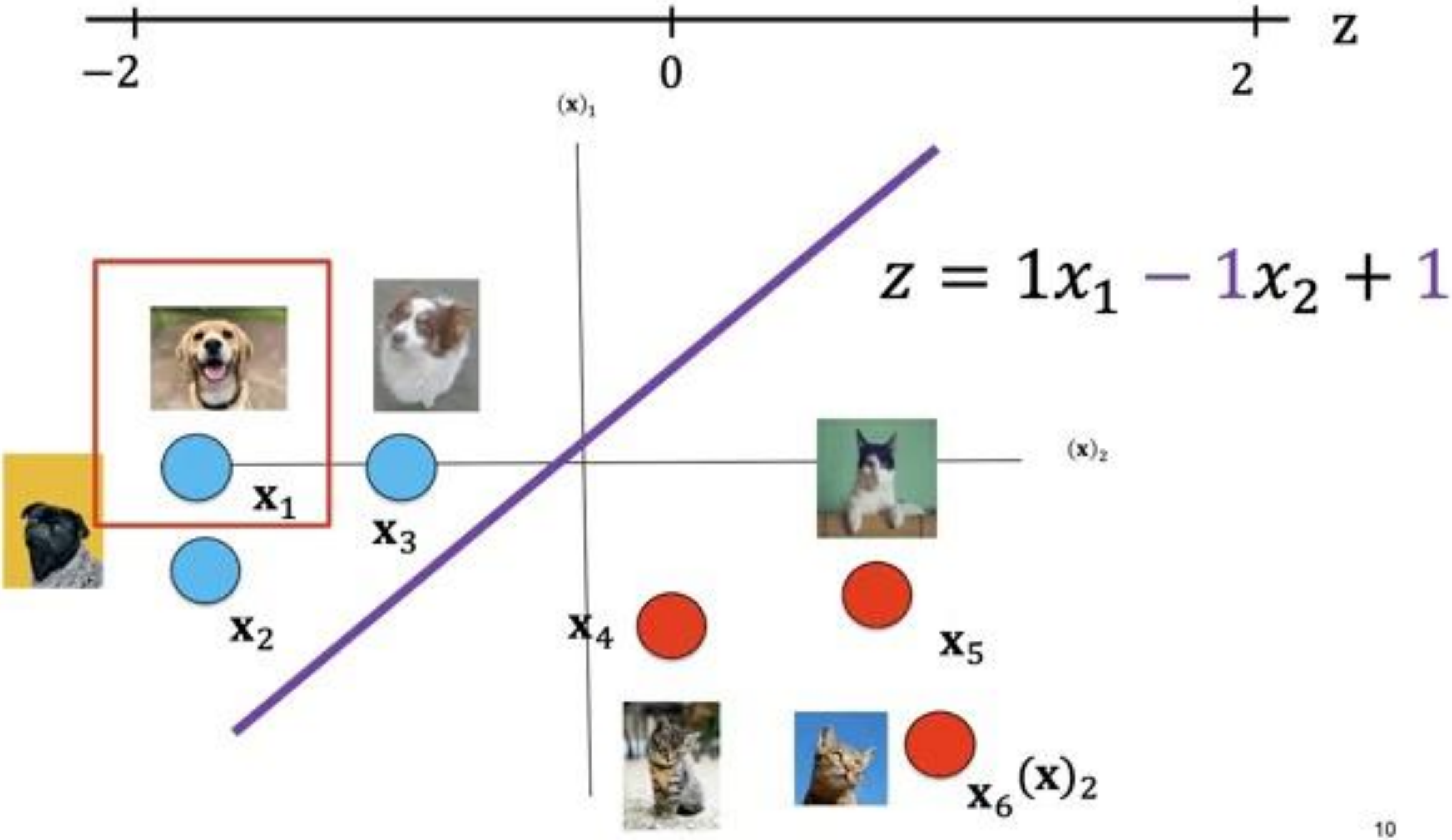
$$z = 1x_1 - 1x_2 + 1 = 0$$

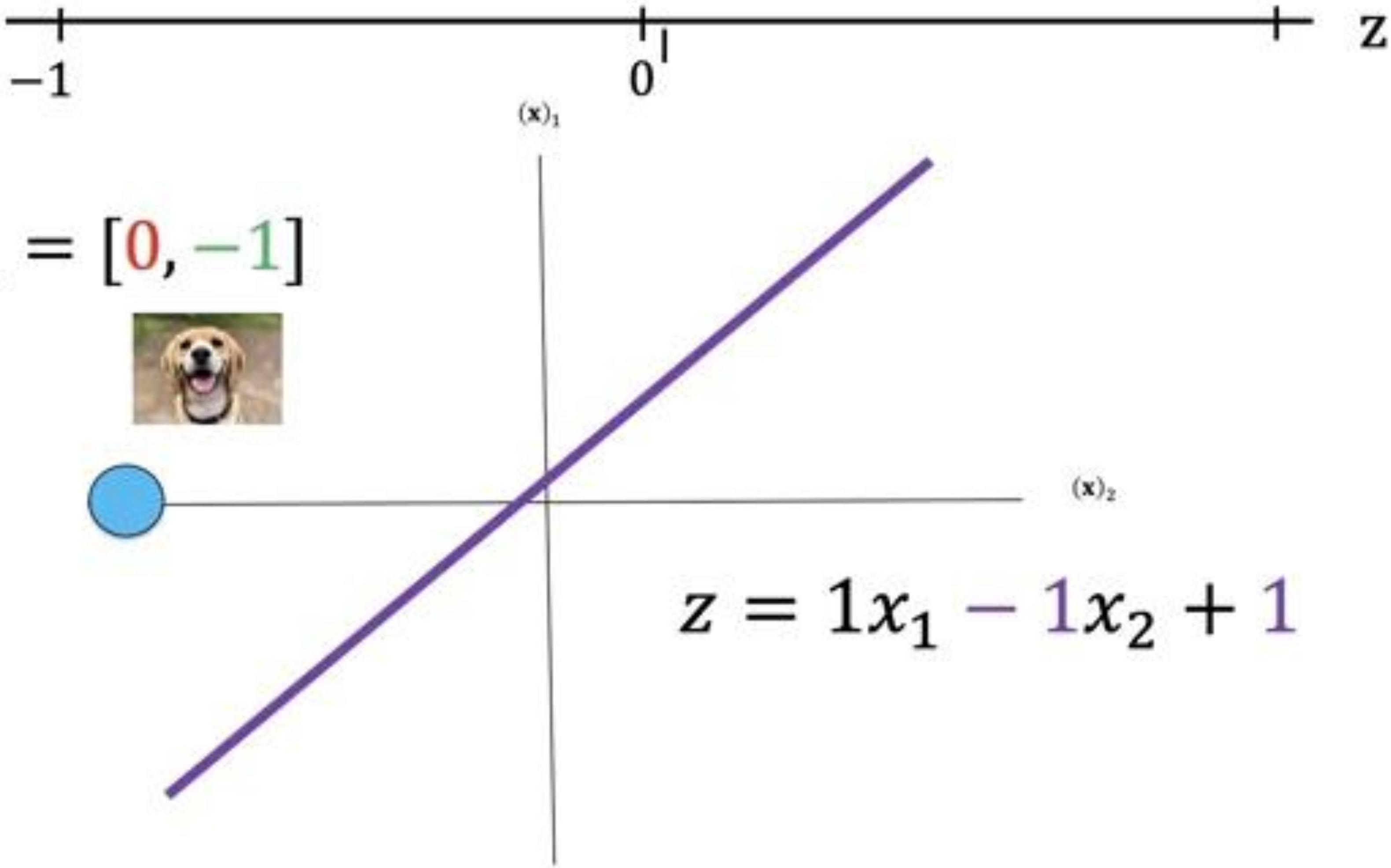


$(\mathbf{x})_1$
$(\mathbf{x})_2$
$\mathbf{x}_1$
$\mathbf{x}_2$
$\mathbf{x}_3$
$\mathbf{x}_4$
$\mathbf{x}_5$
$\mathbf{x}_6$
9



z
−2
0
2
$(\mathbf{x})_1$
$z = 1x_1 - 1x_2 + 1$
$(\mathbf{x})_2$
$\mathbf{x}_1$
$\mathbf{x}_3$
$\mathbf{x}_2$
$\mathbf{x}_4$
$\mathbf{x}_5$
$\mathbf{x}_6$ $(\mathbf{x})_2$
10

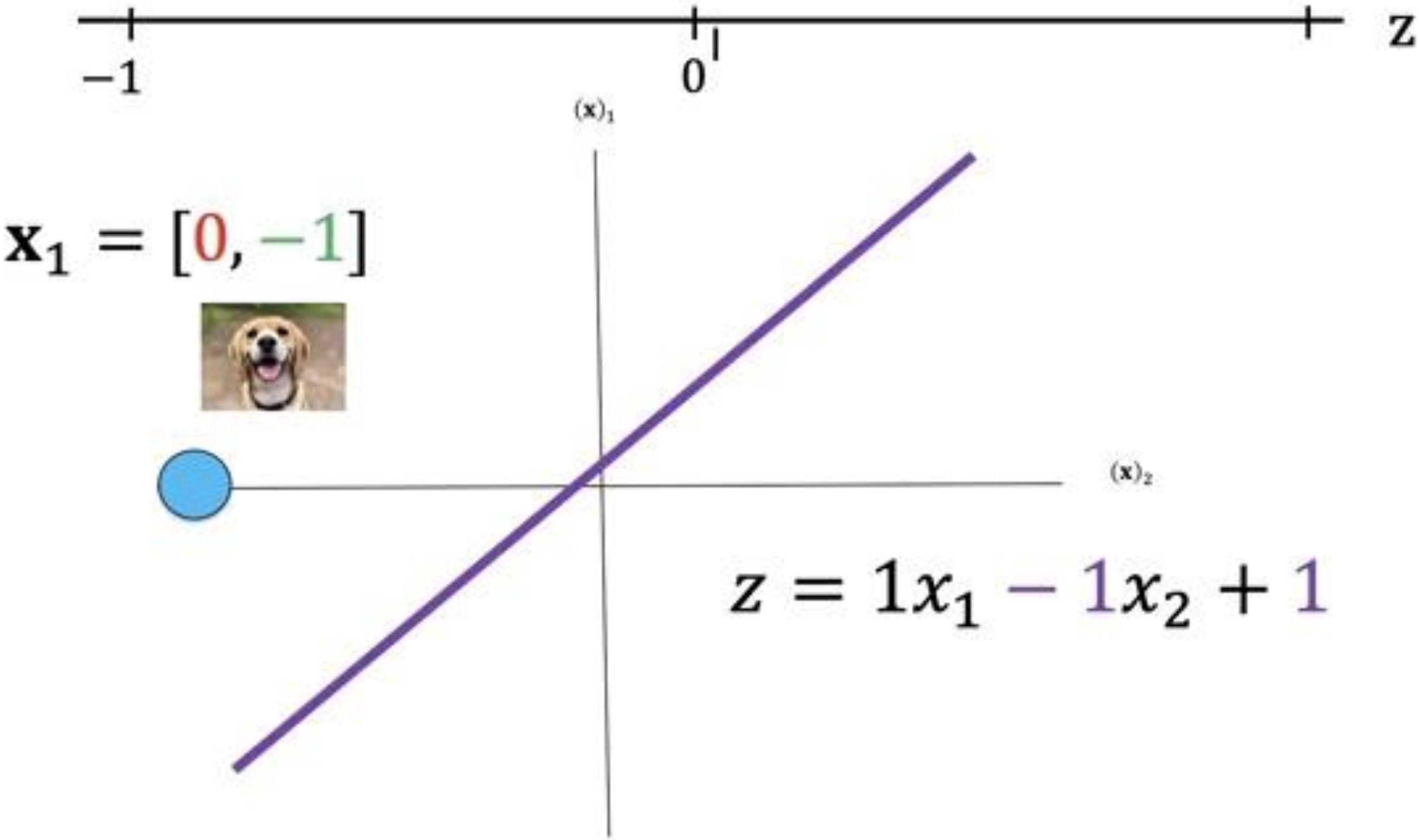

z
−2
0
2
$(\mathbf{x})_1$
$z = 1x_1 - 1x_2 + 1$
$(\mathbf{x})_2$
$\mathbf{x}_1$
$\mathbf{x}_2$
$\mathbf{x}_3$
$\mathbf{x}_4$
$\mathbf{x}_5$
$\mathbf{x}_6$ $(\mathbf{x})_2$
10



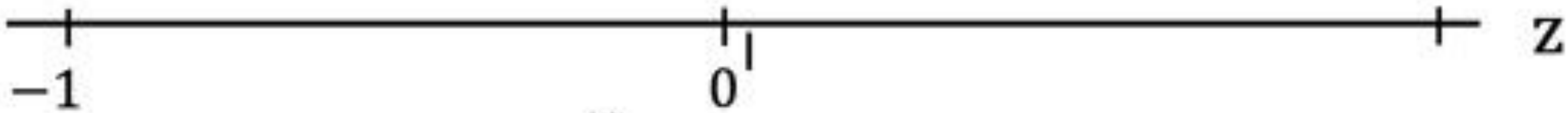
$$\mathbf{x}_1 = [0, -1]$$

$$z = 1x_1 - 1x_2 + 1$$

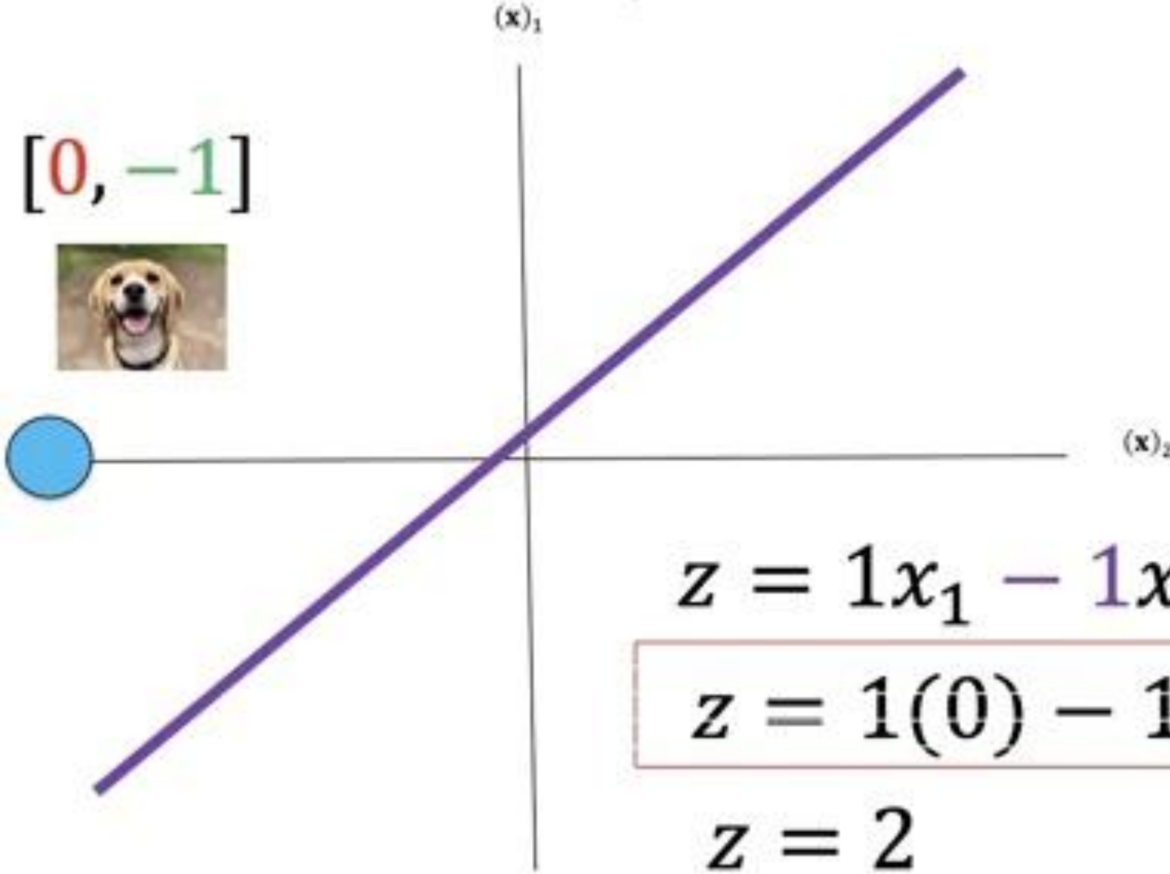
11



z
−1
0
$(\mathbf{x})_1$
$(\mathbf{x})_2$
$\mathbf{x}_1 = [0, -1]$
$z = 1x_1 - 1x_2 + 1$



$\mathbf{x}_1 = [0, -1]$

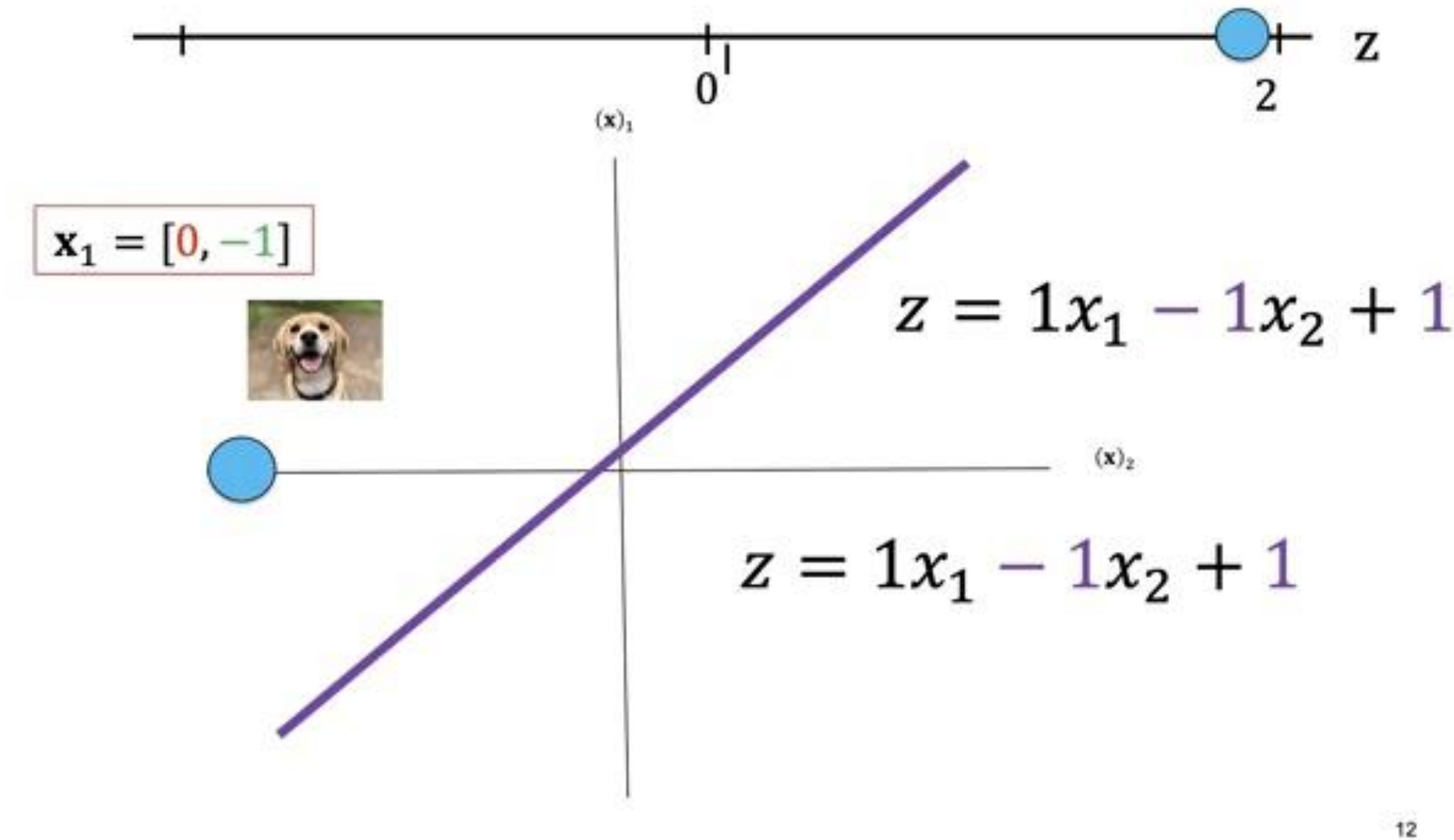


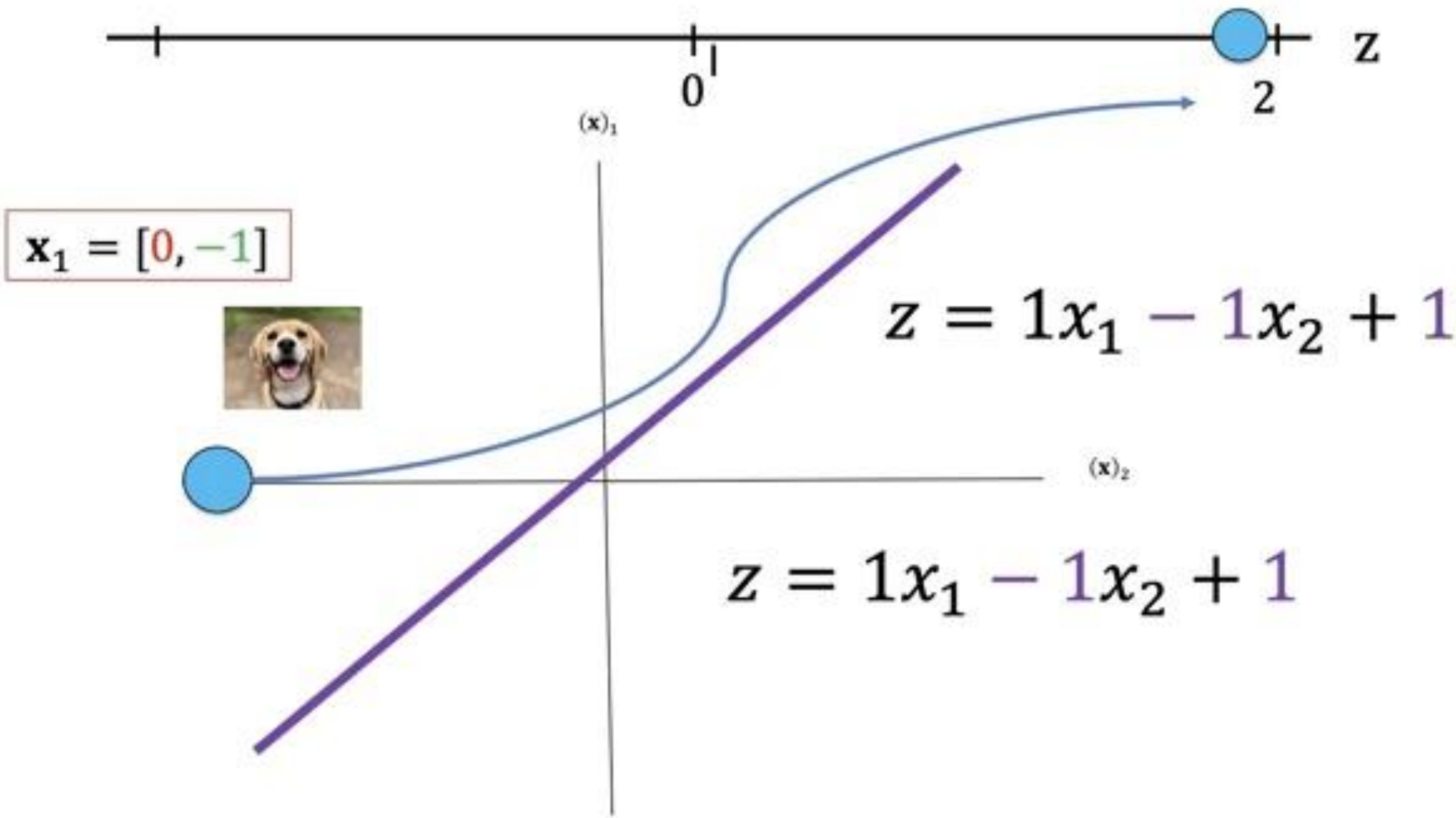
$$z = 1x_1 - 1x_2 + 1$$

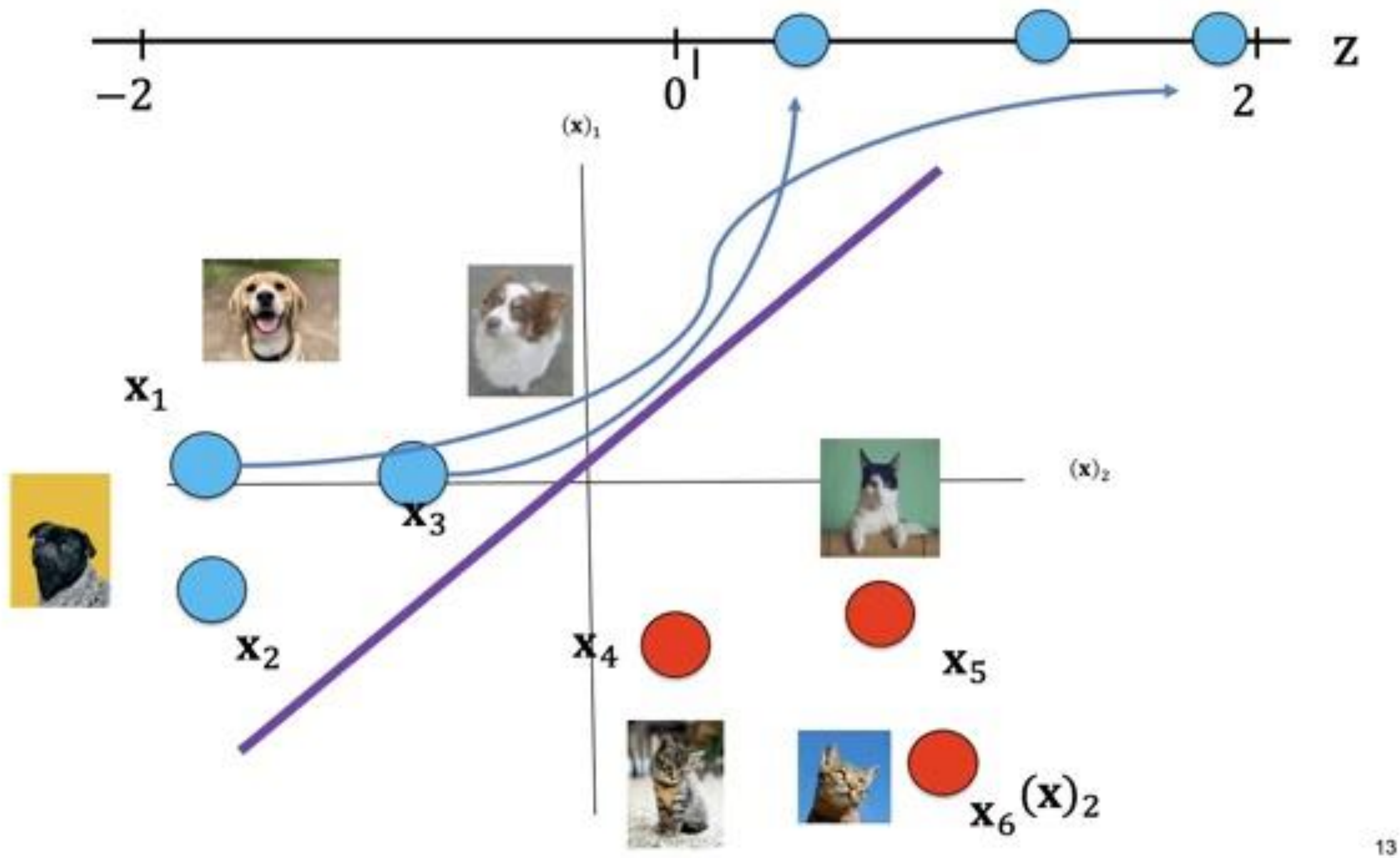
$$\boxed{z = 1(0) - 1(-1) + 1}$$

$$z = 2$$

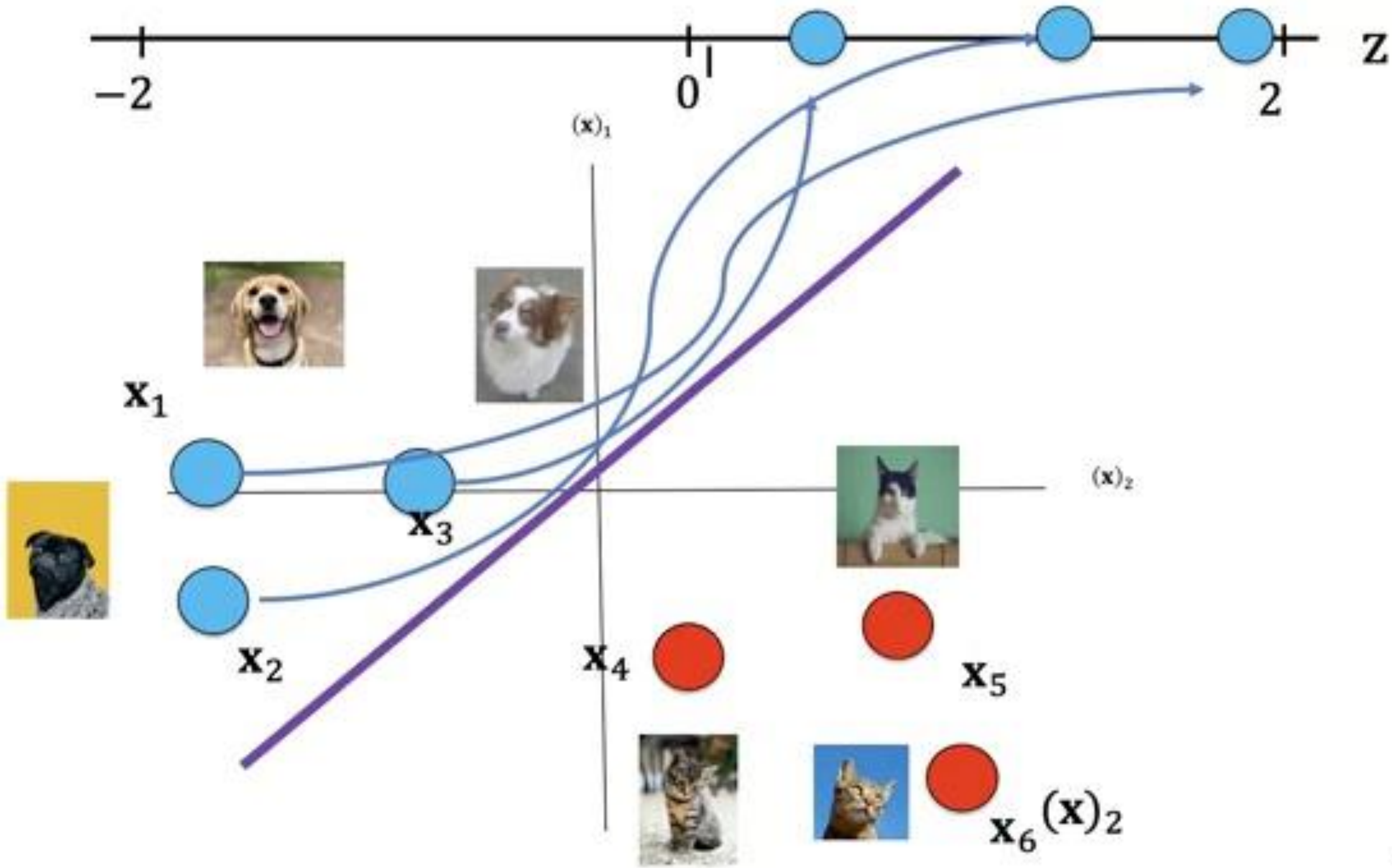
11

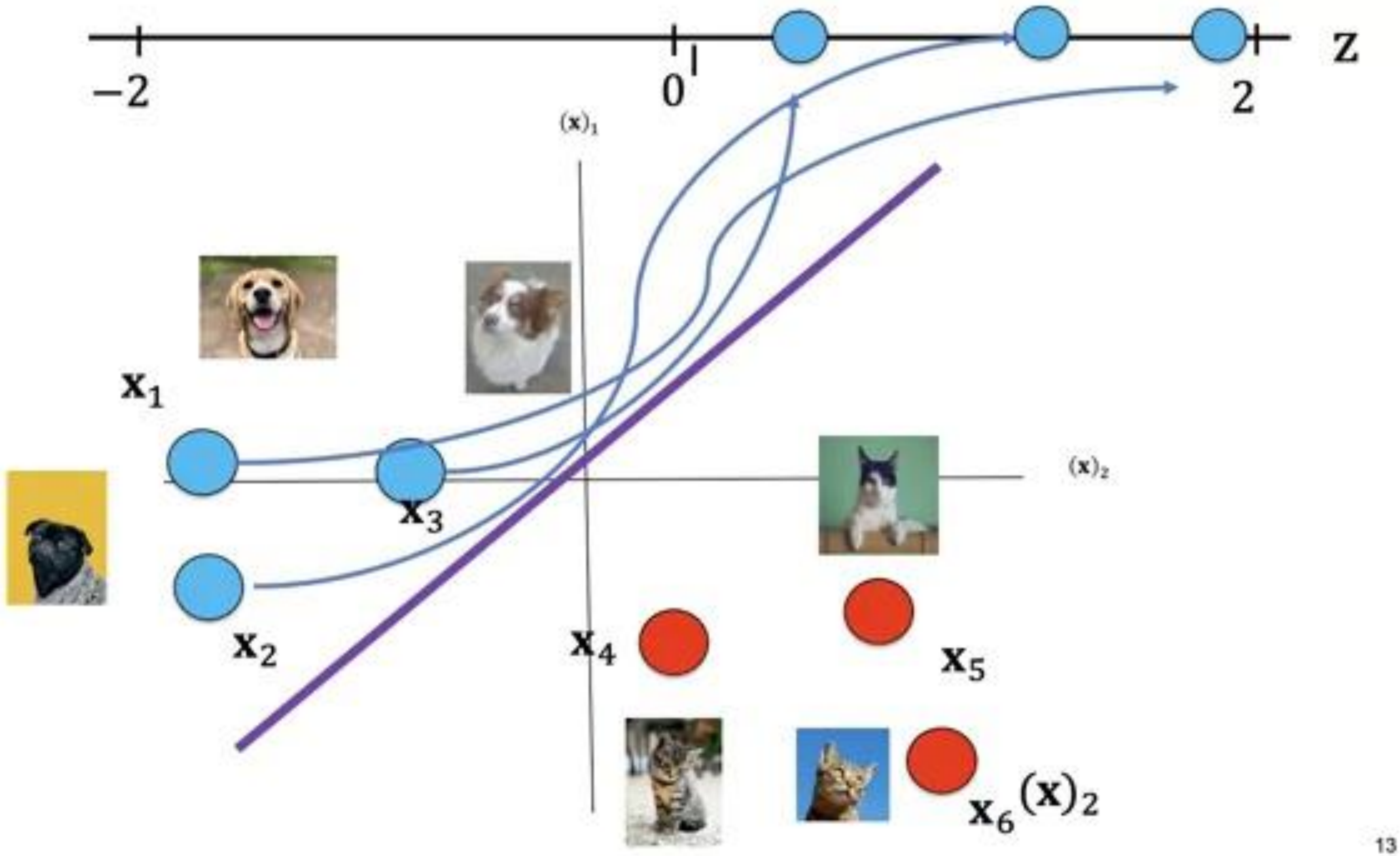

z
0
2
(x)₁
(x)₂
$\mathbf{x}_1 = [0, -1]$
$z = 1x_1 - 1x_2 + 1$
$z = 1x_1 - 1x_2 + 1$
12


z
0
2
(x)1
(x)2
$\mathbf{x}_1 = [0, -1]$
$z = 1x_1 - 1x_2 + 1$
$z = 1x_1 - 1x_2 + 1$

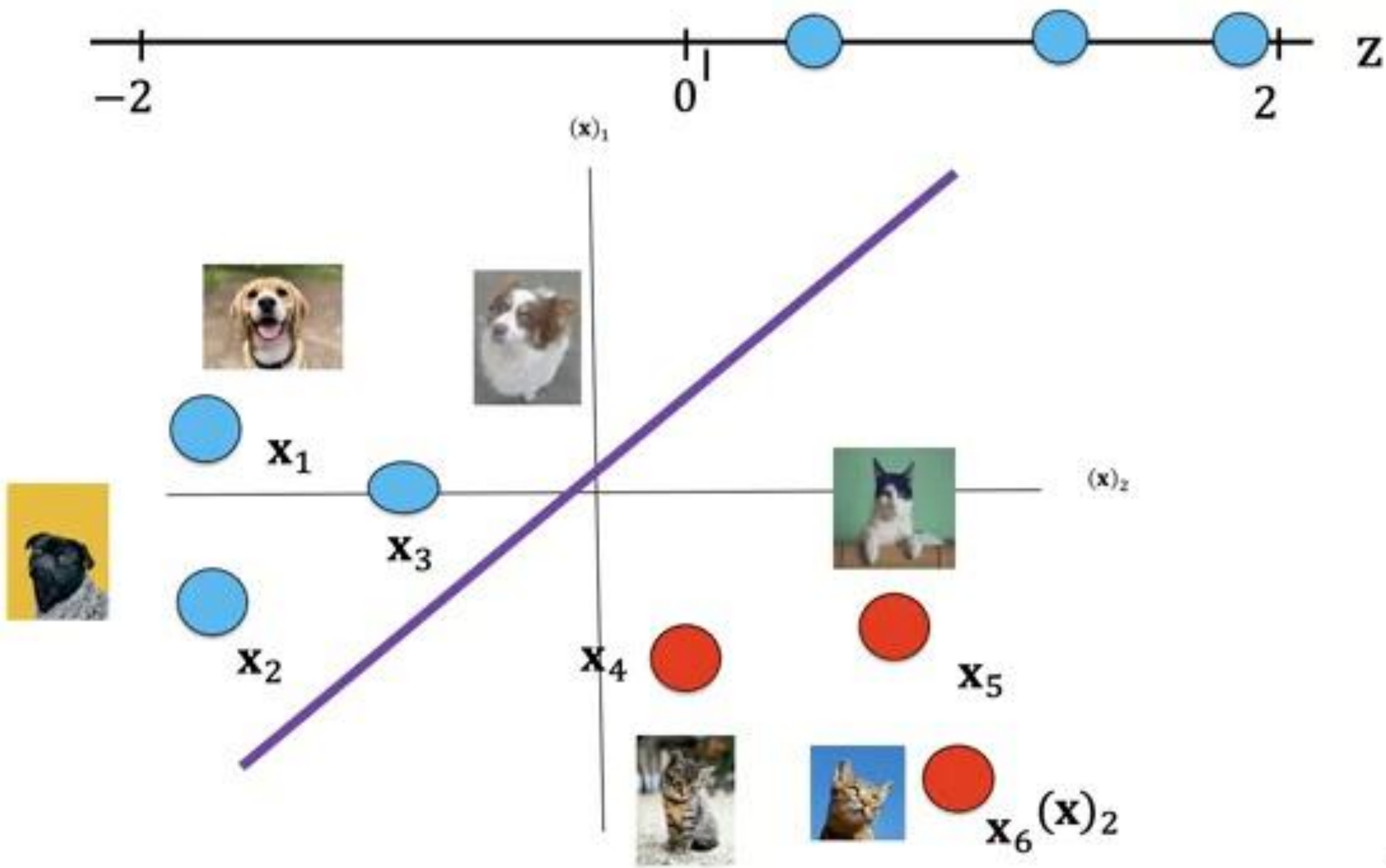


−2
0
2
z
$(\mathbf{x})_1$
$(\mathbf{x})_2$
$\mathbf{x}_1$
$\mathbf{x}_2$
$\mathbf{x}_3$
$\mathbf{x}_4$
$\mathbf{x}_5$
$\mathbf{x}_6$
$(\mathbf{x})_2$
13

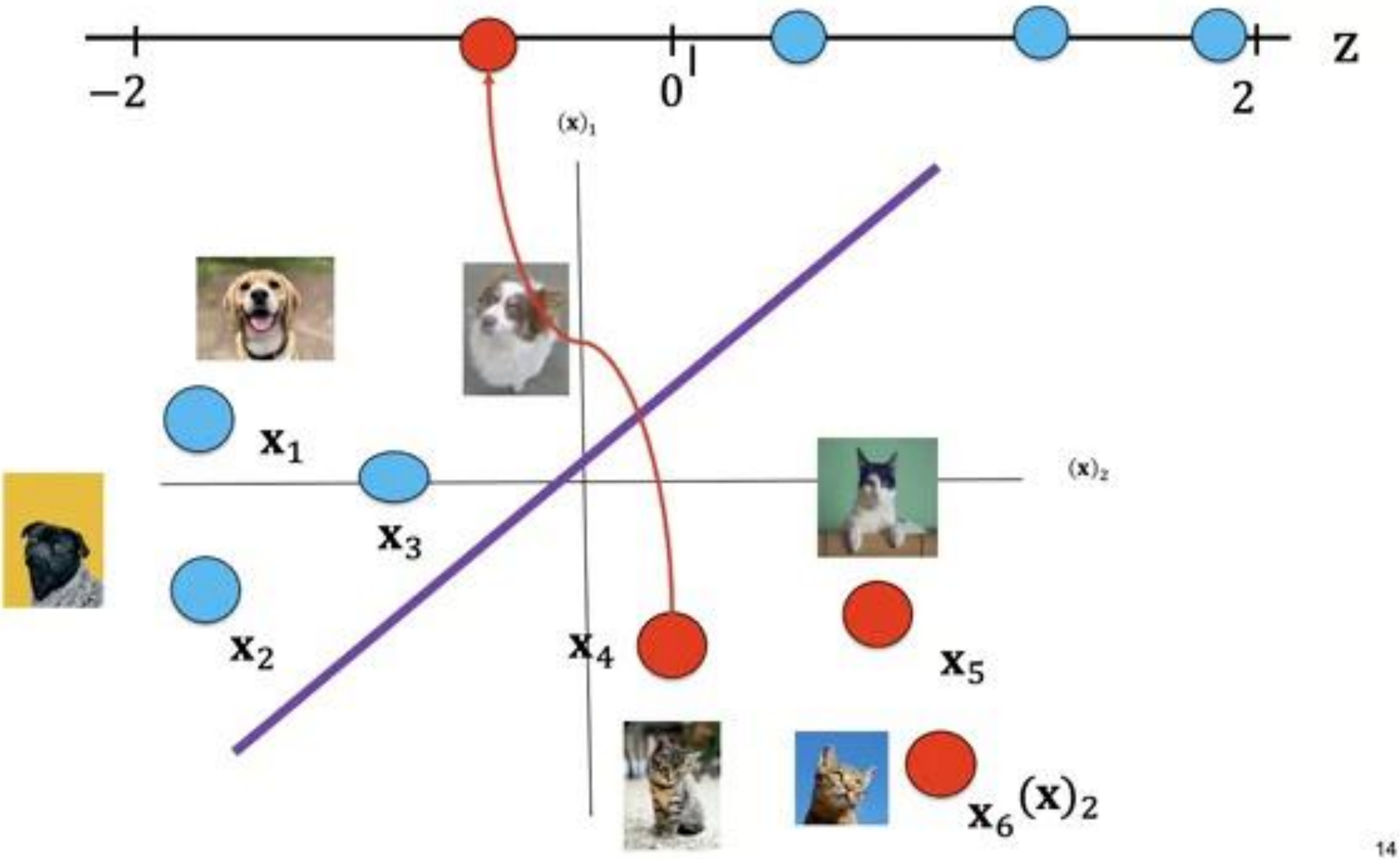

z
−2
0
2
$(\mathbf{x})_1$
$(\mathbf{x})_2$
$\mathbf{x}_1$
$\mathbf{x}_2$
$\mathbf{x}_3$
$\mathbf{x}_4$
$\mathbf{x}_5$
$\mathbf{x}_6$
$(\mathbf{x})_2$
13



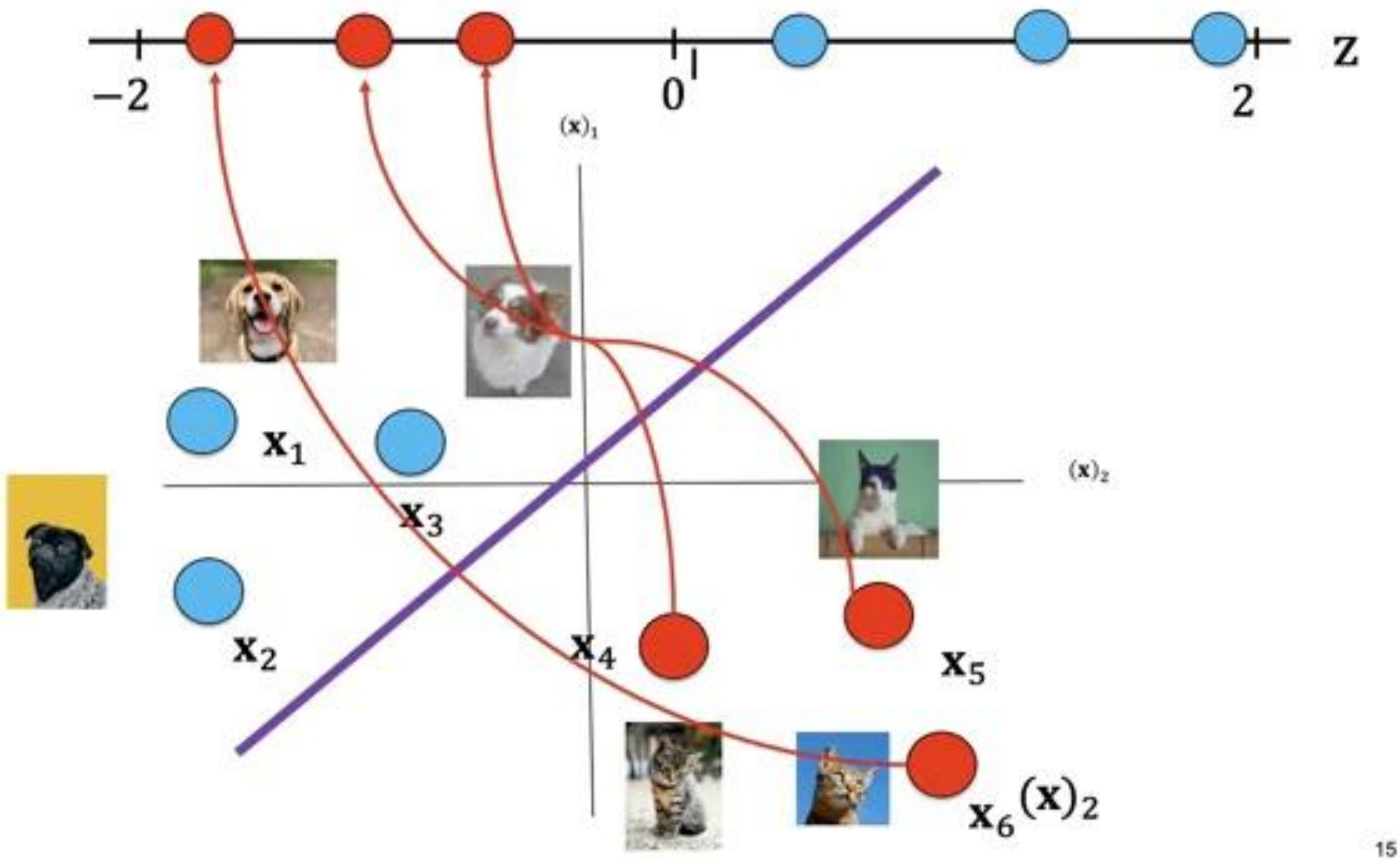
−2
0
2
z
(x)₁
(x)₂
x₁
x₂
x₃
x₄
x₅
x₆
(x)₂
13



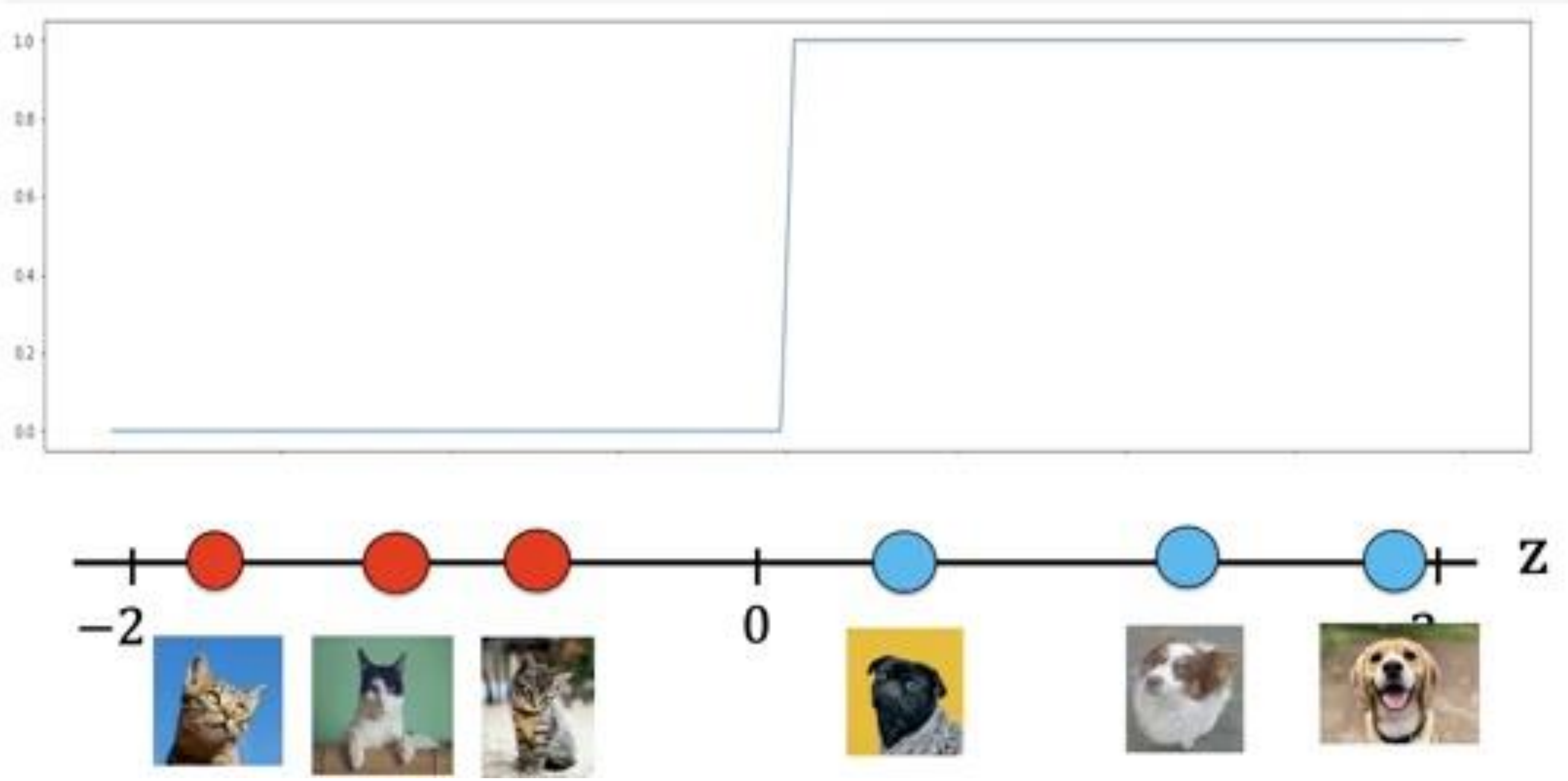
−2
0
2
z
(x)1
(x)2
x1
x2
x3
x4
x5
x6
(x)2
14



−2
0
2
z
$(\mathbf{x})_1$
$(\mathbf{x})_2$
$\mathbf{x}_1$
$\mathbf{x}_2$
$\mathbf{x}_3$
$\mathbf{x}_4$
$\mathbf{x}_5$
$\mathbf{x}_6$
$(\mathbf{x})_2$
14

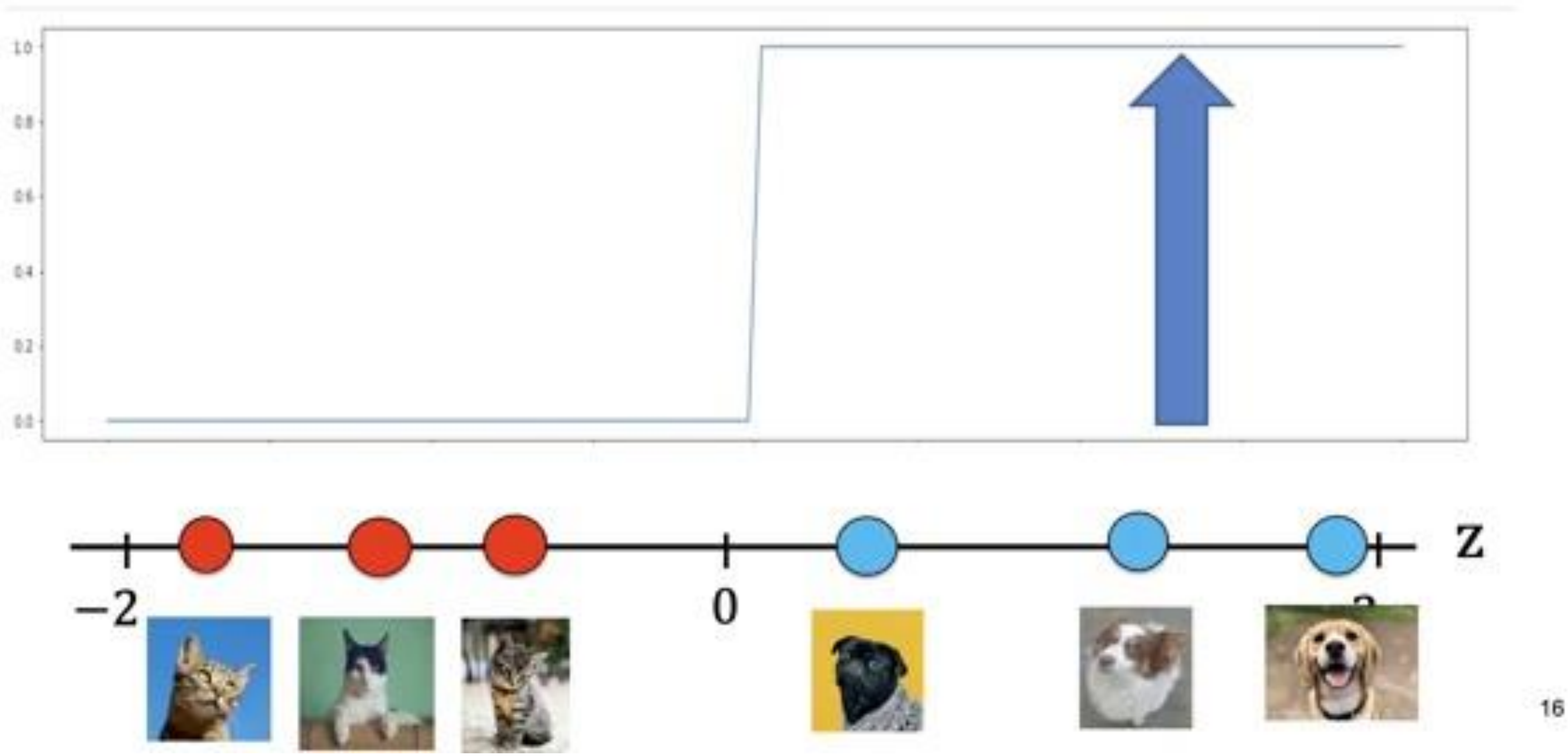

−2
0
2
Z
$(\mathbf{x})_1$
$(\mathbf{x})_2$
$\mathbf{x}_1$
$\mathbf{x}_2$
$\mathbf{x}_3$
$\mathbf{x}_4$
$\mathbf{x}_5$
$\mathbf{x}_6$
$(\mathbf{x})_2$
15

$$\hat{y} = f(z)$$

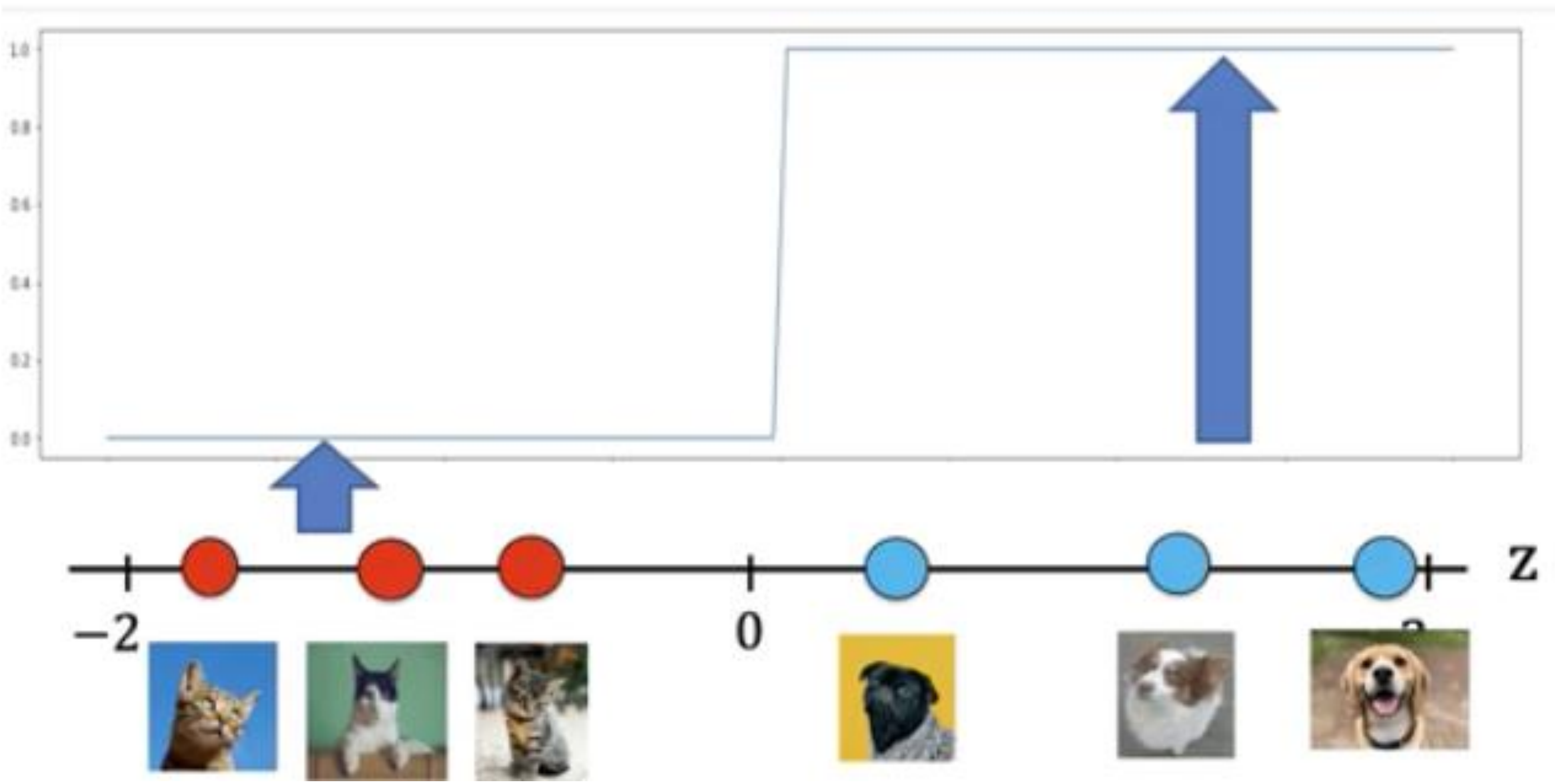


16

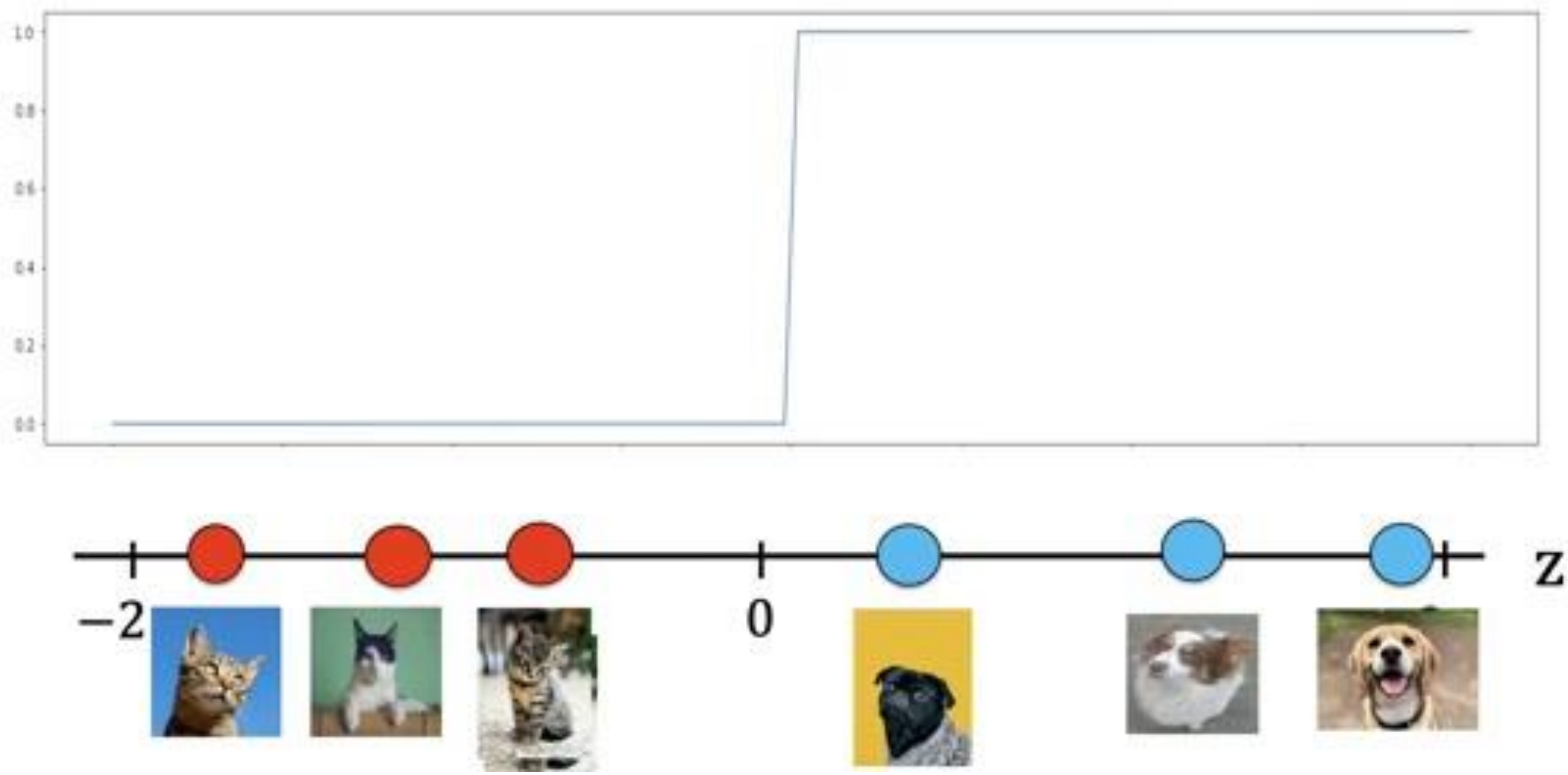
$$\hat{y} = f(z)$$



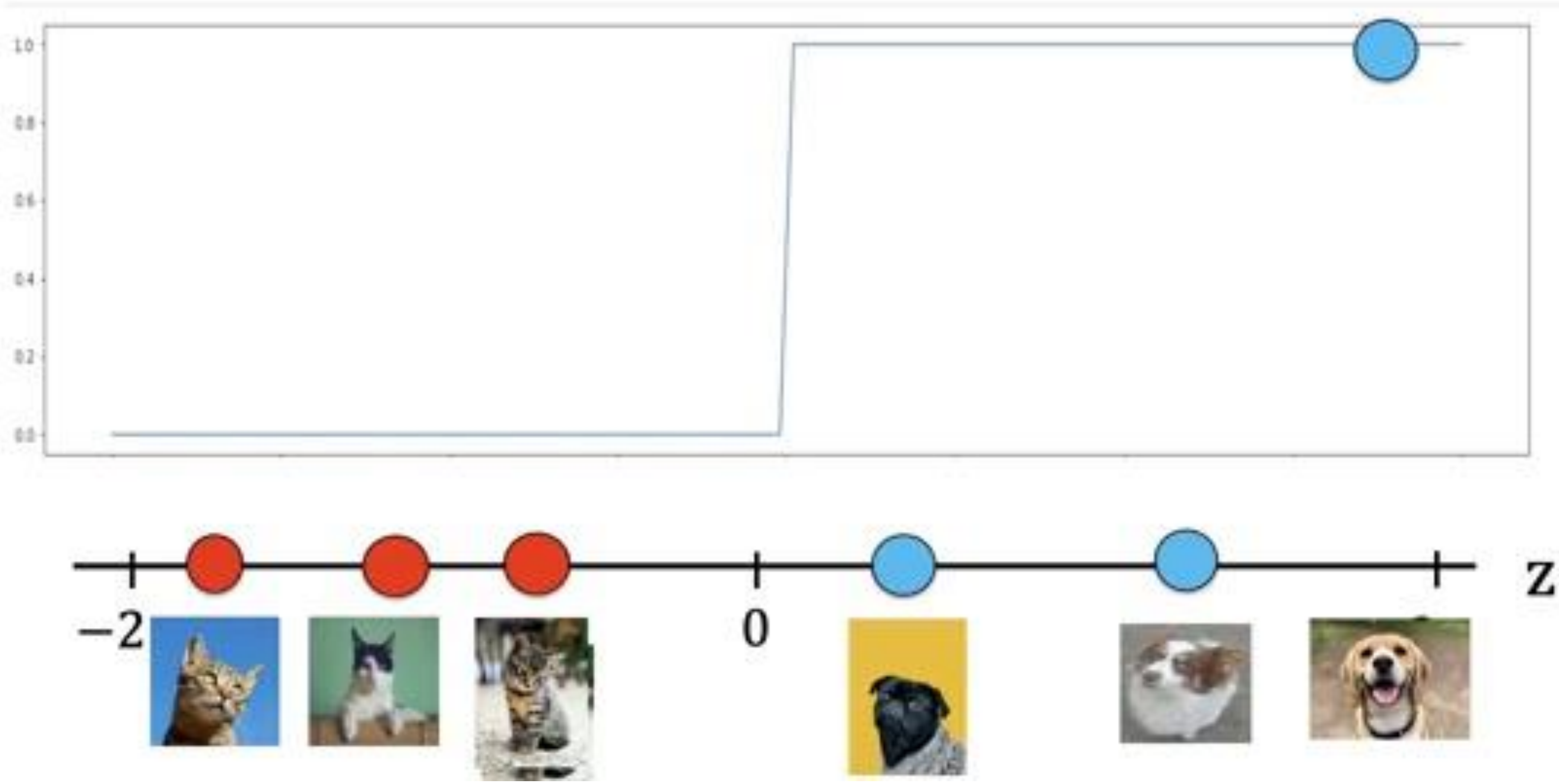
$$\hat{y} = f(z)$$



$$\hat{y}_1 = f($$  $$)$$

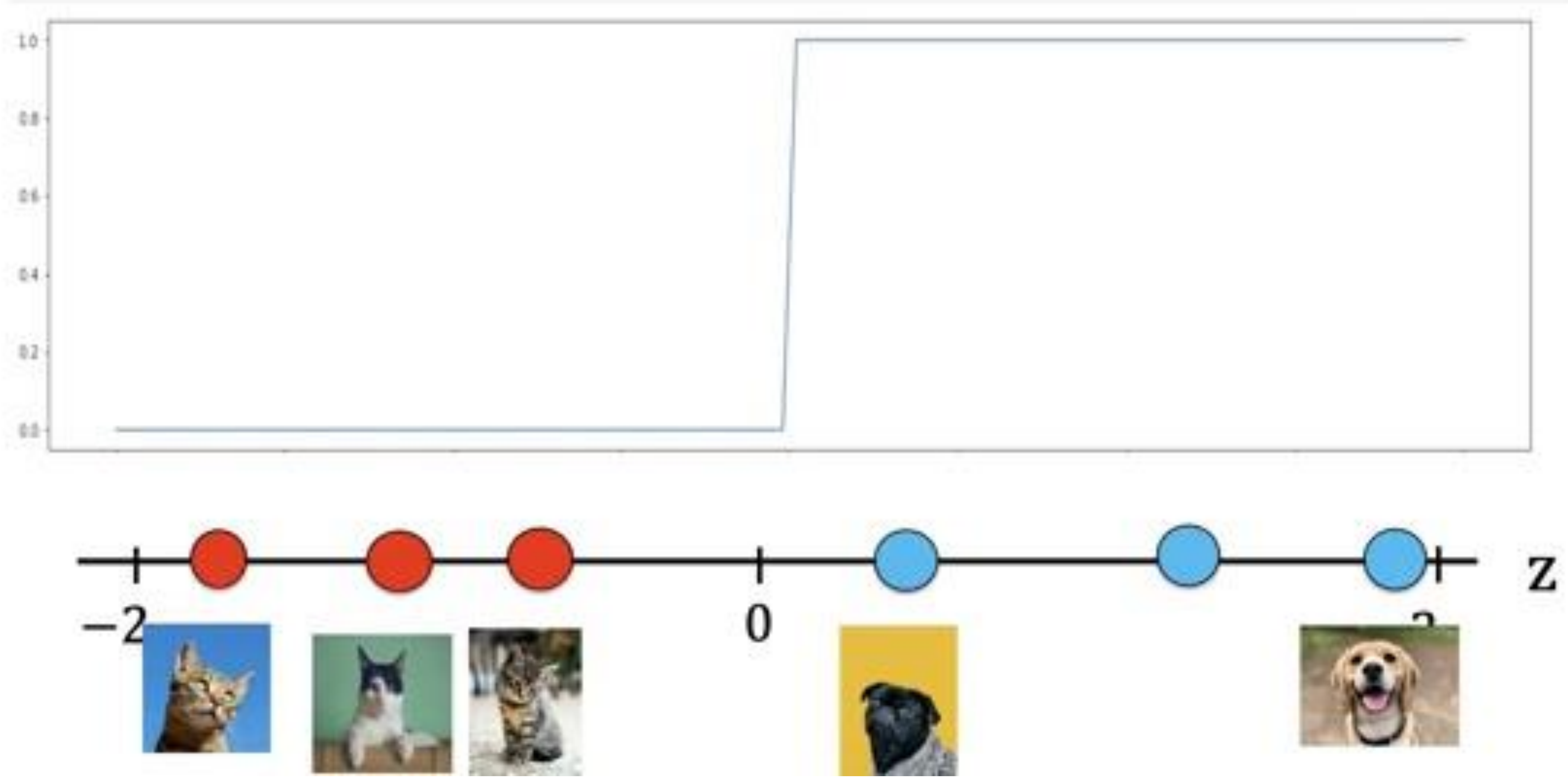


$\hat{y}_1 = f($  $) = 1$

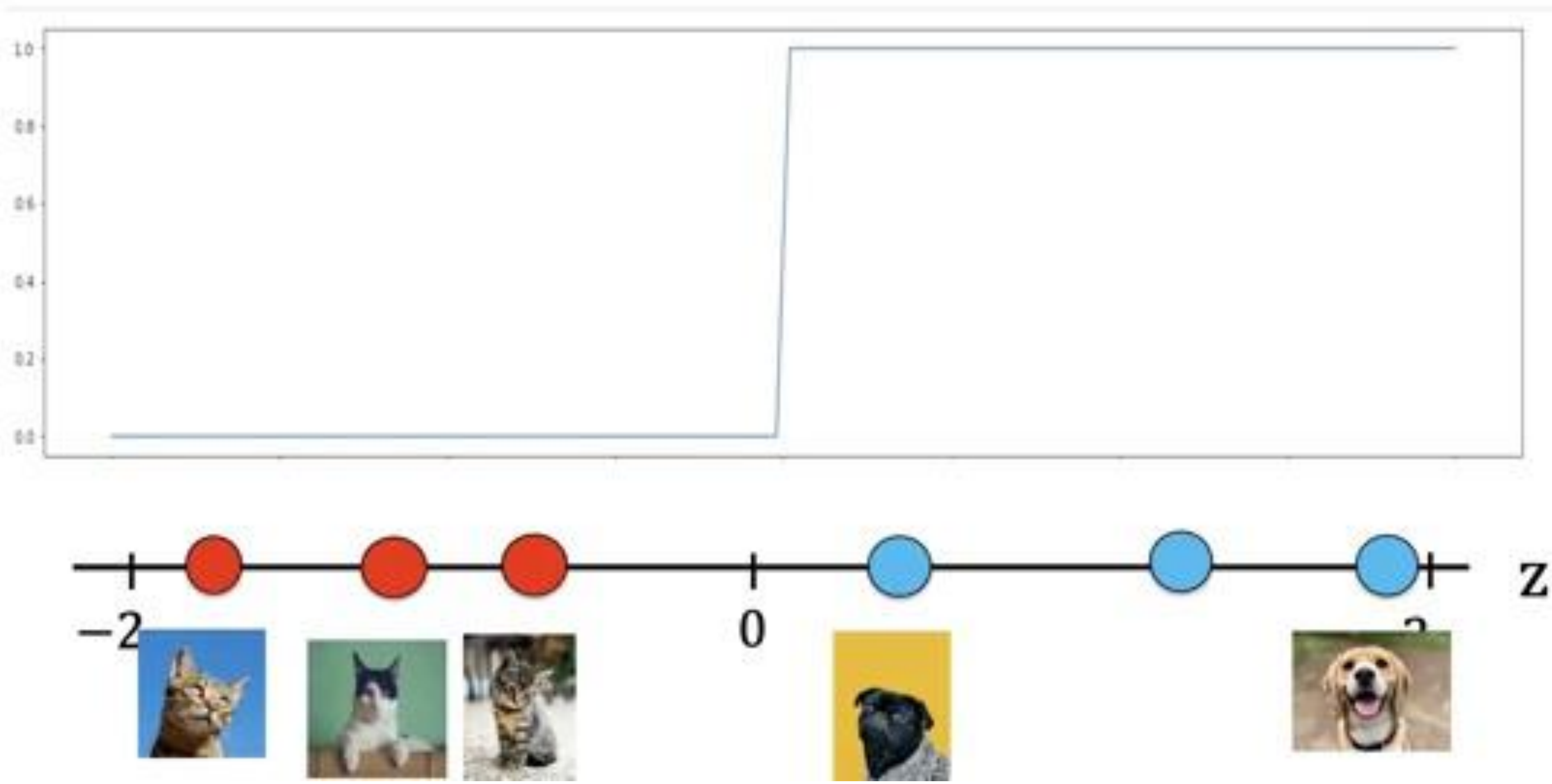


17

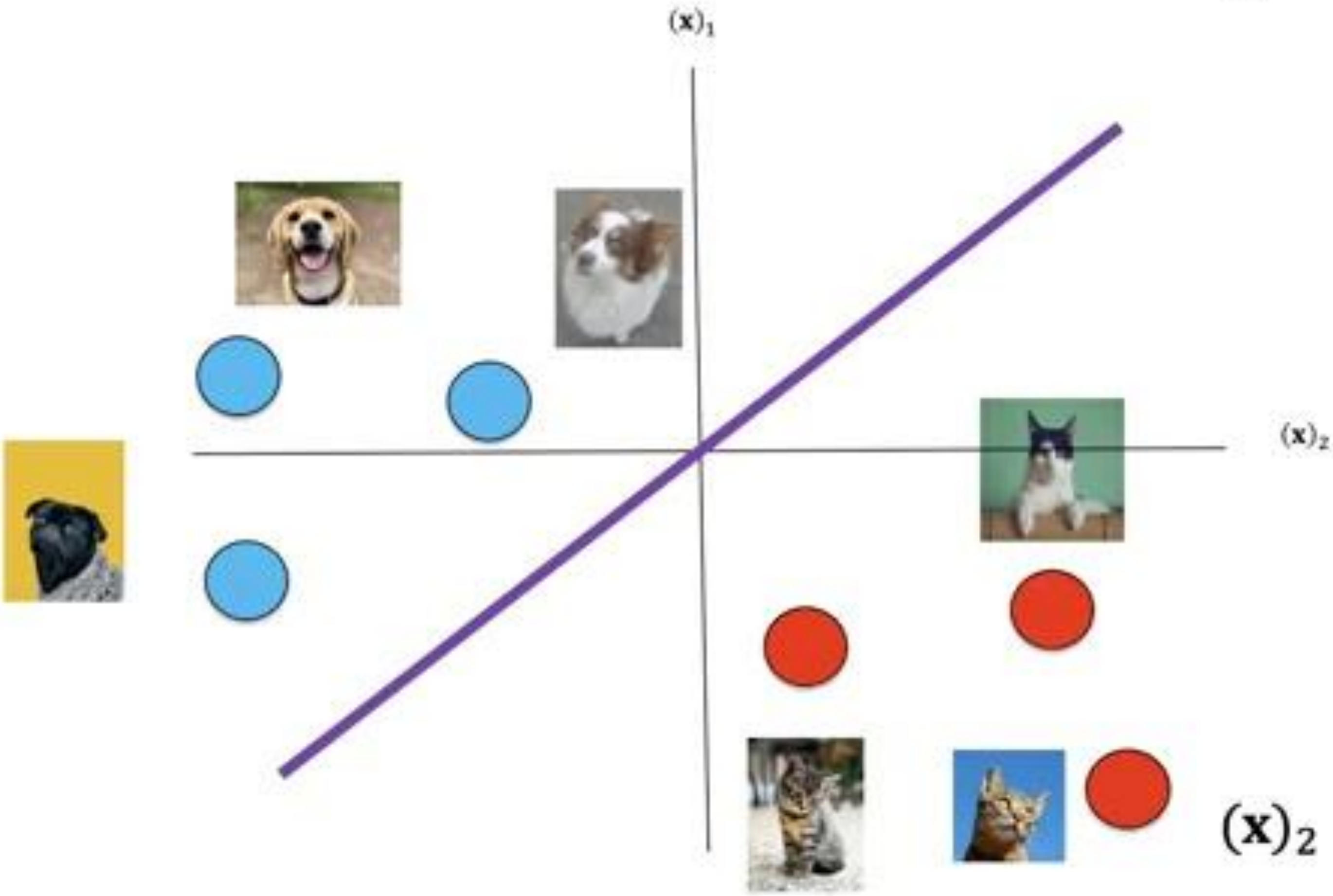
$\hat{y}_1 = f($  $)$

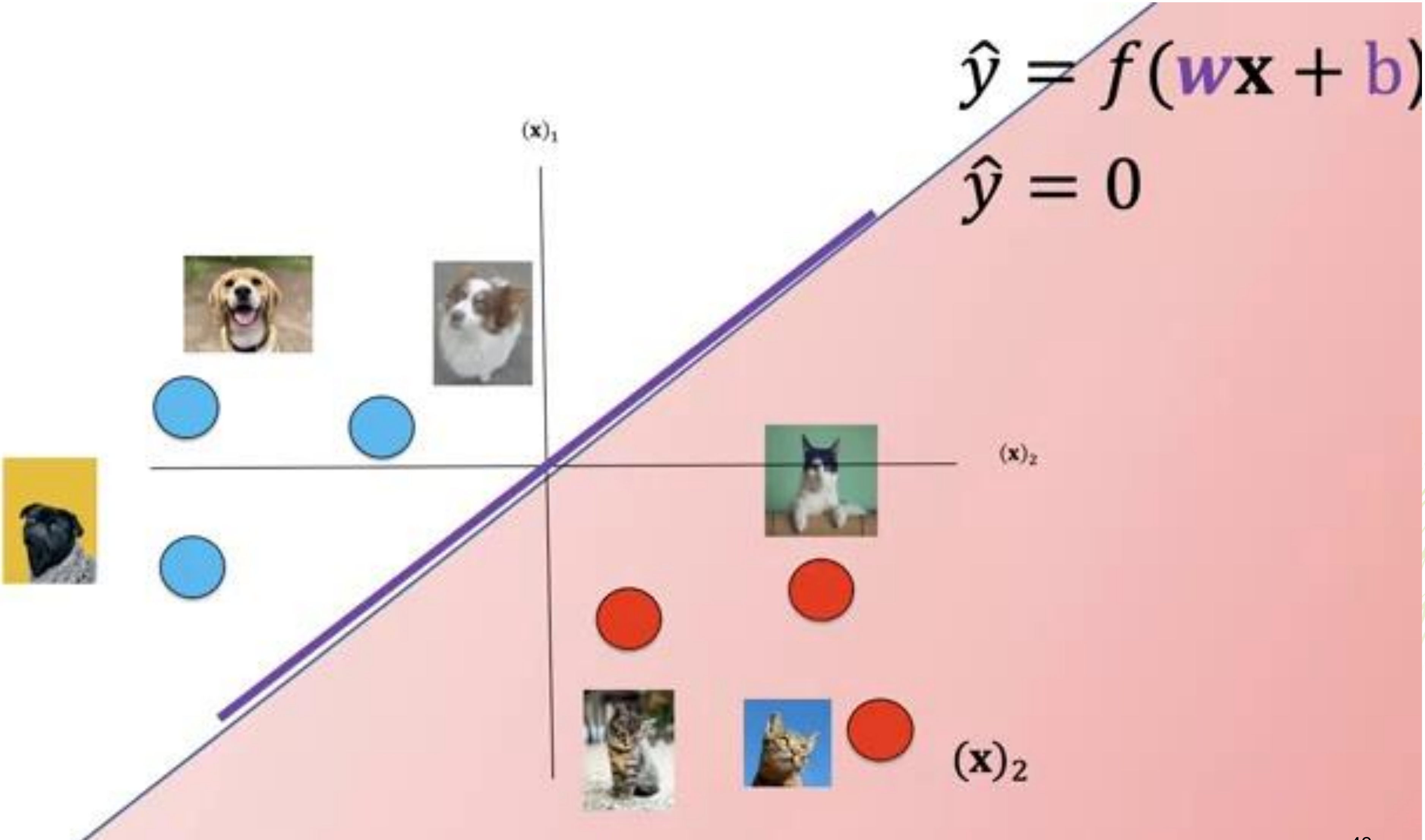


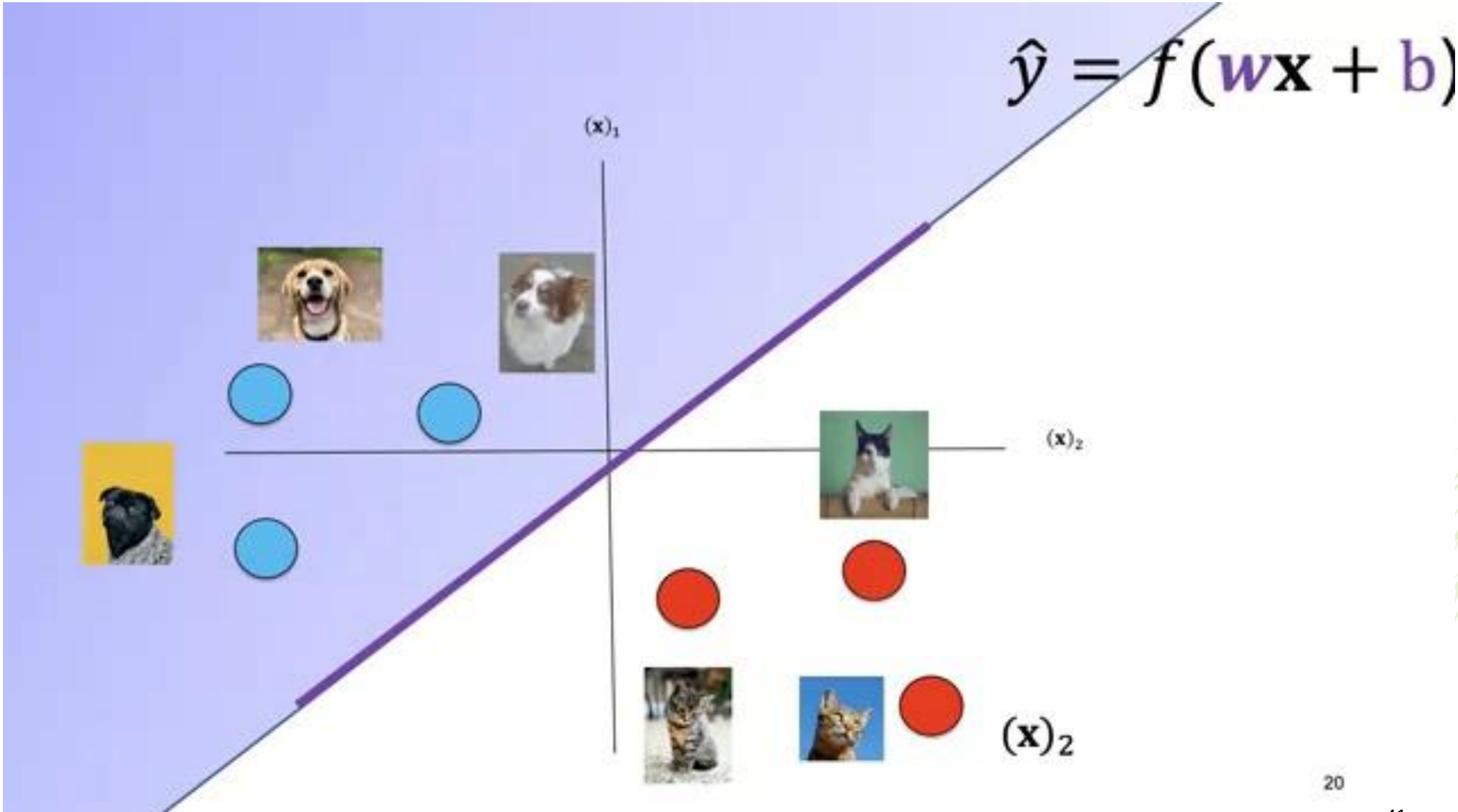
$\hat{y}_1 = f($  $) = 0$

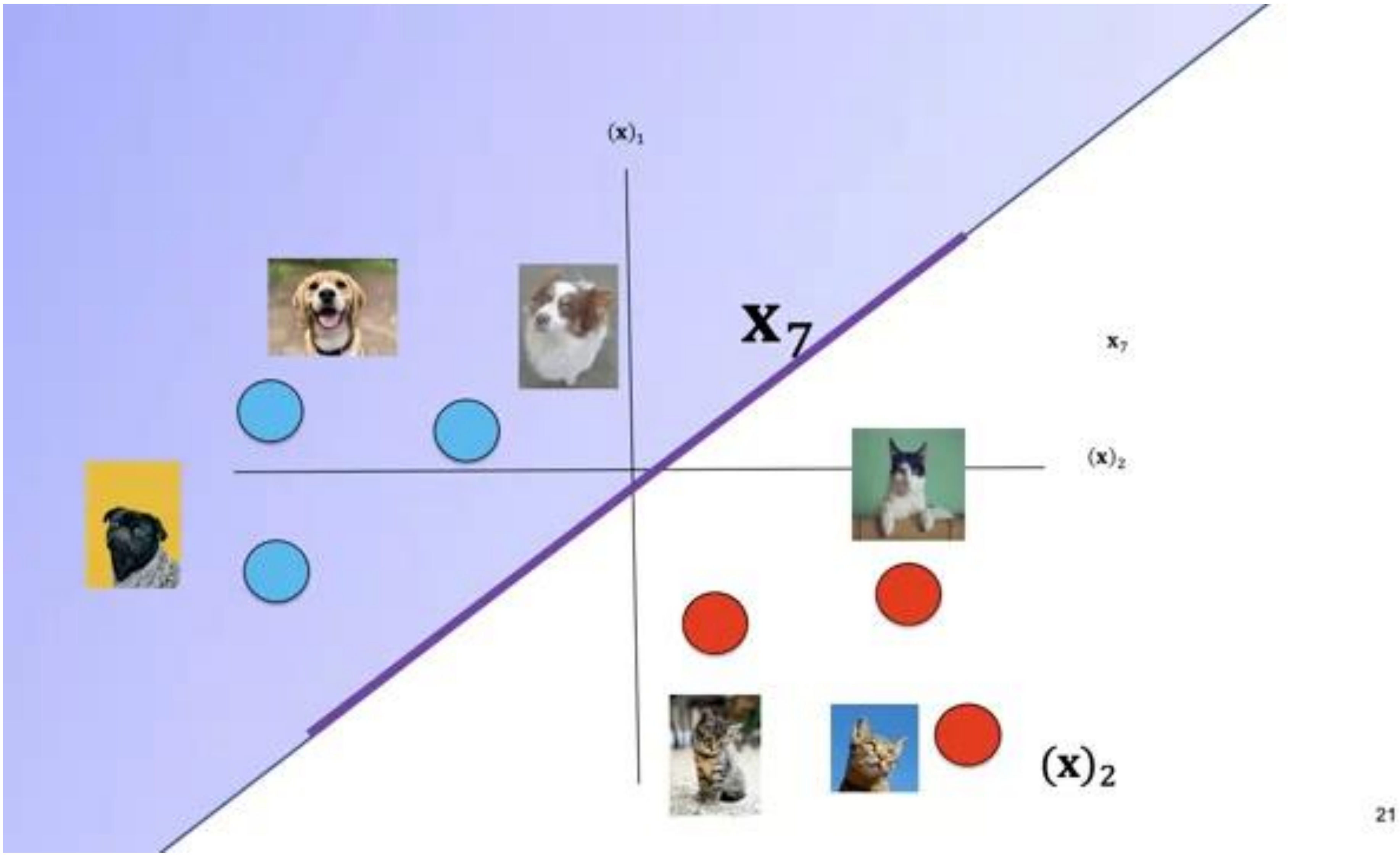


$$\hat{y} = f(\boldsymbol{w}\mathbf{x} + b)$$

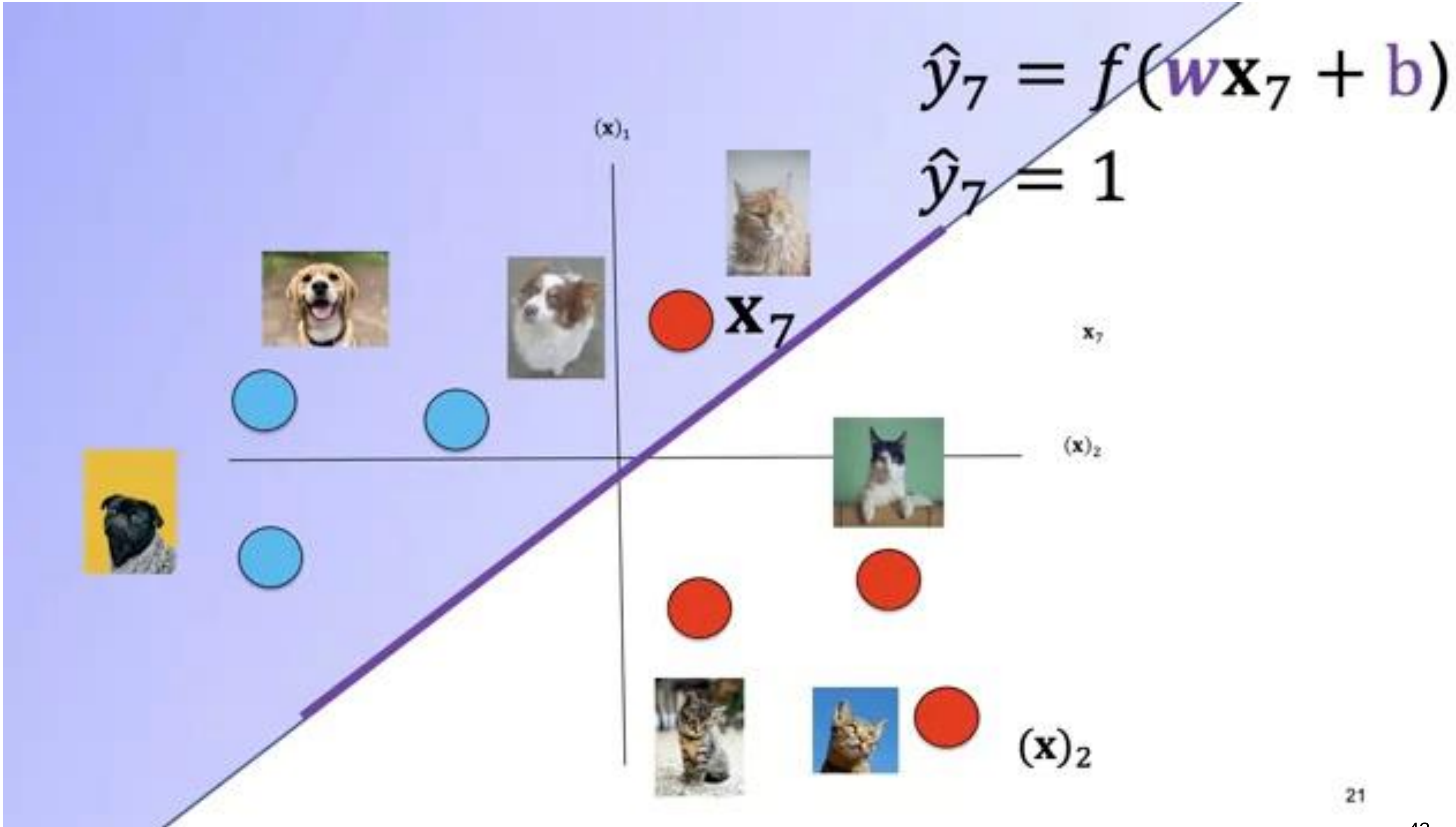



$\hat{y} = f(\boldsymbol{w}\mathbf{x} + \mathrm{b})$
$\hat{y} = 0$
$(\mathbf{x})_1$
$(\mathbf{x})_2$
$(\mathbf{x})_2$


$\hat{y} = f(w\mathbf{x} + \mathrm{b})$
$(\mathbf{x})_1$
$(\mathbf{x})_2$
$(\mathbf{x})_2$
20



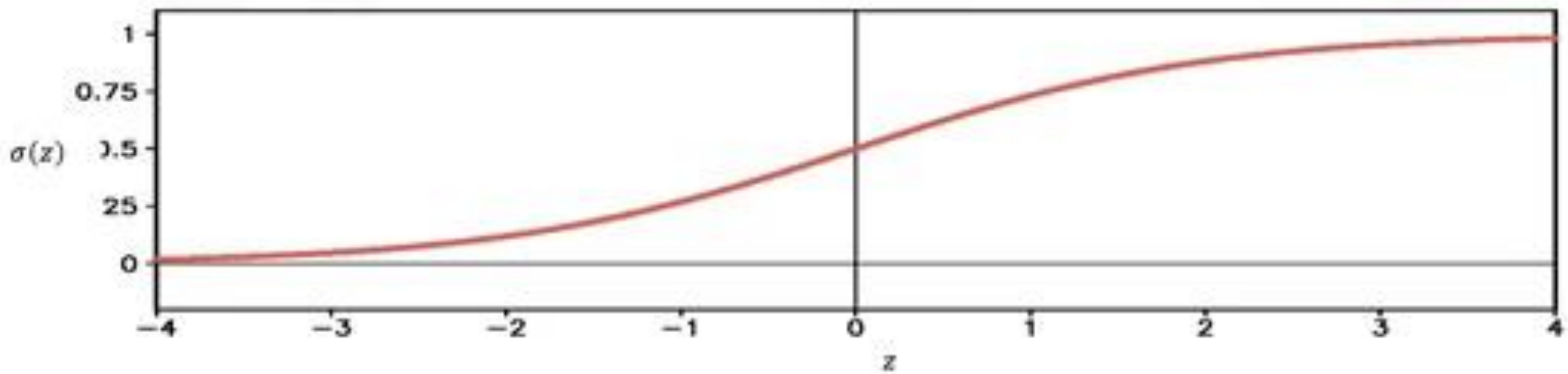
$(\mathbf{x})_1$
$\mathbf{x}_7$
$\mathbf{x}_7$
$(\mathbf{x})_2$
$(\mathbf{x})_2$
21



$\hat{y}_7 = f(\boldsymbol{w}\mathbf{x}_7 + \mathrm{b})$
$\hat{y}_7 = 1$
$(\mathbf{x})_1$
$\mathbf{x}_7$
$\mathbf{x}_7$
$(\mathbf{x})_2$
$(\mathbf{x})_2$
21

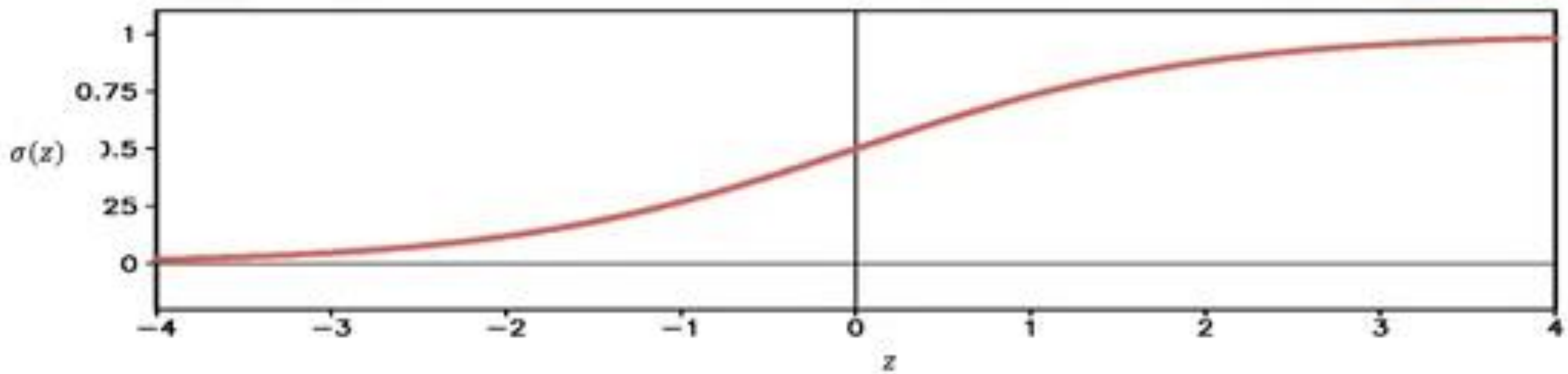
Logistic Regression

- Logistic Function



Logistic Regression

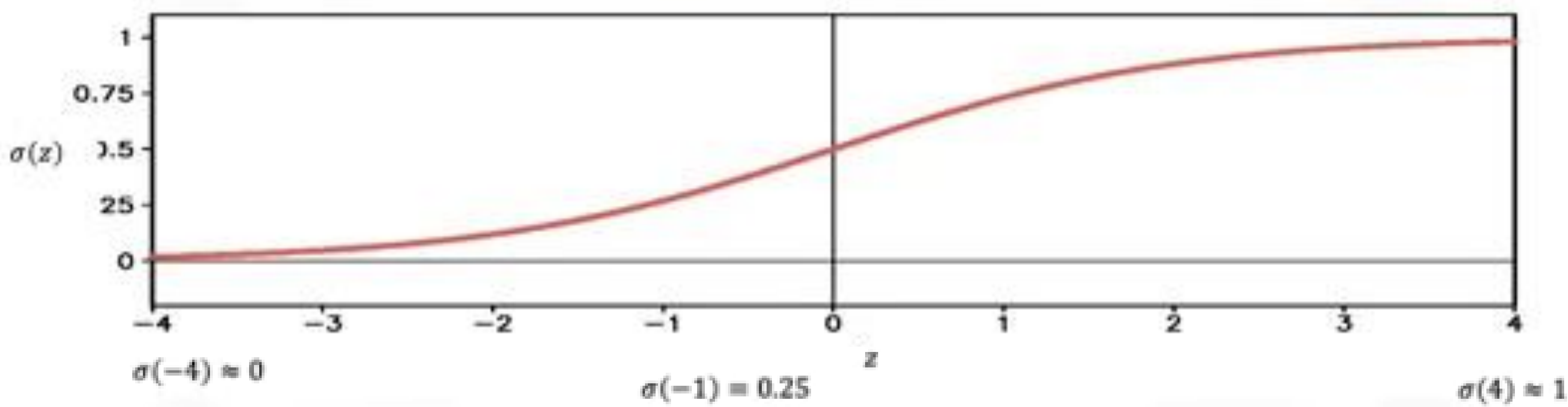
- Logistic Function



$$\sigma(z) = \frac{1}{1 + e^{-z}}$$

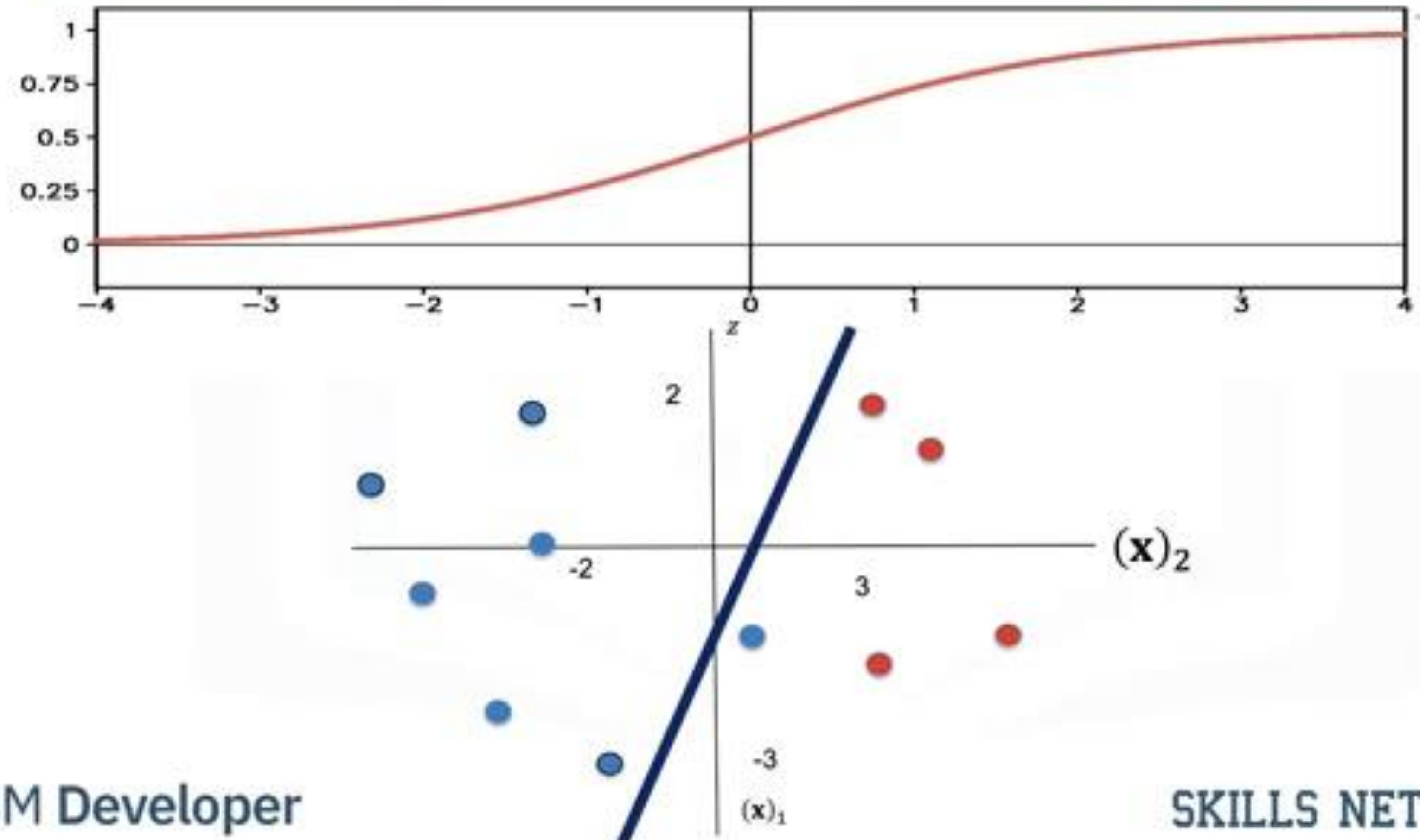
Logistic Regression

- Logistic Function

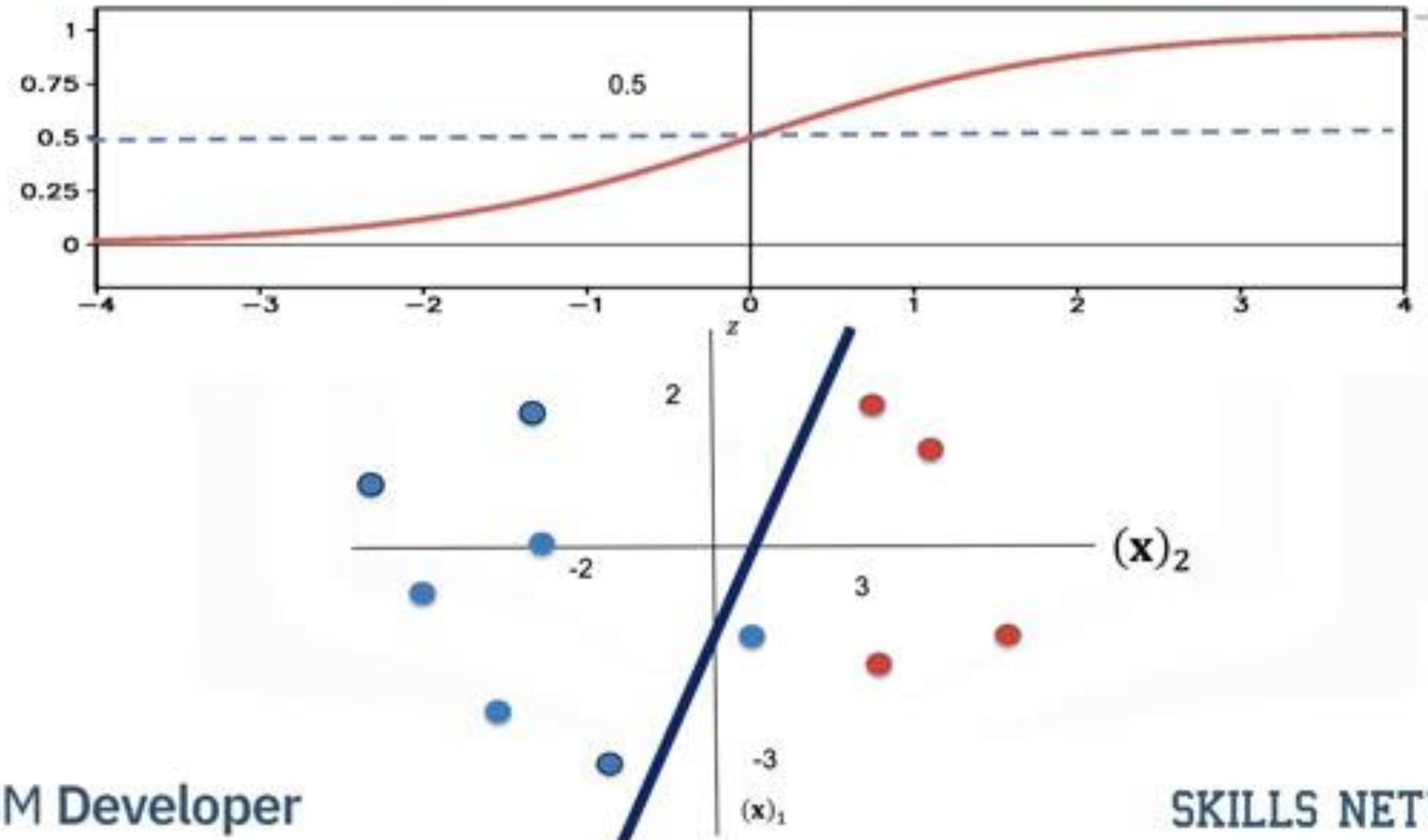


$$\sigma(z) = \frac{1}{1 + e^{-z}}$$

Logistic Regression



Logistic Regression



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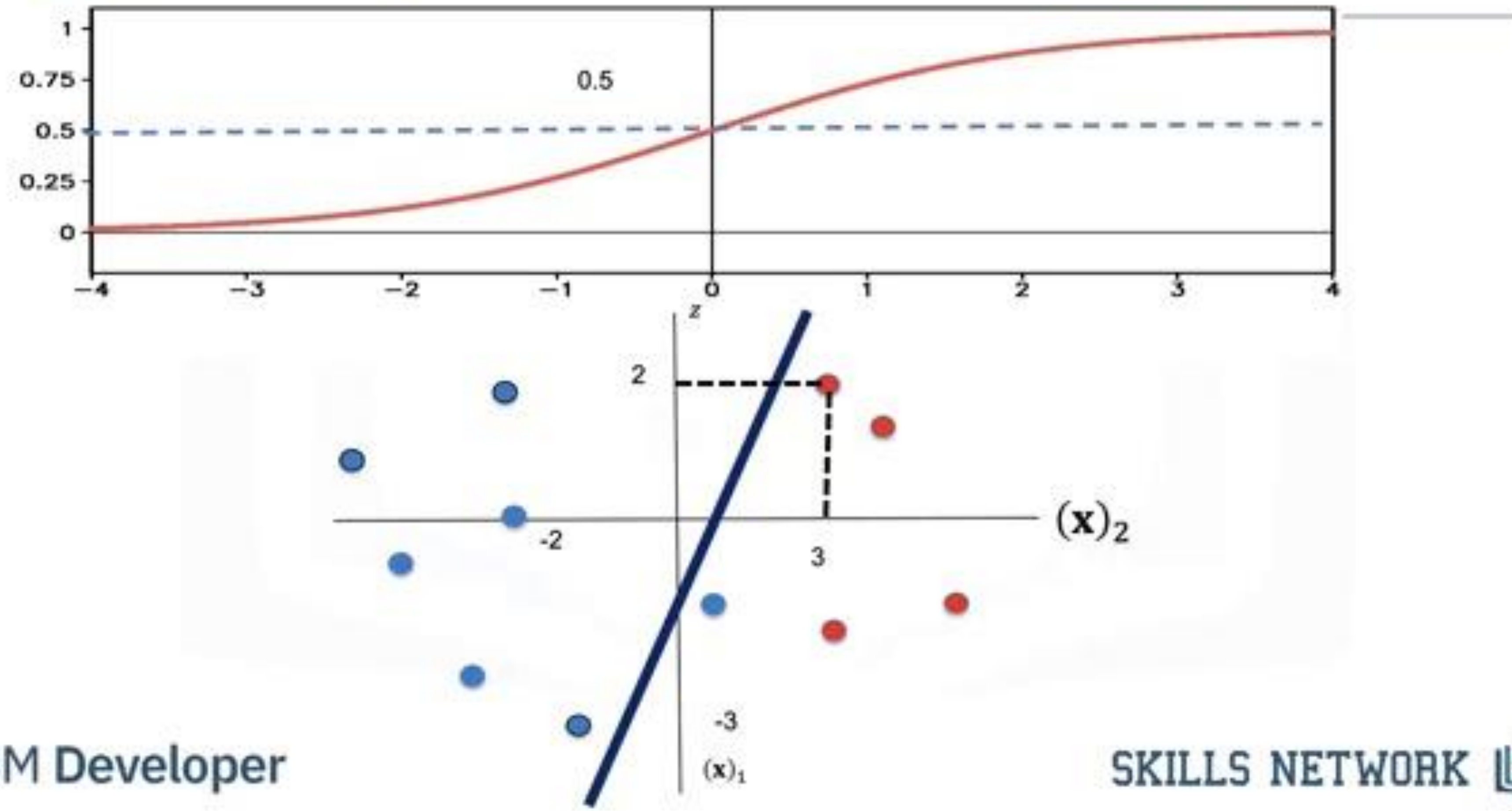
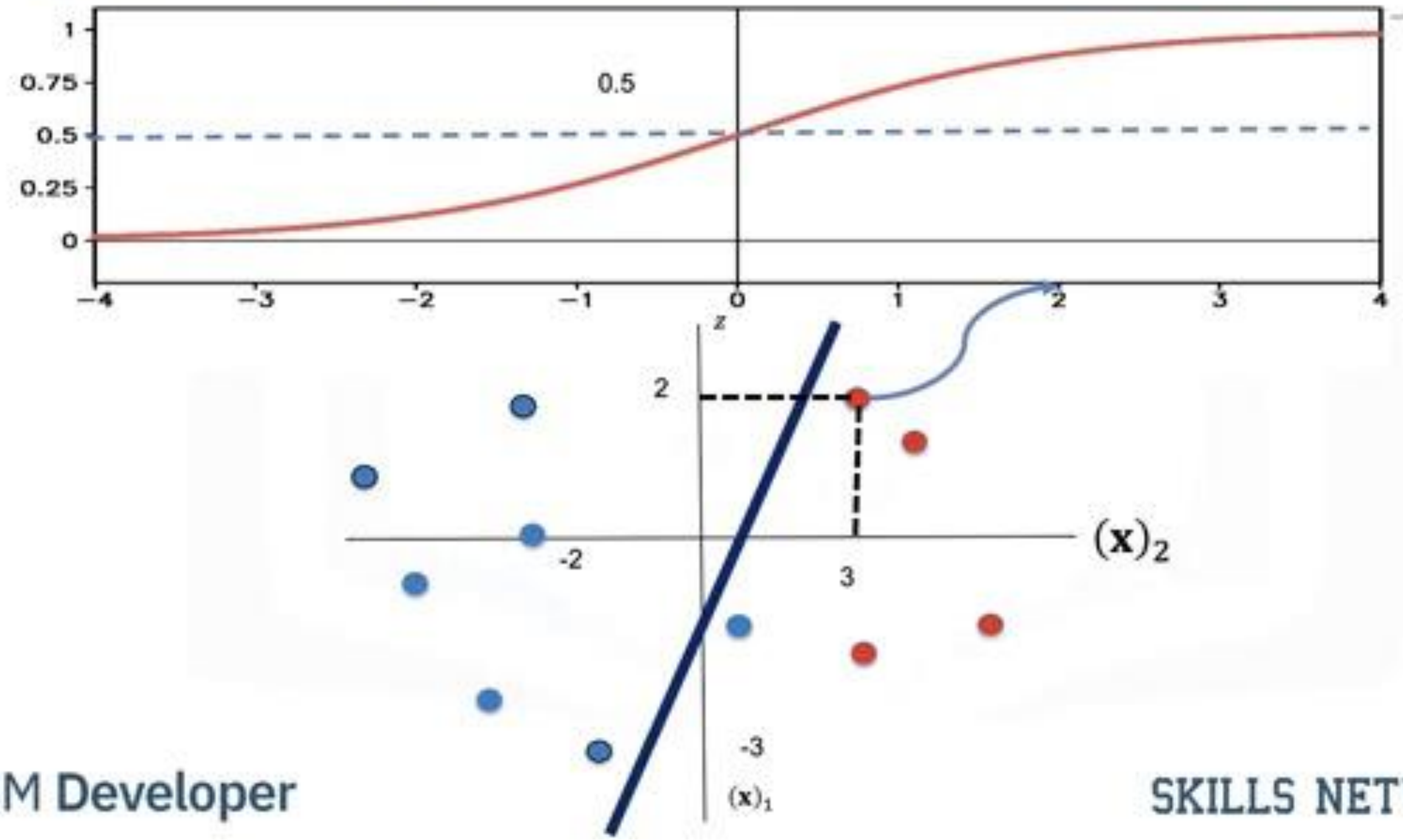
SKILLS NETWORK

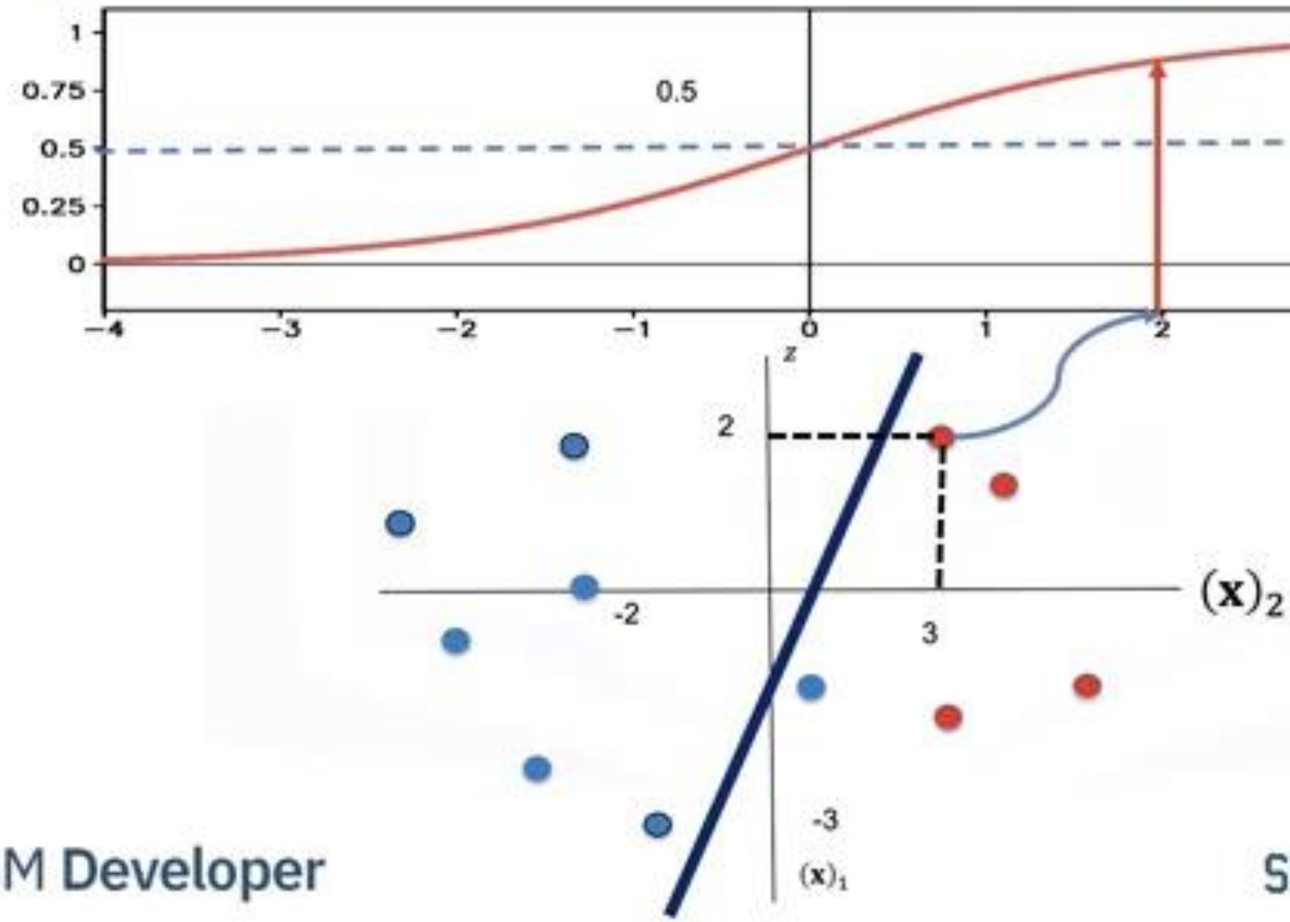
Logistic Regression



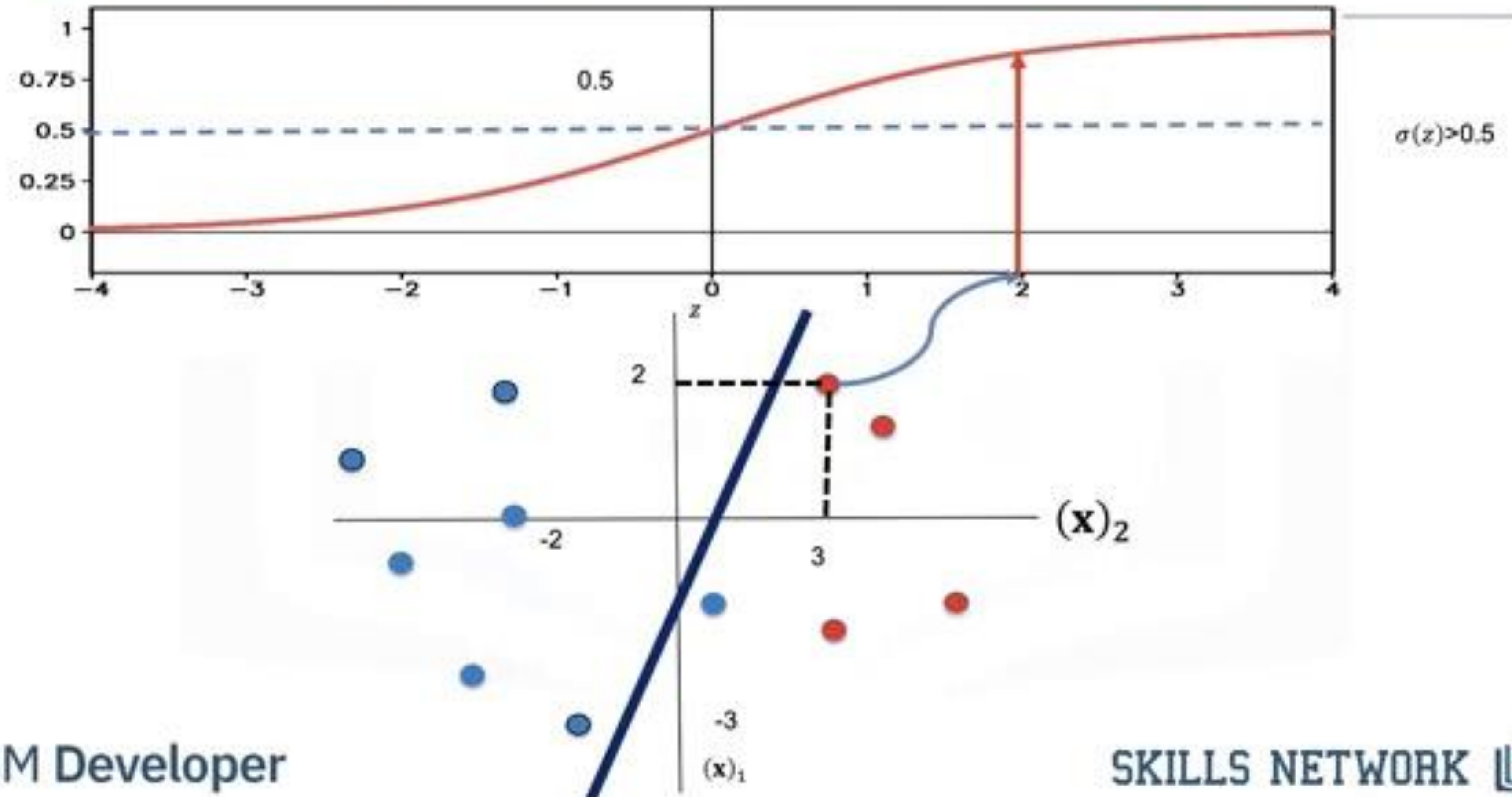
Logistic Regression



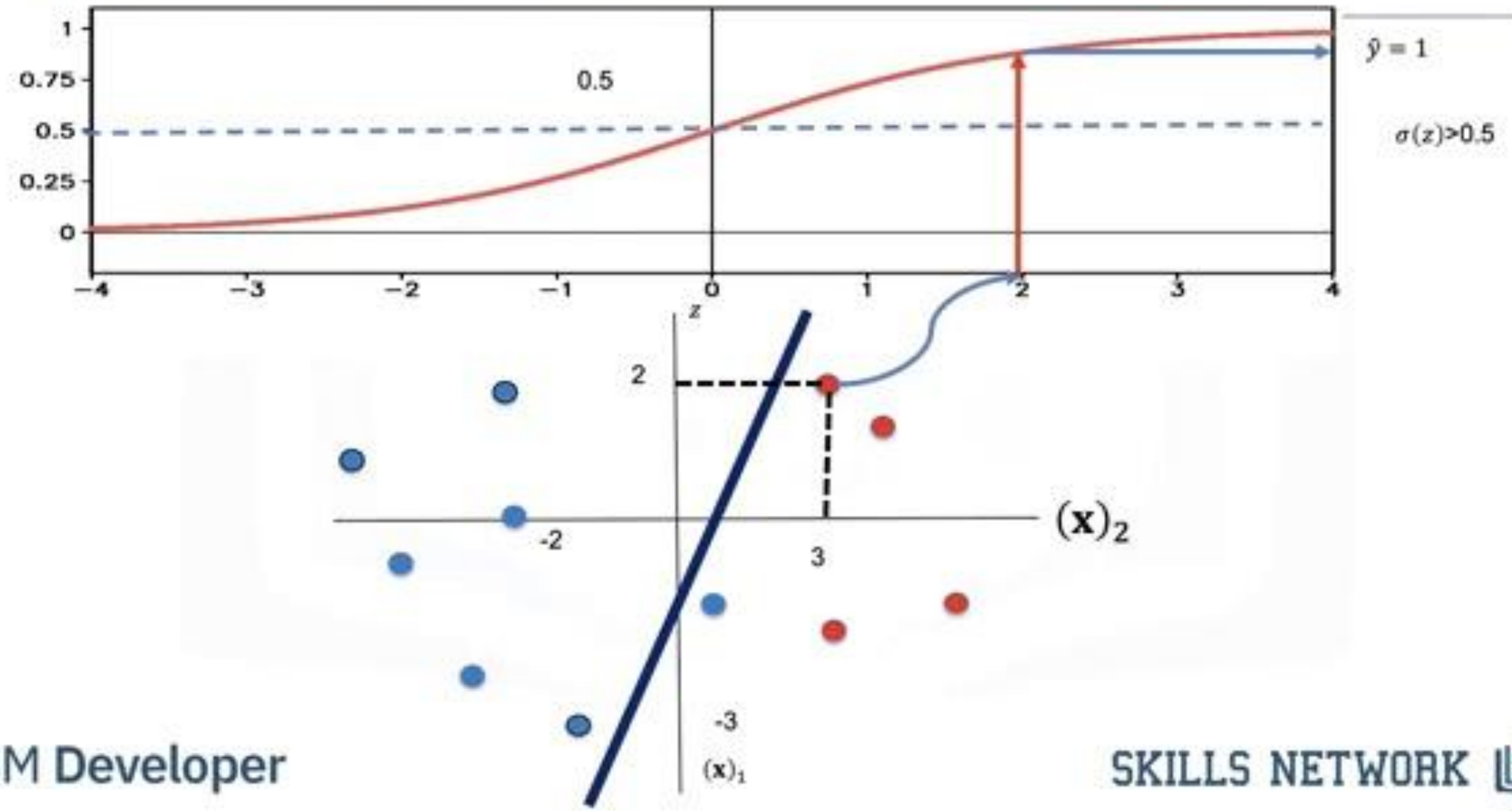
Logistic Regression



Logistic Regression



Logistic Regression



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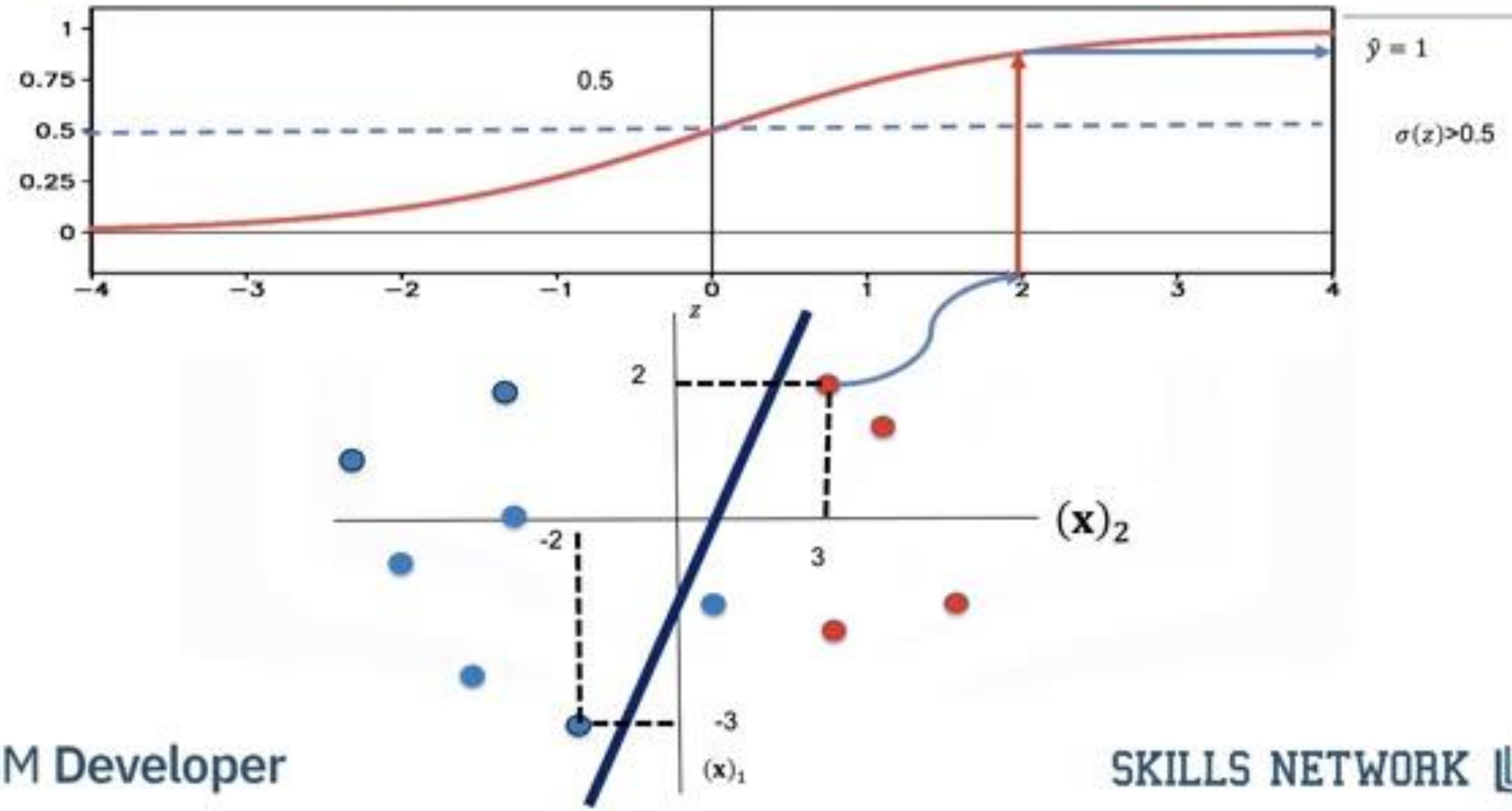
Logistic Regression



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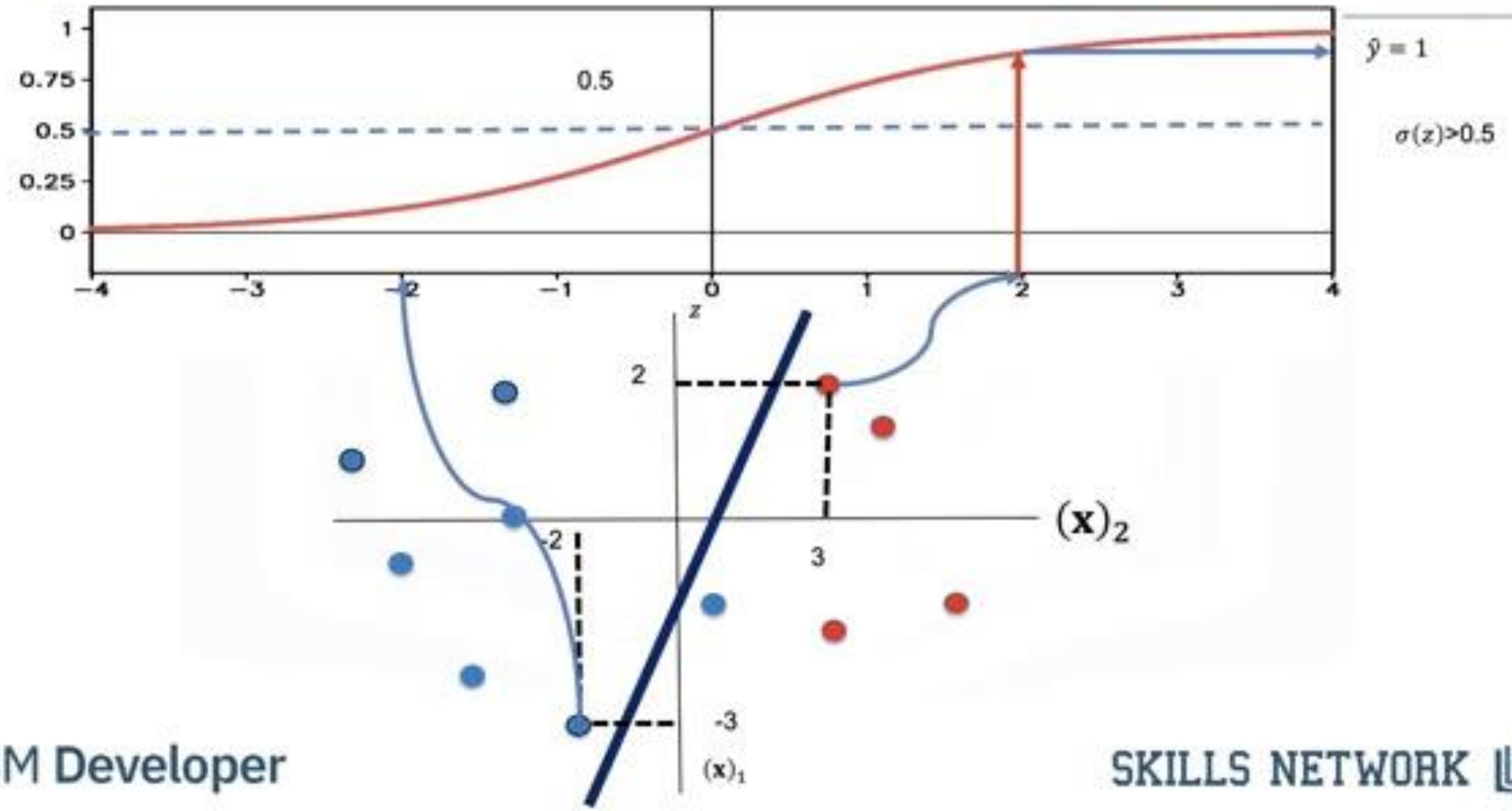
SKILLS NETWORK

Logistic Regression



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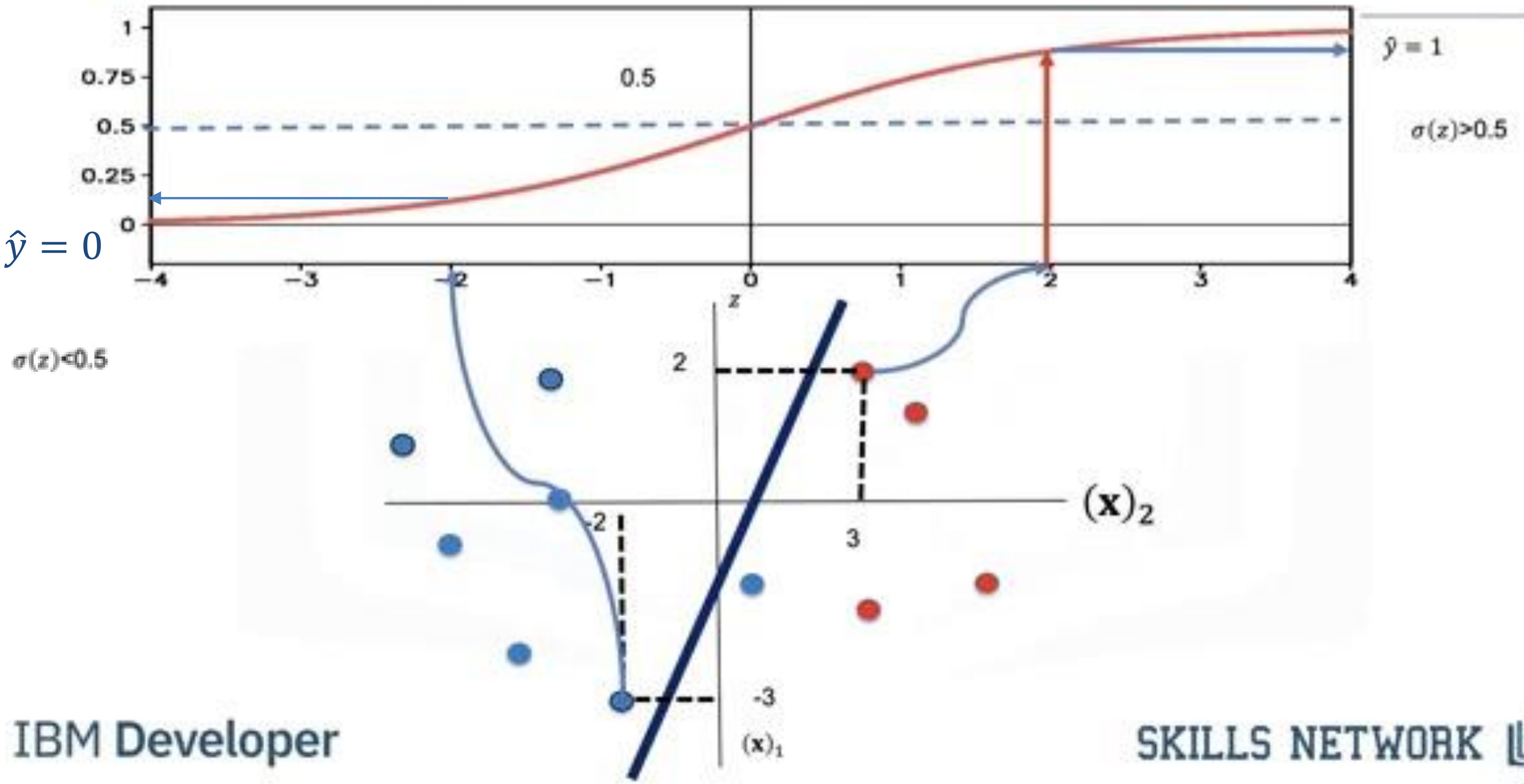
SKILLS NETWORK

Logistic Regression



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SKILLS NETWORK

$\overbrace{p}^{\sigma}\Big($  $\Big) = 0.92$ Probability this image is a Dog

$\overbrace{p}^{\sigma}($  $) = 0.92$ Probability this image is a Dog

$1 - p($  $) = 0.08$ Probability this image is a Cat

$p($  $)$

$1 - p($  $)$

$p($  $) = 0.10$ Probability this image is a Dog

$1 - p($  $)$

$p($  $) = 0.10$

Probability this image is a Dog

$1 - p($  $) = 0.9$

Probability this image is a Cat

$\hat{y} = f($  $)$

$$\hat{y} = 0$$

- https://scikit-learn.org/stable/modules/generated/sklearn.linear_model.LogisticRegression.html

Examples

```
>>> from sklearn.datasets import load_iris
>>> from sklearn.linear_model import LogisticRegression
>>> X, y = load_iris(return_X_y=True)
>>> clf = LogisticRegression(random_state=0).fit(X, y)
>>> clf.predict(X[:2, :])
array([0, 0])
>>> clf.predict_proba(X[:2, :])
array([[9.8...e-01, 1.8...e-02, 1.4...e-08],
       [9.7...e-01, 2.8...e-02, ...e-08]])
>>> clf.score(X, y)
0.97...
```