TAUTOLOGY
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NEURAL NETWORK & DEEP LEARNING

NEURAL NETWORK & DEEP LEARNING

BY TAUTOLOGY

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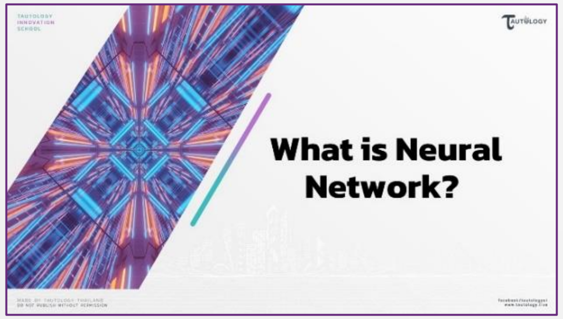
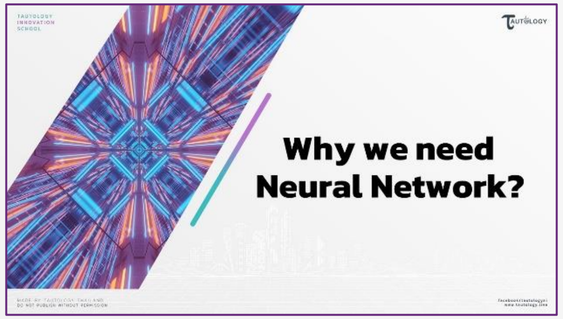
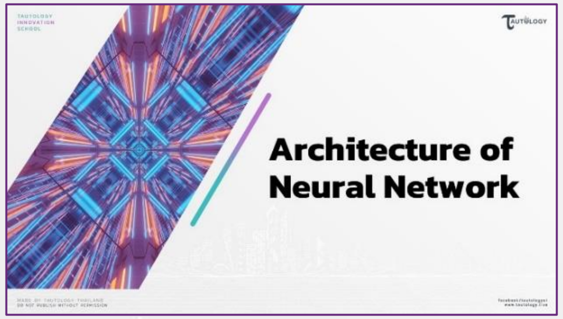
Neural Network & Deep Learning

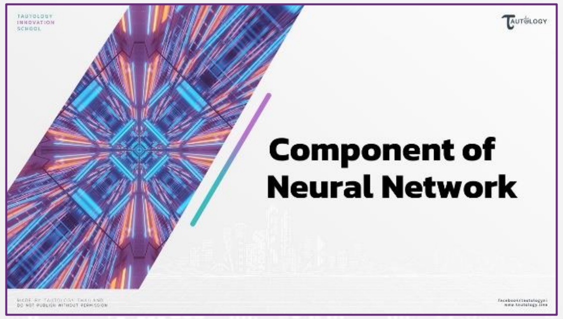
- Neural Network
- Deep Learning
- Deep Learning for Regression
- Deep Learning for Classification
- Workshop

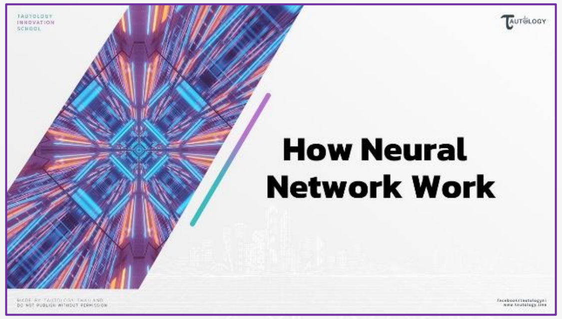
Neural Network











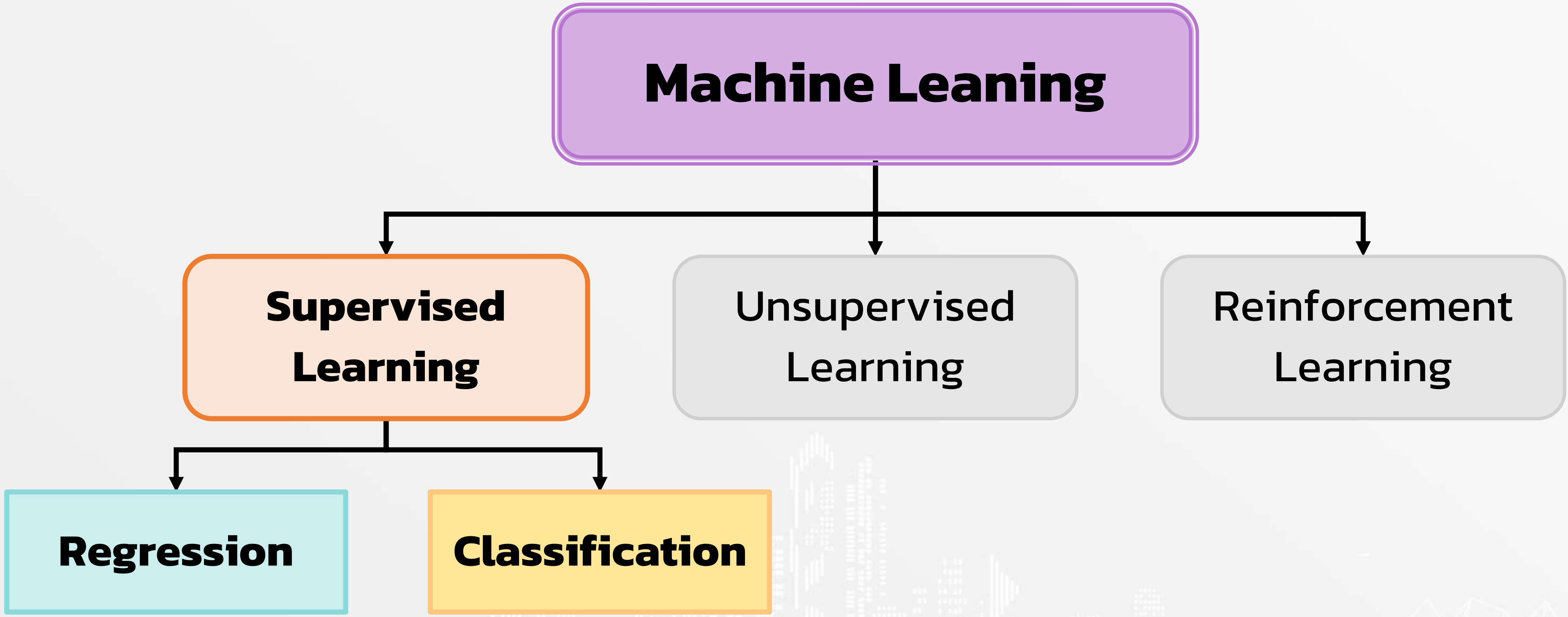
What is Neural Network?

What is Neural Network?

Neural Network เป็นหนึ่งใน algorithm ประเภท supervised learning ที่ใช้สำหรับแก้ปัญหา regression และ classification

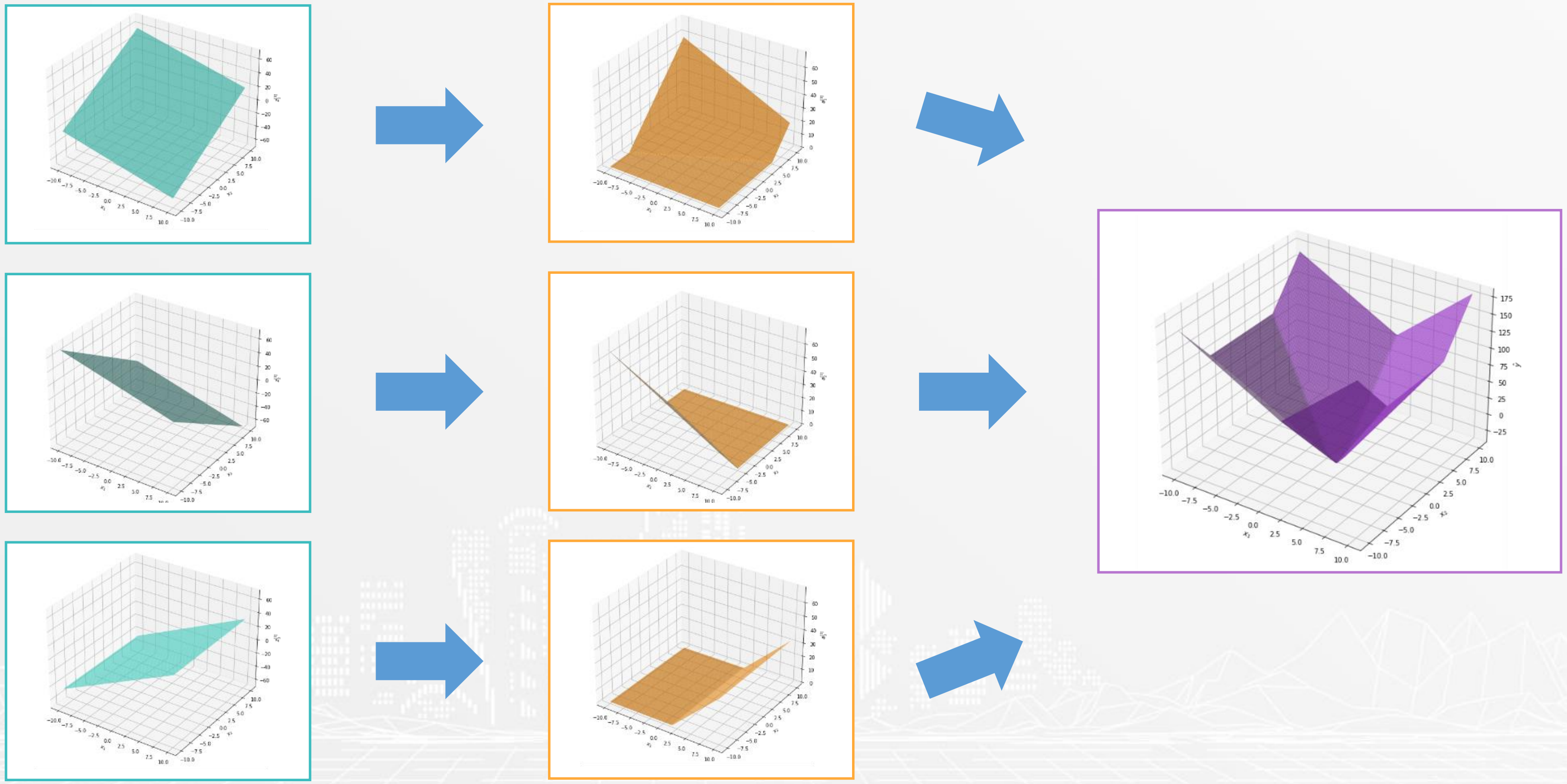
โดยมีหลักการทำงาน คือ **การนำ nonlinear function มาประกอบกัน** เพื่อประมาณ nonlinear function ที่ซับซ้อนได้

What is Neural Network?



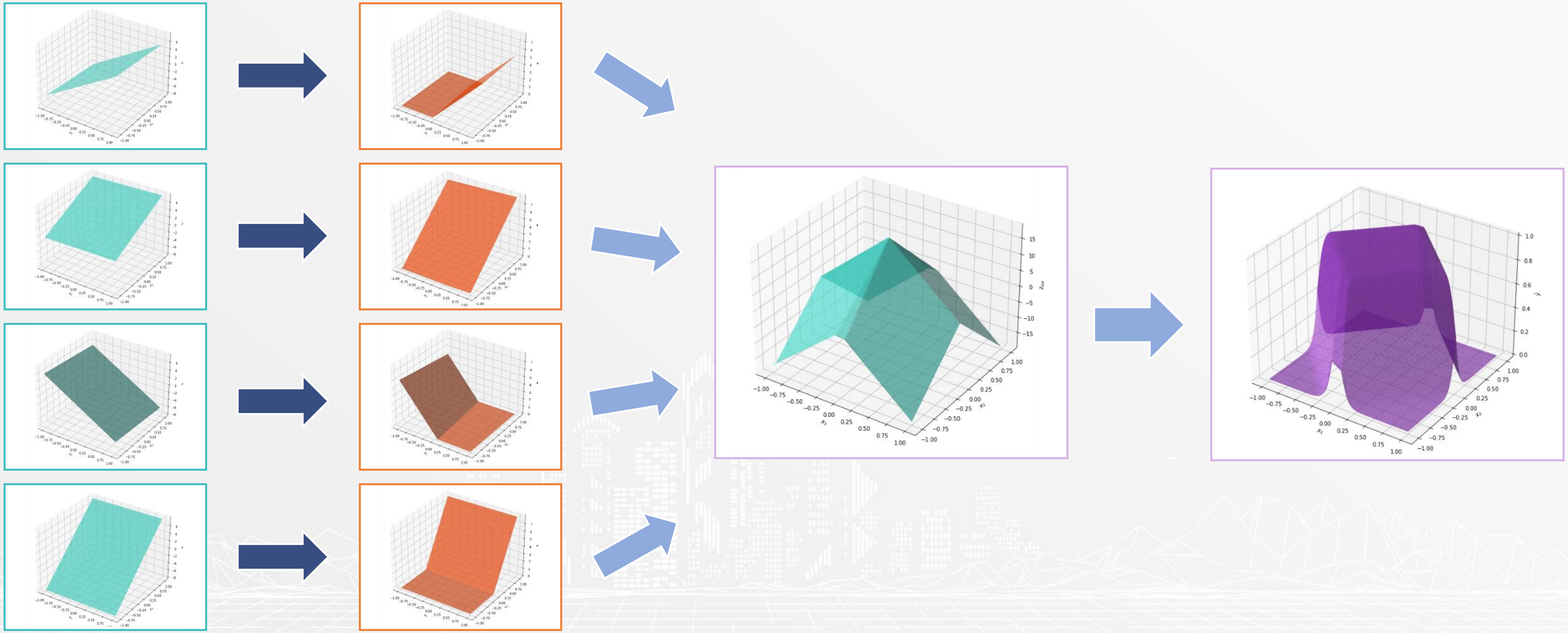
What is Neural Network?

Regression



What is Neural Network?

Classification



Neural Network

What is Neural Network?

Why we need Neural Network?

Real World Application

Architecture of Neural Network

Component of Neural Network

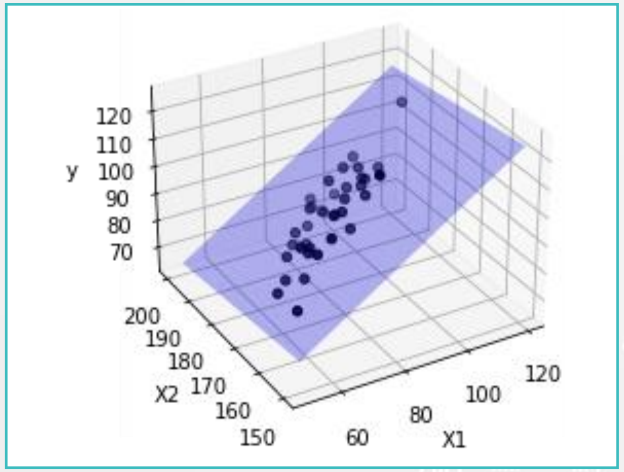
How Neural Network Work

Why we need Neural Network?

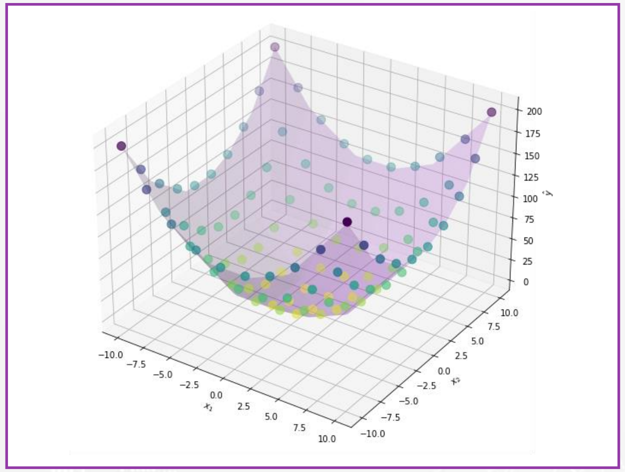
Why we need Neural Network?

Regression

Neural network ใช้เพื่อประมาณ nonlinear function



Linear Regression

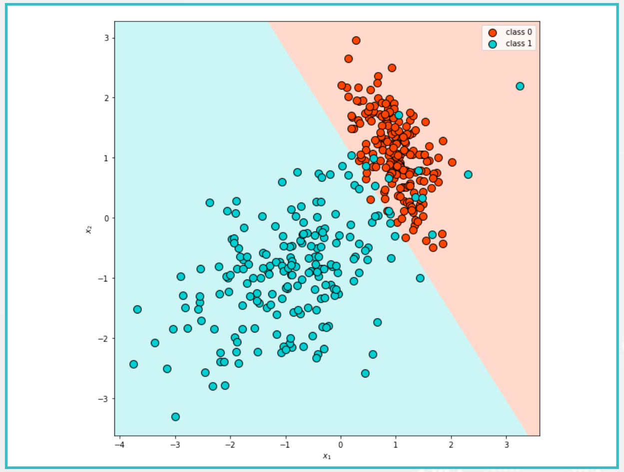


Neural Network

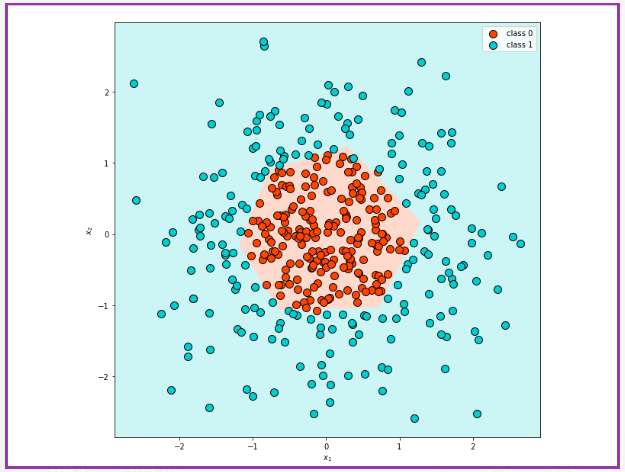
Why we need Neural Network?

Classification

Neural network สามารถสร้าง decision boundary ที่ไม่ใช่เส้นตรงได้



Logistic Regression

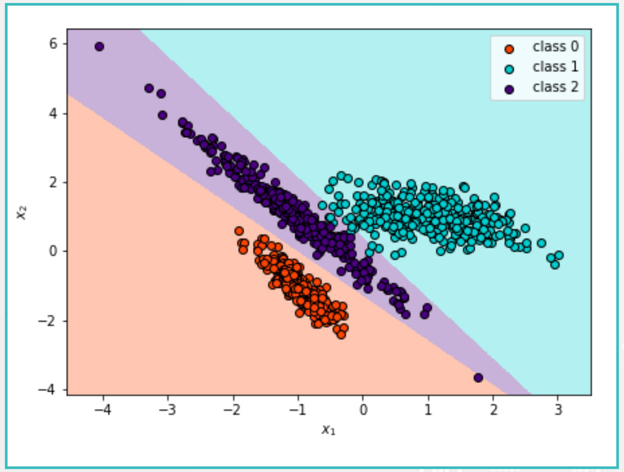


Neural Network

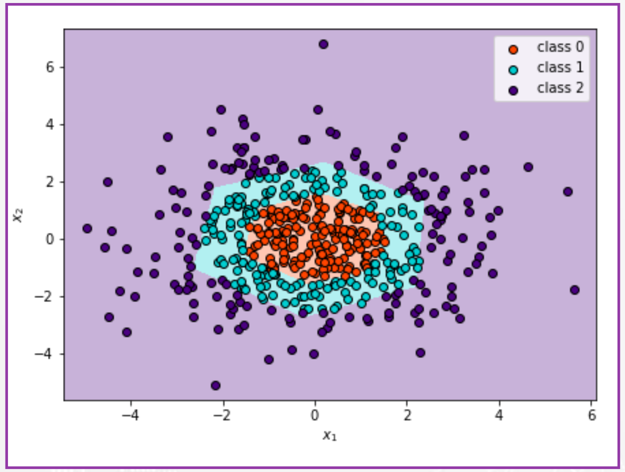
Why we need Neural Network?

Classification

Neural network สามารถสร้าง decision boundary ที่ไม่ใช่เส้นตรงได้

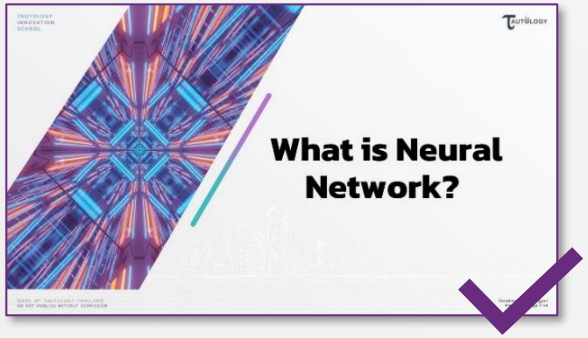


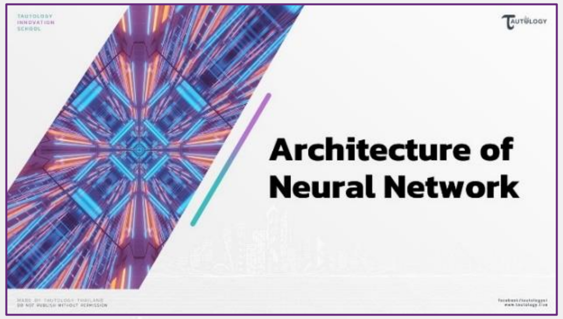
Logistic Regression

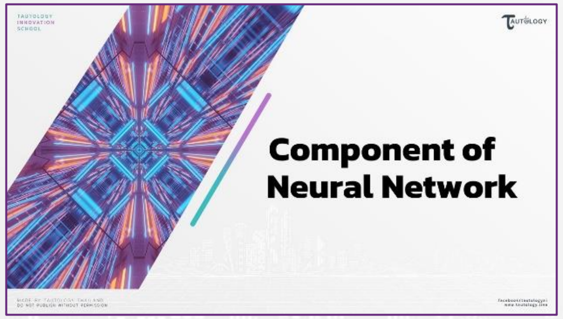


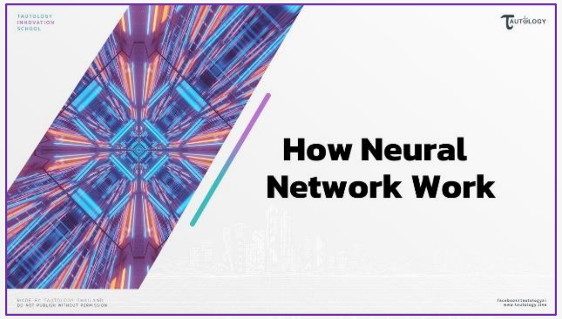
Neural Network

Neural Network









Real World Application

Real World Application

[2020, H. I. Lee et al] Urban Flood Prediction Using Deep Neural Network with Data Augmentation

การคาดการณ์ปริมาณน้ำสะสมในอ่างระบายน้ำแห่งหนึ่งในเกาหลี

โดยพิจารณาจากข้อมูลสถิติต่าง ๆ ของวันที่ฝนตกหนักเป็นเวลา 6 ชั่วโมง เช่น ปริมาณน้ำฝนทั้งหมด ปริมาณน้ำฝนสูงสุดของแต่ละชั่วโมง ปริมาณน้ำฝนเฉลี่ยต่อชั่วโมง เป็นต้น

Real World Application

[2016, J. Perricone et al.] Predicting Results for Professional Basketball Using NBA API Data

การทำนายผลบาสเกตบอล NBA

โดยพิจารณาจากข้อมูลสถิติต่าง ๆ ของแต่ละทีม เช่น จำนวนครั้งในการยิงสามแต้ม คะแนนที่ได้จากการยิงในพื้นที่ใต้แป้น เปอร์เซ็นต์ความแม่นยำในการยิง เป็นต้น

Real World Application

[2018, D. H. Mantzaris et al.] Medical Disease Prediction Using Artificial Neural Networks

การวิเคราะห์ระดับความเสี่ยงที่จะเป็นโรคกระดูกพรุน

โดยพิจารณาจากข้อมูลของผู้ป่วย ได้แก่ อายุ เพศ ส่วนสูง น้ำหนัก

Neural Network

- What is Neural Network?
- Why we need Neural Network?
- Real World Application
- Architecture of Neural Network
- Component of Neural Network
- How Neural Network Work

Architecture of Neural Network

Architecture of Neural Network

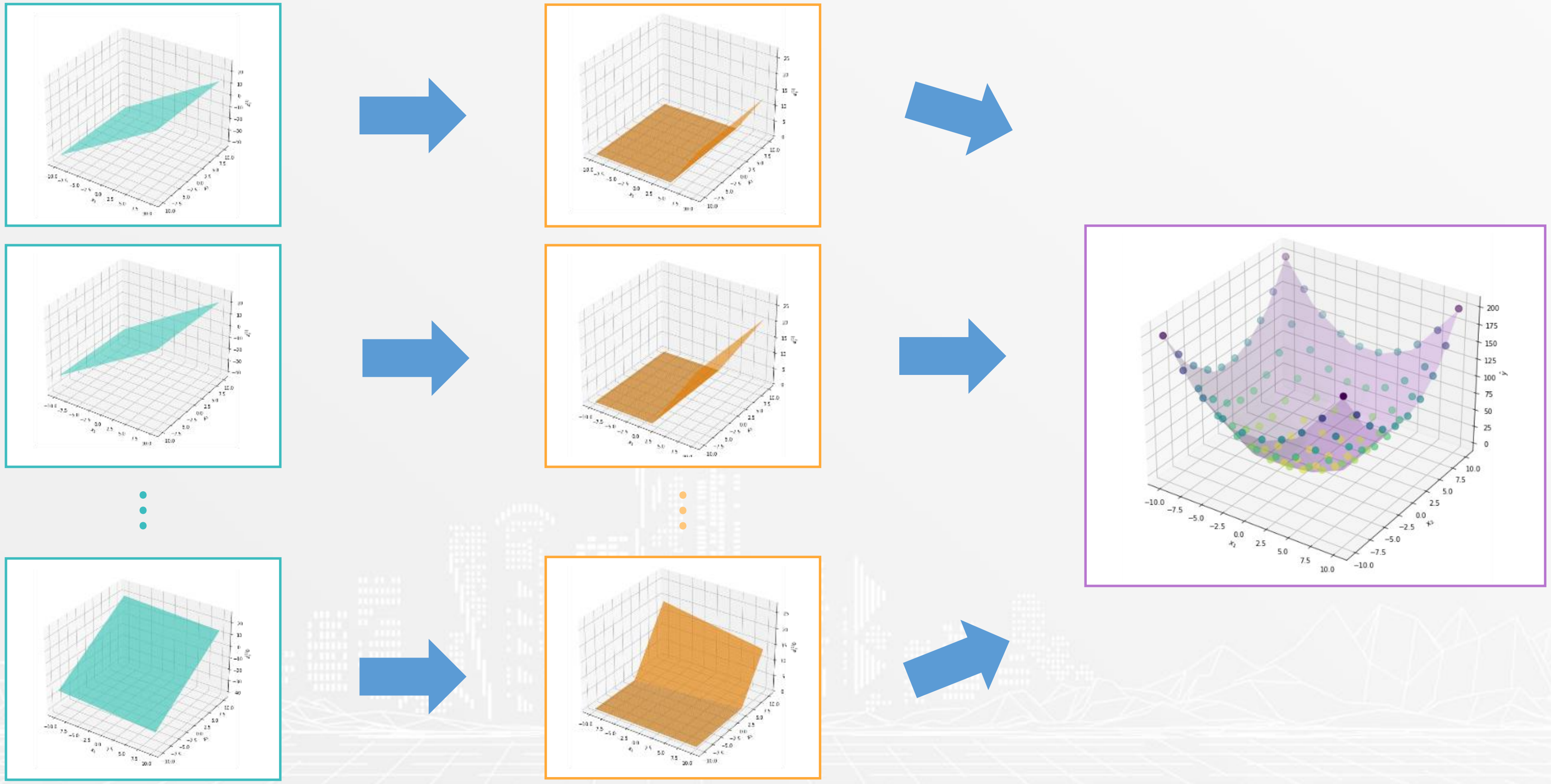
Regression

Binary Classification

Multi-Class Classification

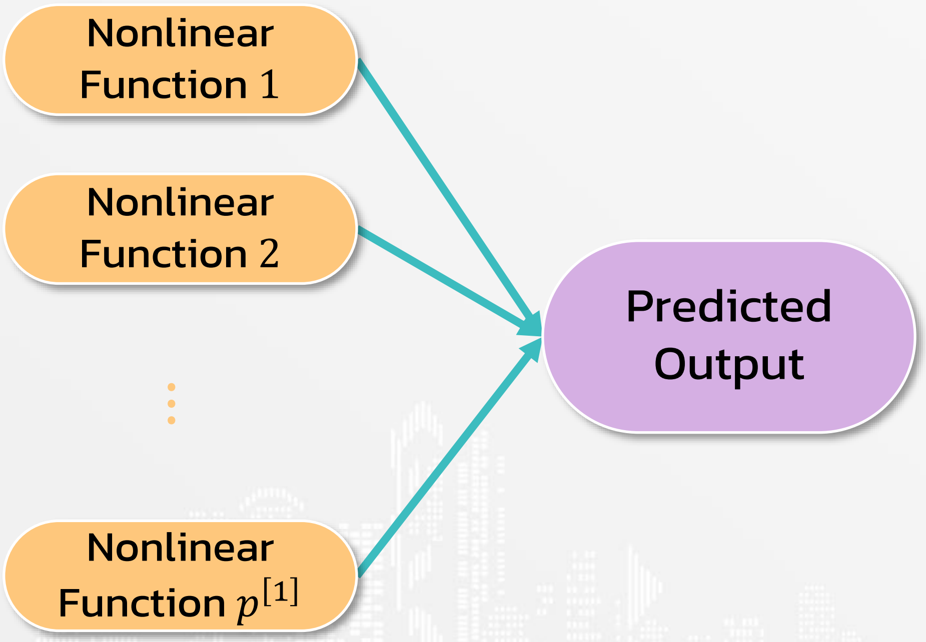
Architecture of Neural Network

Regression

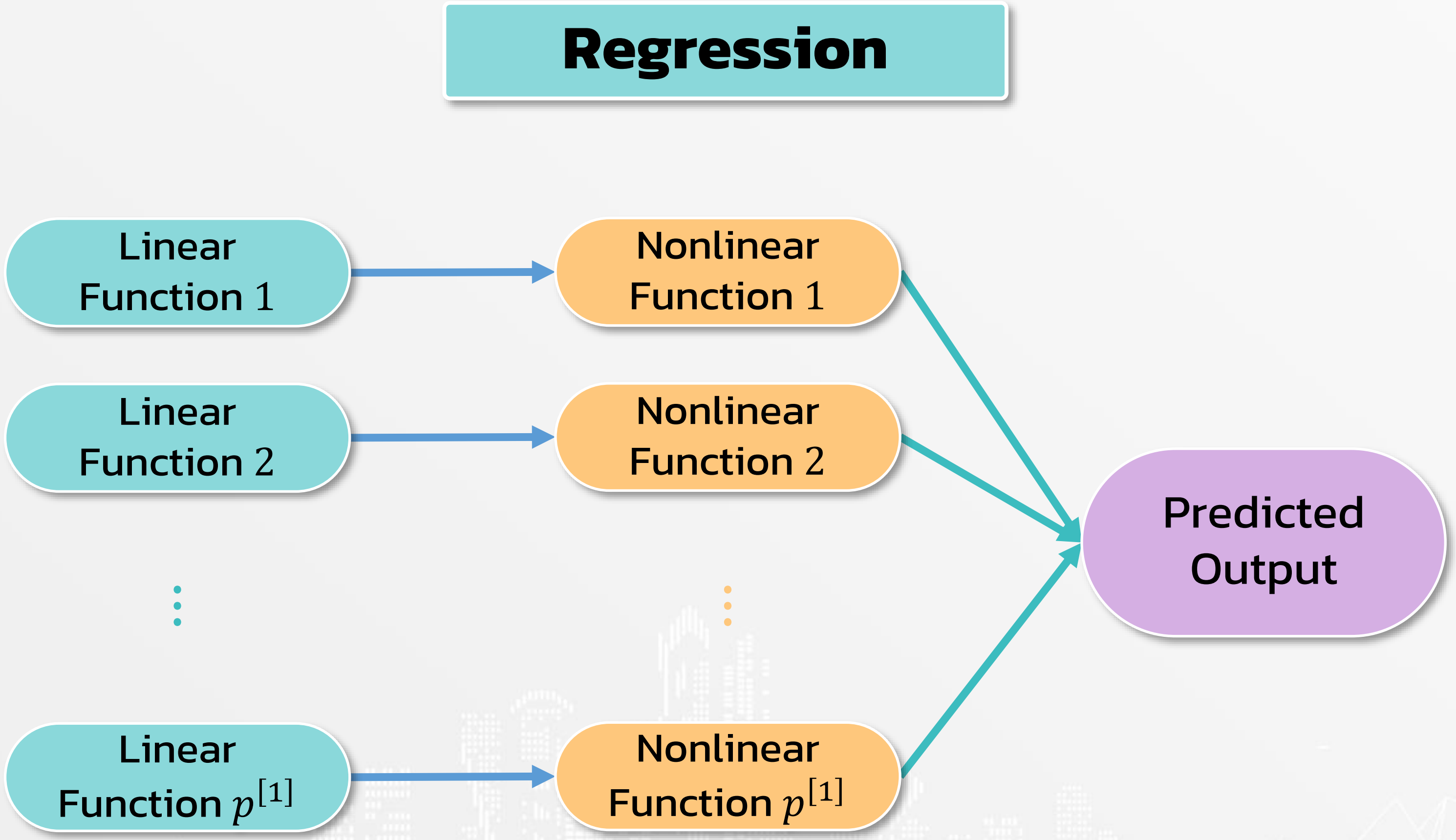


Architecture of Neural Network

Regression

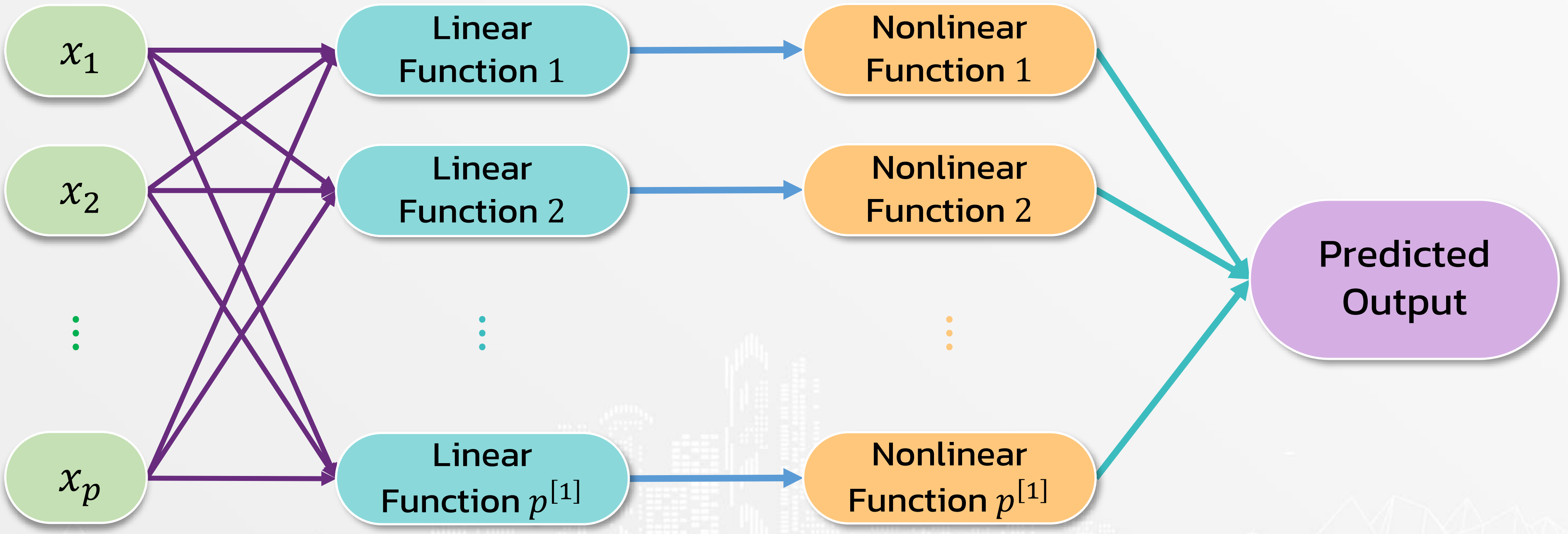


Architecture of Neural Network



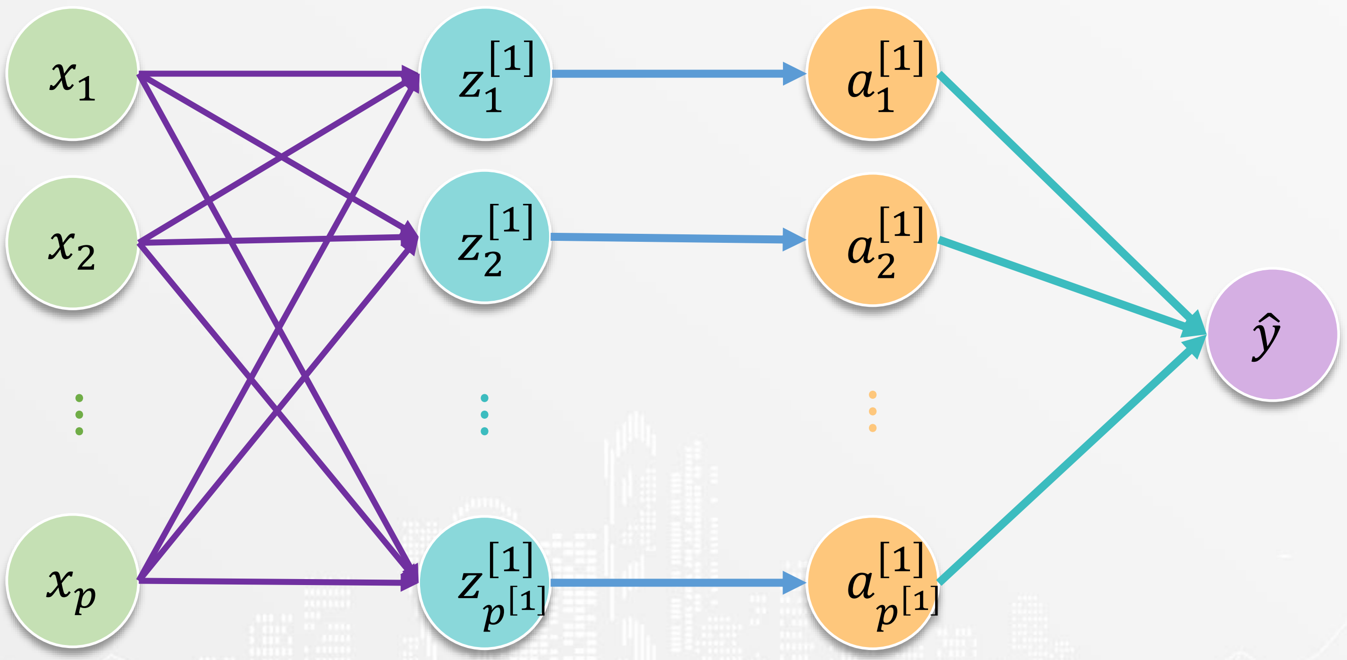
Architecture of Neural Network

Regression



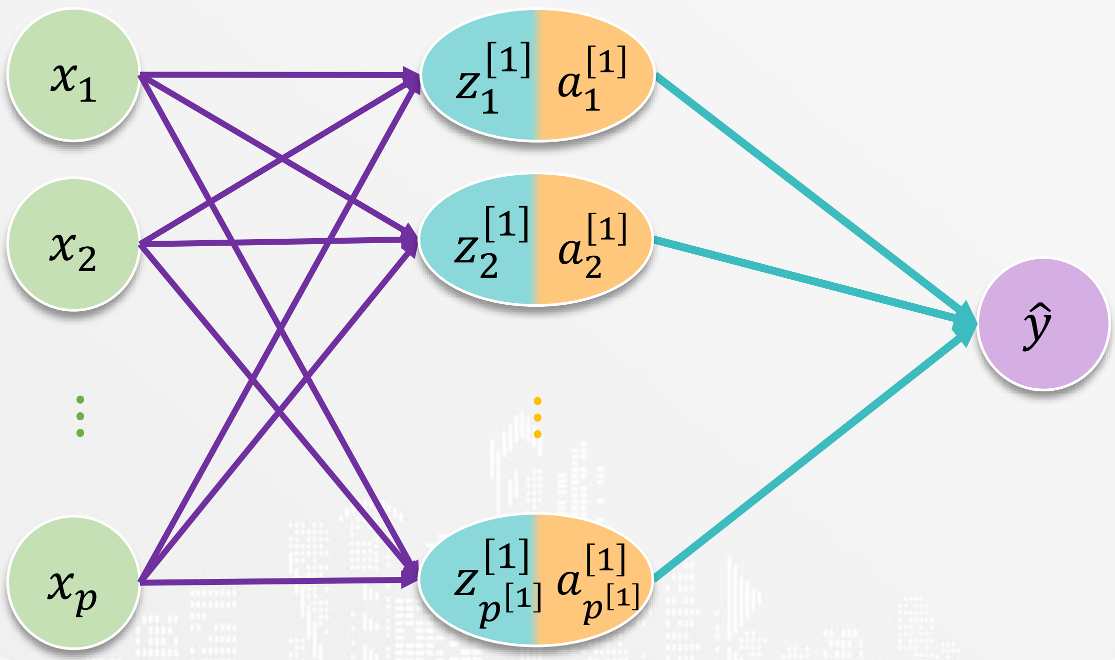
Architecture of Neural Network

Regression



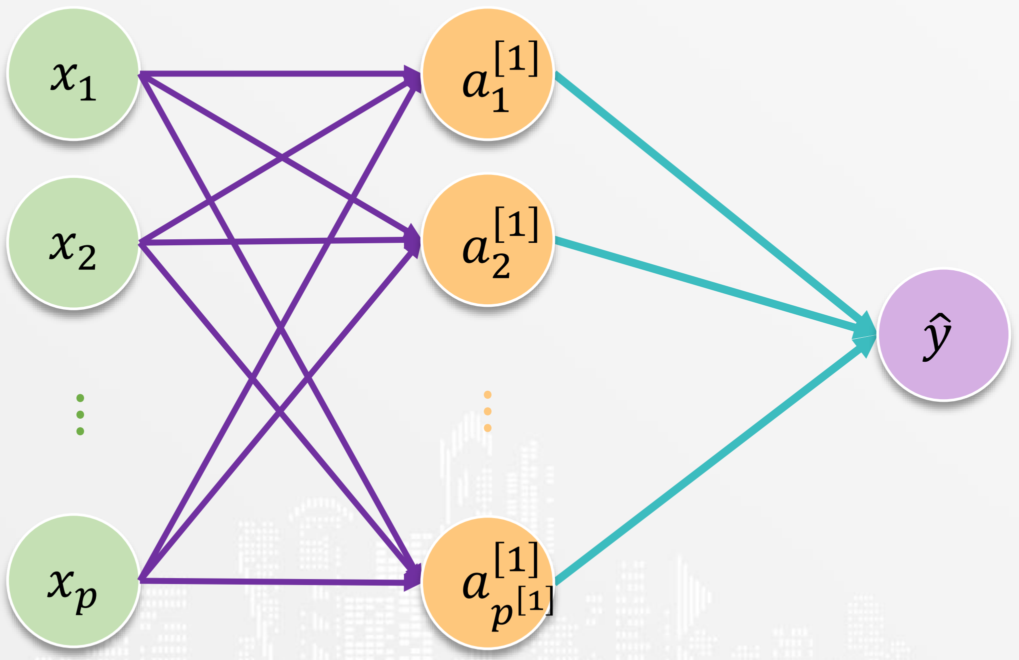
Architecture of Neural Network

Regression



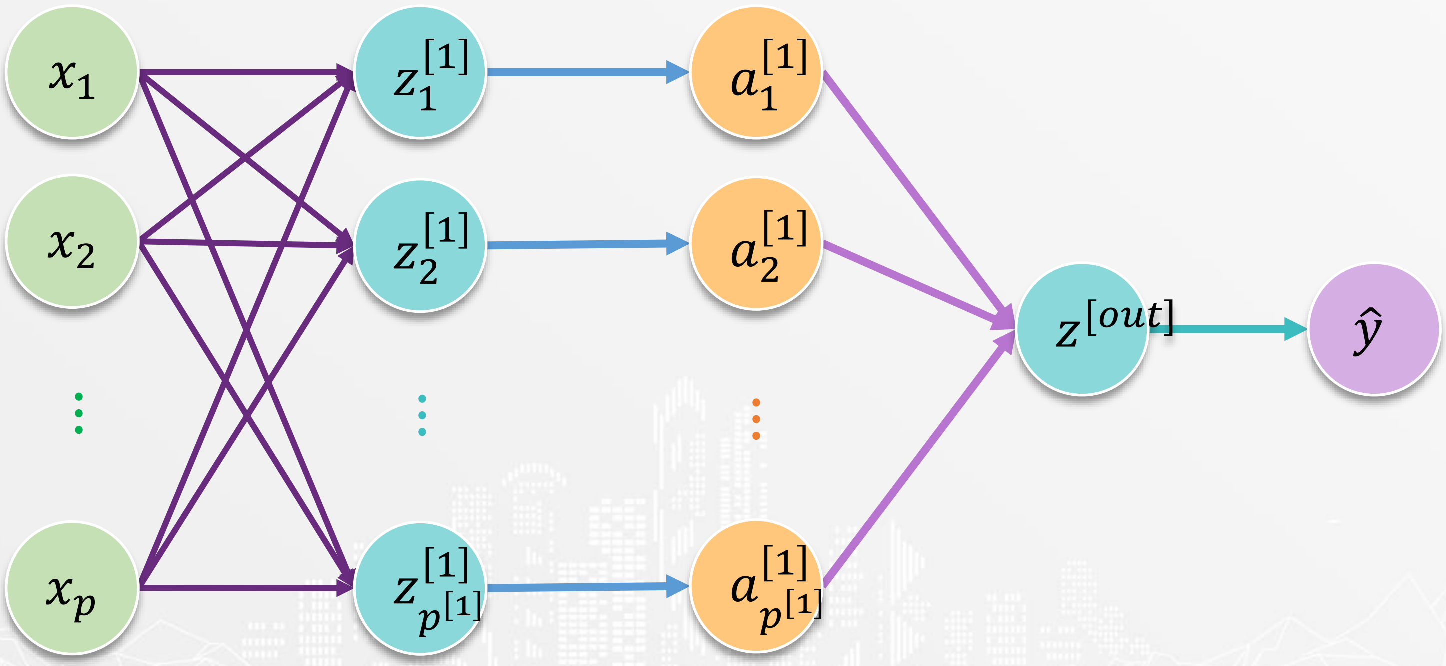
Architecture of Neural Network

Regression



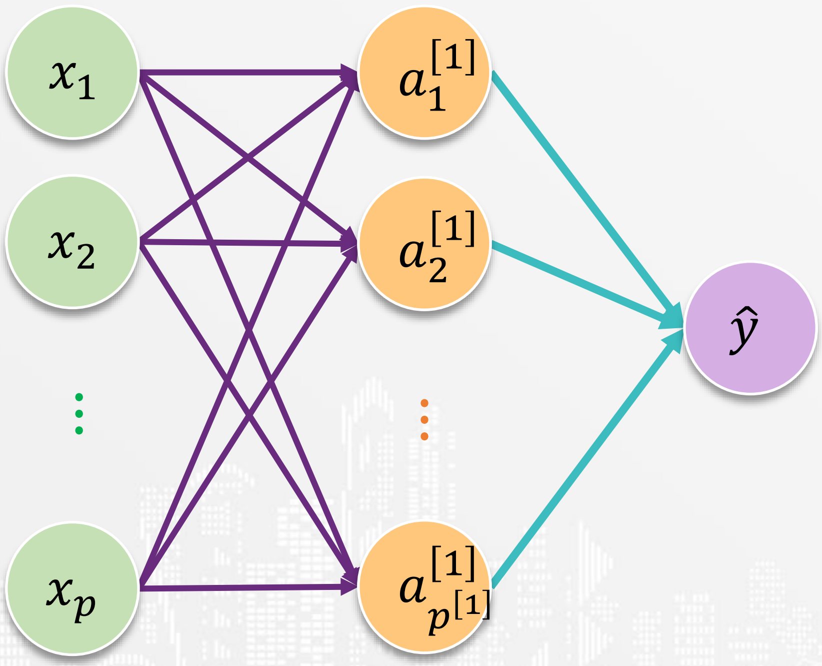
Architecture of Neural Network

Binary Classification



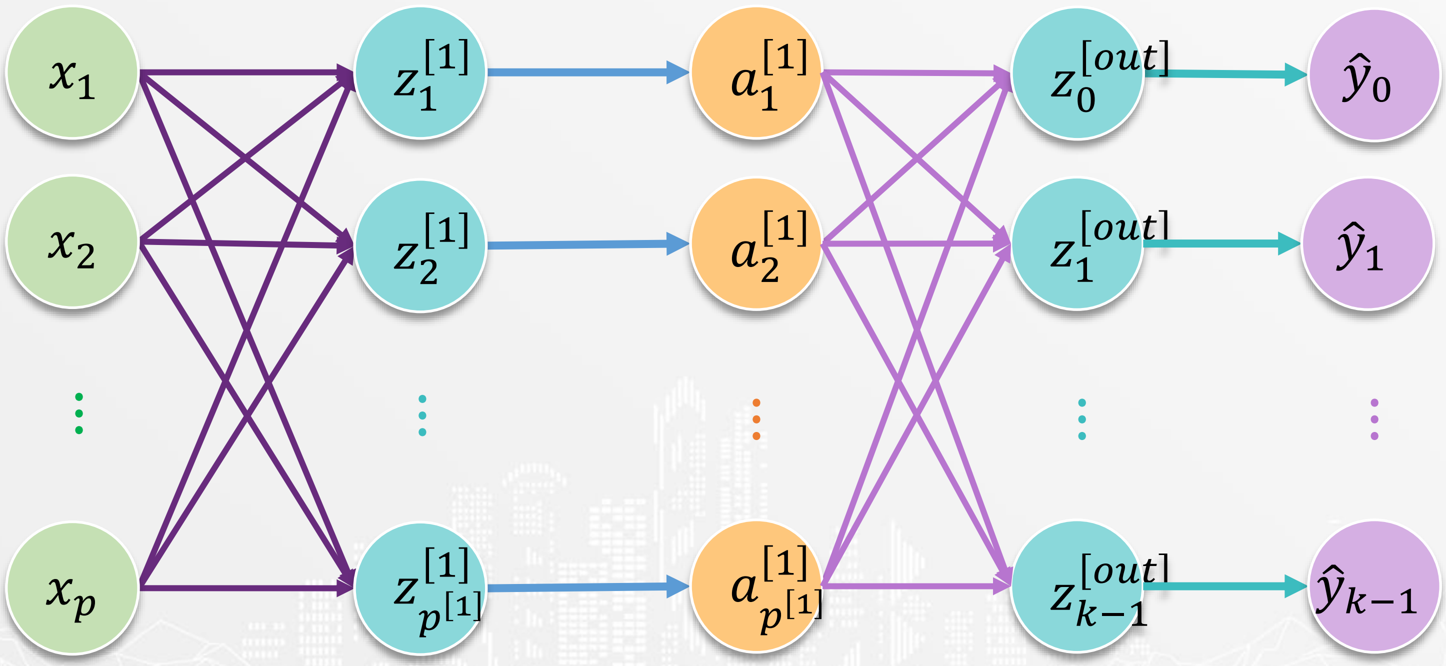
Architecture of Neural Network

Binary Classification



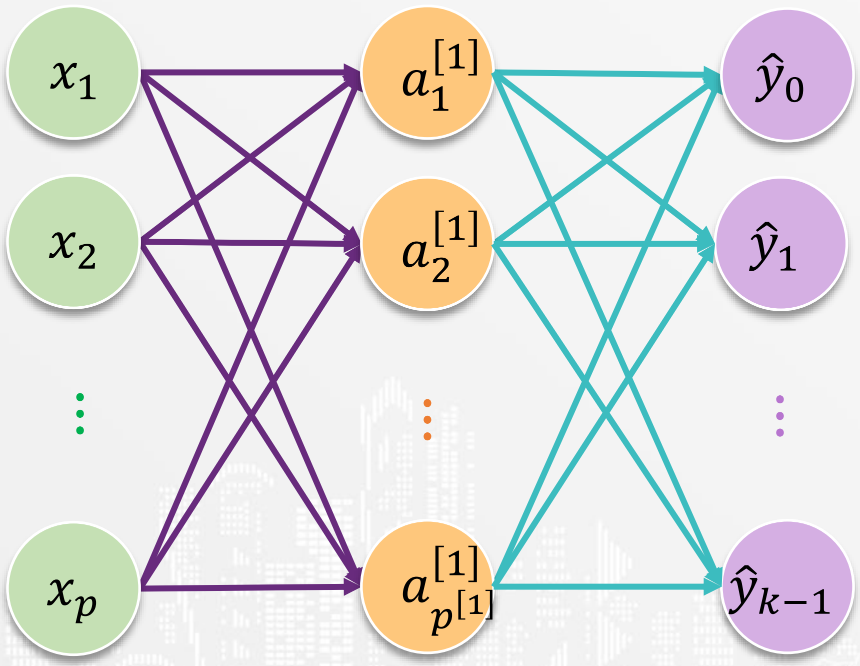
Architecture of Neural Network

Multi-Class Classification

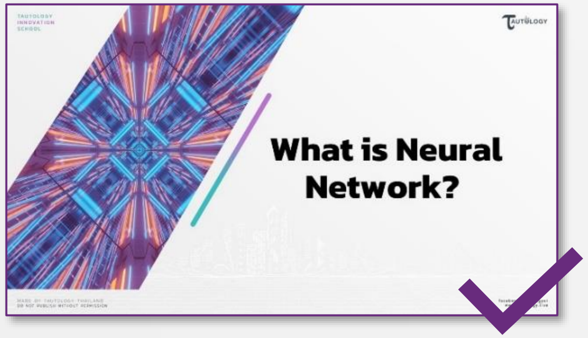


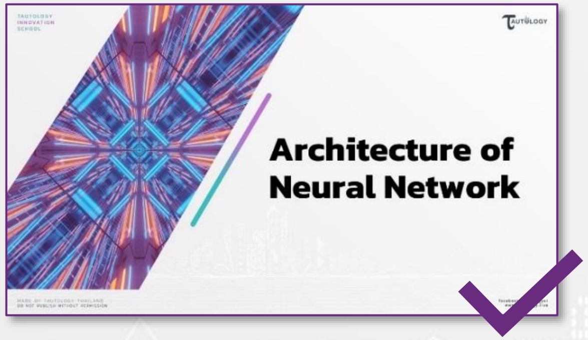
Architecture of Neural Network

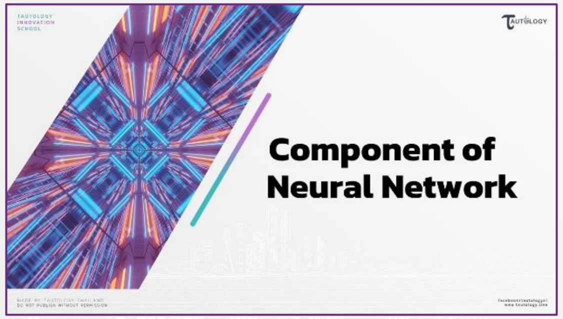
Multi-Class Classification

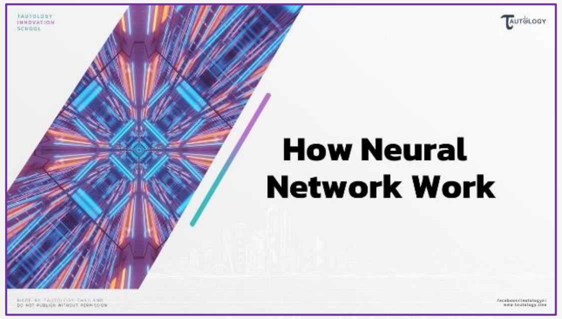


Neural Network









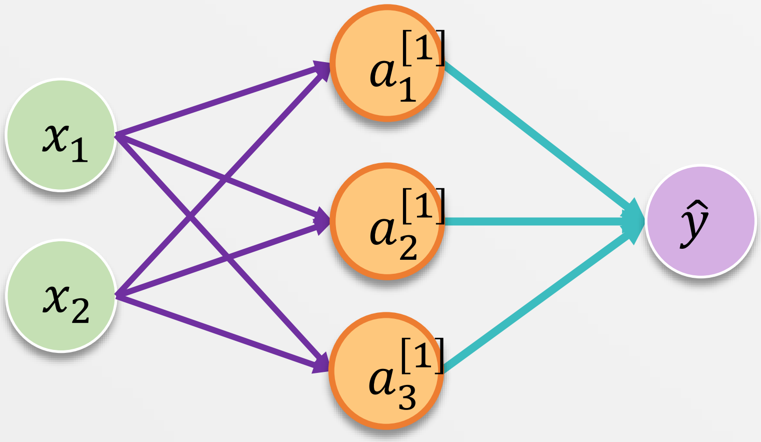
Component of Neural Network

Component of Neural Network

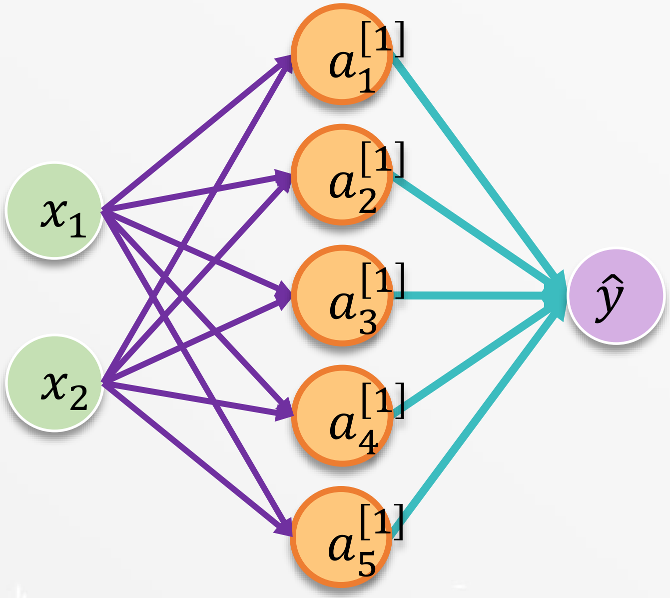
- Hidden Node
- Hidden Layer
- Weight & Bias
- Activation Function

Hidden Node

Hidden Node คือ จำนวนของ nonlinear function ที่ใช้



Hidden Node = 3



Hidden Node = 5

Component of Neural Network

Hidden Node

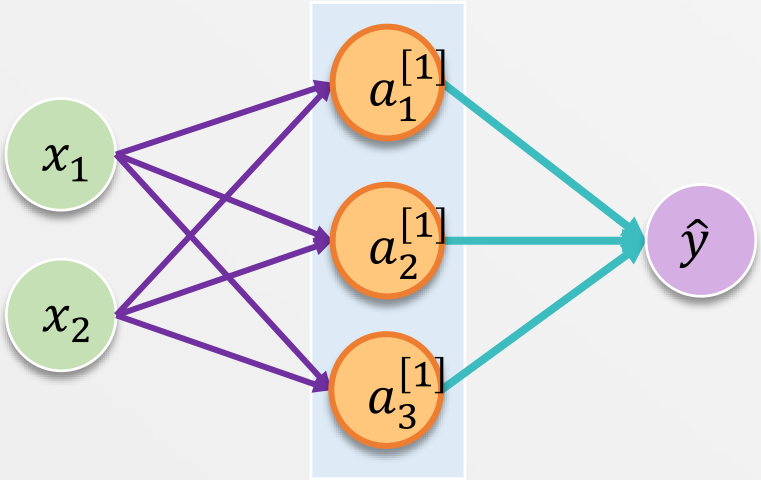
Hidden Layer

Weight & Bias

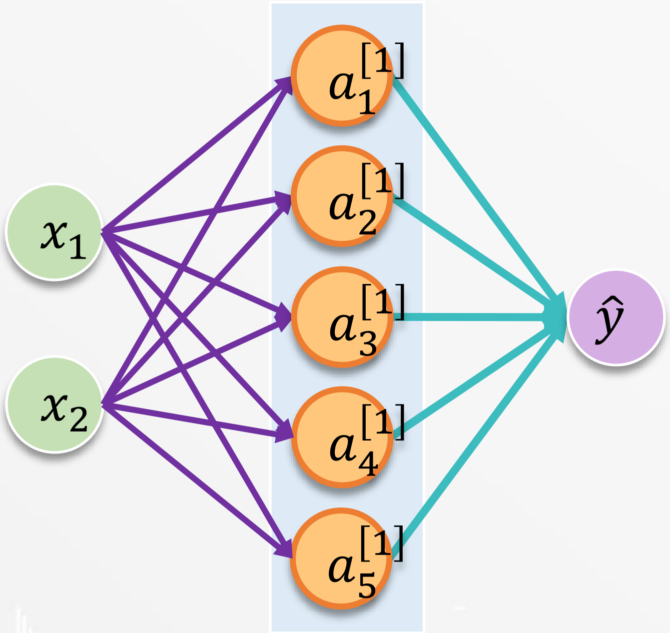
Activation Function

Hidden Layer

Hidden Layer คือ ชั้นที่เก็บ hidden node



จำนวน Hidden Layer = 1
(Hidden Node = 3)



จำนวน Hidden Layer = 1
(Hidden Node = 5)

Component of Neural Network

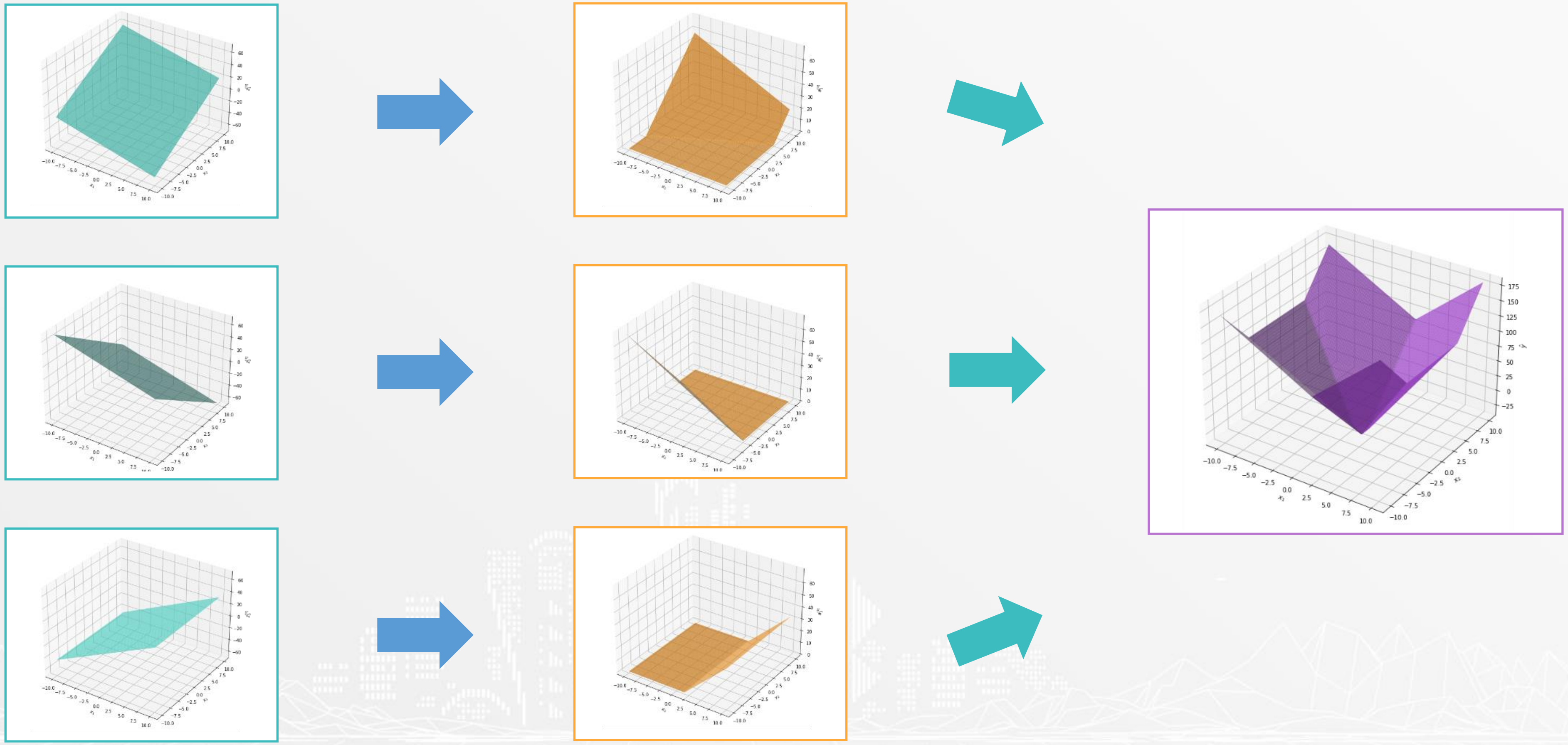
Hidden Node

Hidden Layer

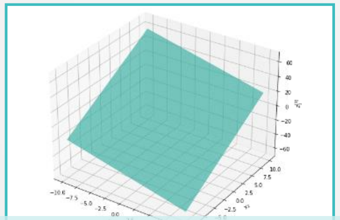
Weight & Bias

Activation Function

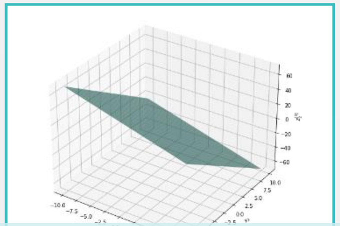
Weight & Bias



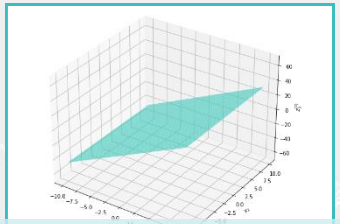
Weight & Bias



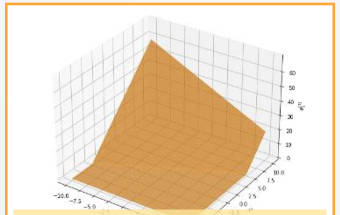
$z_1^{[1]} = b_1^{[1]} + w_{1,1}^{[1]} x_1 + w_{2,1}^{[1]} x_2$



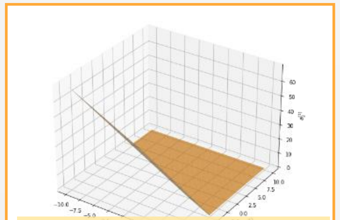
$z_2^{[1]} = b_2^{[1]} + w_{1,2}^{[1]} x_1 + w_{2,2}^{[1]} x_2$



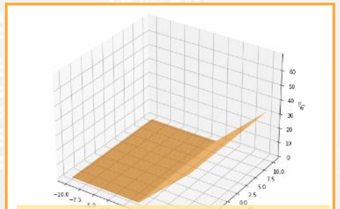
$z_3^{[1]} = b_3^{[1]} + w_{1,3}^{[1]} x_1 + w_{2,3}^{[1]} x_2$



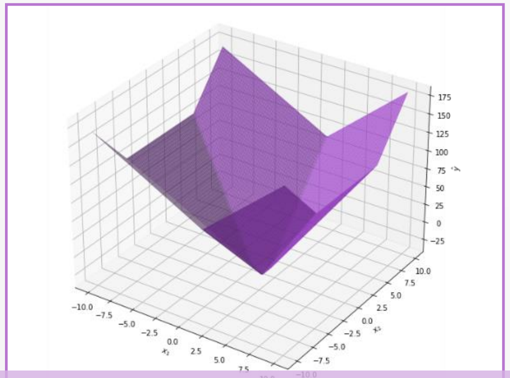
$a_1^{[1]} = af\left(z_1^{[1]}\right)$



$a_2^{[1]} = af\left(z_2^{[1]}\right)$

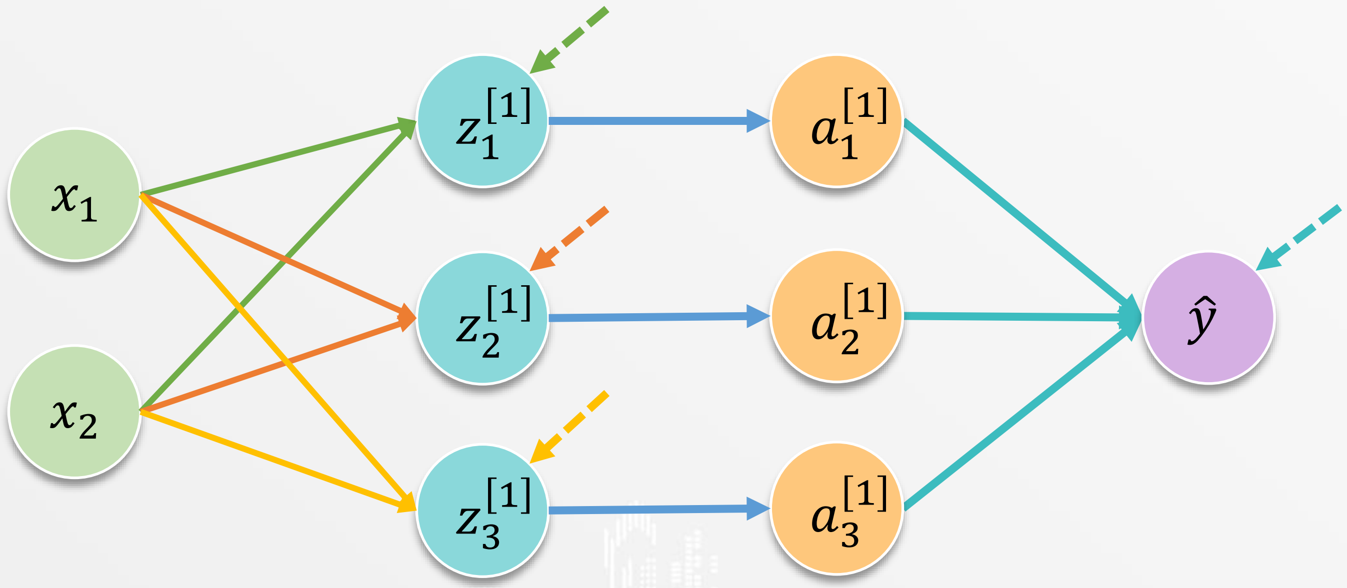


$a_1^{[1]} = af\left(z_1^{[1]}\right)$



$$\hat{y} = b^{[out]} + w_1^{[out]} a_1^{[1]} + w_2^{[out]} a_2^{[1]} + w_3^{[out]} a_3^{[1]}$$

Weight & Bias

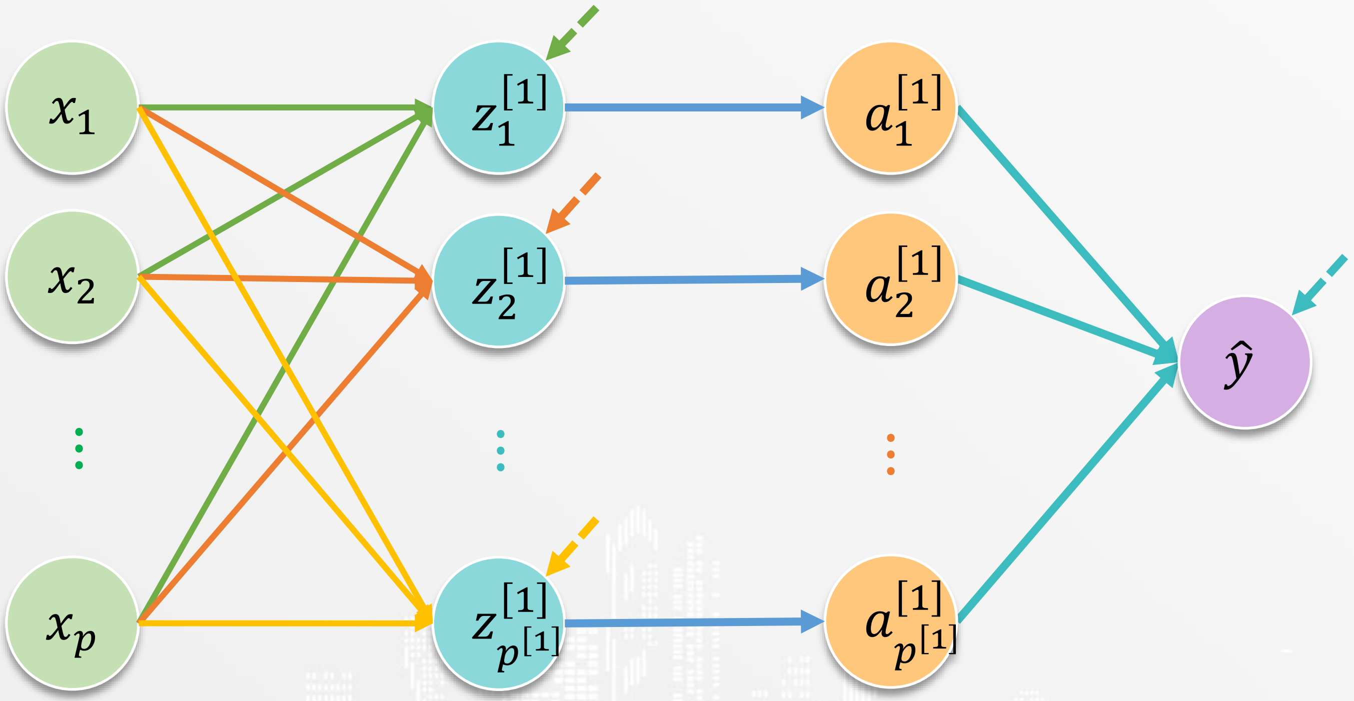


Weight & Bias

$$\mathbf{b}^{[1]} = \begin{bmatrix} b_1^{[1]} & b_2^{[1]} & b_3^{[1]} \end{bmatrix}, \; W^{[1]} = \begin{bmatrix} w_{1,1}^{[1]} & w_{1,2}^{[1]} & w_{1,3}^{[1]} \\ w_{2,1}^{[1]} & w_{2,2}^{[1]} & w_{2,3}^{[1]} \end{bmatrix}$$

$$\mathbf{b}^{[\boldsymbol{out}]} = \begin{bmatrix} b^{[out]} \end{bmatrix}, \; W^{[out]} = \begin{bmatrix} w_1^{[out]} \\ w_2^{[out]} \\ w_3^{[out]} \end{bmatrix}$$

Weight & Bias



Weight & Bias

$$z_1^{[1]} = b_1^{[1]} + w_{1,1}^{[1]} x_1 + w_{2,1}^{[1]} x_2 + \cdots + w_{p,1}^{[1]} x_p$$

$$z_2^{[1]} = b_2^{[1]} + w_{1,2}^{[1]} x_1 + w_{2,2}^{[1]} x_2 + \cdots + w_{p,2}^{[1]} x_p$$

$$\vdots$$

$$z_{p^{[1]}}^{[1]} = b_{p^{[1]}}^{[1]} + w_{1,p^{[1]}}^{[1]} x_1 + w_{2,p^{[1]}}^{[1]} x_2 + \cdots + w_{p,p^{[1]}}^{[1]} x_p$$

Weight & Bias

$$a_1^{[1]} = af(z_1^{[1]})$$

$$a_2^{[1]} = af\ (z_2^{[1]})$$

$$\vdots$$

$$a_{p^{[1]}}^{[1]} = af(z_{p^{[1]}}^{[1]})$$

$$\hat{y} = b^{[out]} + w_1^{[out]} a_1^{[1]} + w_2^{[out]} a_2^{[1]} + \cdots + w_{p^{[1]}}^{[out]} a_{p^{[1]}}^{[1]}$$

Weight & Bias

$$\mathbf{b}^{[1]} = \begin{bmatrix} b_1^{[1]} & b_2^{[1]} & \cdots & b_{p^{[1]}}^{[1]} \end{bmatrix}, \; W^{[1]} = \begin{bmatrix} w_{1,1}^{[1]} & w_{1,2}^{[1]} & \cdots & w_{1,p^{[1]}}^{[1]} \\ w_{2,1}^{[1]} & w_{2,2}^{[1]} & \cdots & w_{2,p^{[1]}}^{[1]} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p,1}^{[1]} & w_{p,2}^{[1]} & \cdots & w_{p,p^{[1]}}^{[1]} \end{bmatrix}$$

$$\mathbf{b}^{[\boldsymbol{out}]} = \begin{bmatrix} b^{[out]} \end{bmatrix}, \; W^{[out]} = \begin{bmatrix} w_1^{[out]} \\ w_2^{[out]} \\ \vdots \\ w_{p^{[1]}}^{[out]} \end{bmatrix}$$

Component of Neural Network

- **Hidden Node**
- **Hidden Layer**
- **Weight & Bias**
- Activation Function

Activation Function

Activation Function คือ function ที่ส่งค่า linear function ไปเป็น nonlinear function

Activation Function

- ☐ List of Activation Function
- ☐ Comparison of Activation Function
- ☐ What if no Activation Function

List of Activation Function

1. ReLU
2. Parametric ReLU
3. Sigmoid
4. Tanh
5. SELU
6. ELU
7. Softplus
8. Exponential
9. Gaussian
10. Swish

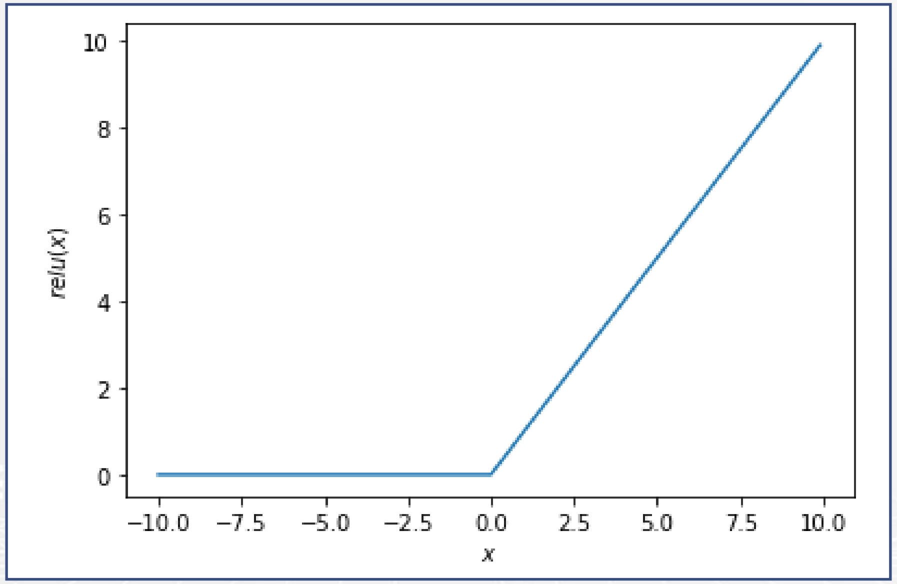
List of Activation Function

1. ReLU
2. Parametric ReLU
3. Sigmoid
4. Tanh
5. SELU
6. ELU
7. Softplus
8. Exponential
9. Gaussian
10. Swish

List of Activation Function

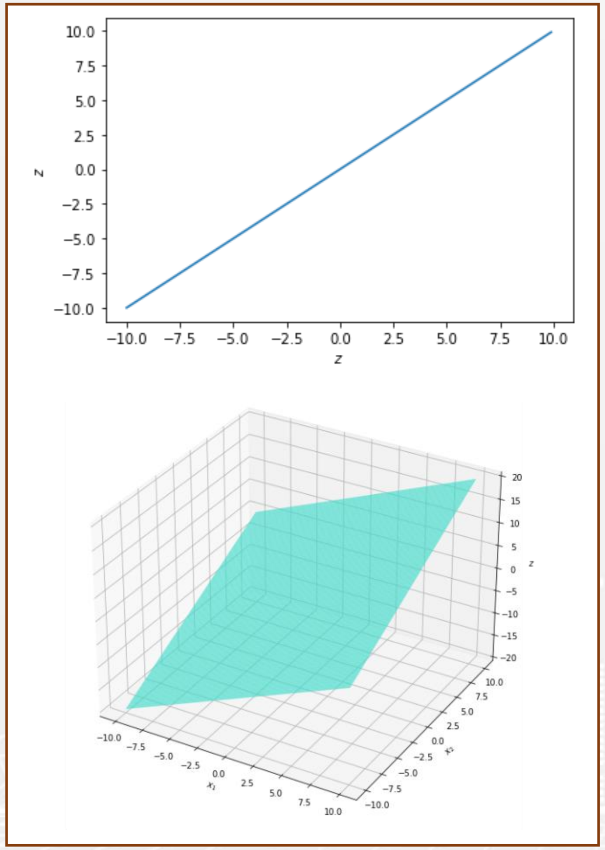
1. **ReLU (Rectified Linear Unit)** – สร้างจุดหักโดยใช้จุด 0 เป็นตัวกำหนด

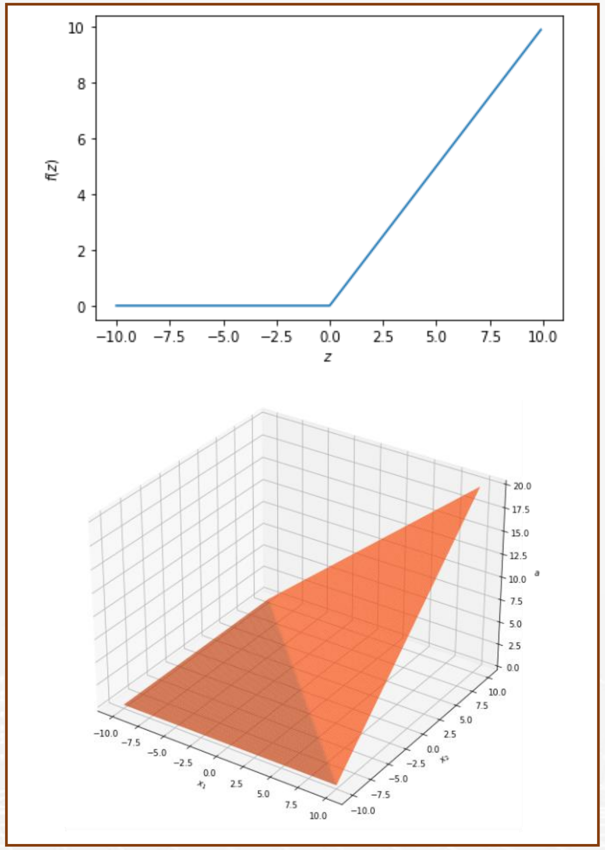
$$ReLU(z) = \begin{cases} z & ; \quad z > 0 \\ 0 & ; \quad z \leq 0 \end{cases}$$



List of Activation Function

1. ReLU (Rectified Linear Unit)





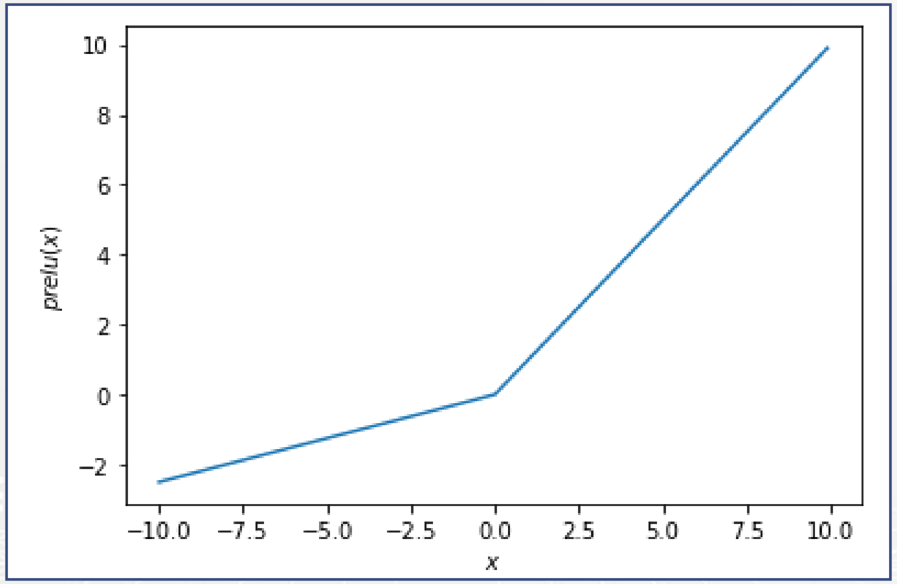
List of Activation Function

1. **ReLU ✓**
2. Parametric ReLU
3. Sigmoid
4. Tanh
5. SELU
6. ELU
7. Softplus
8. Exponential
9. Gaussian
10. Swish

List of Activation Function

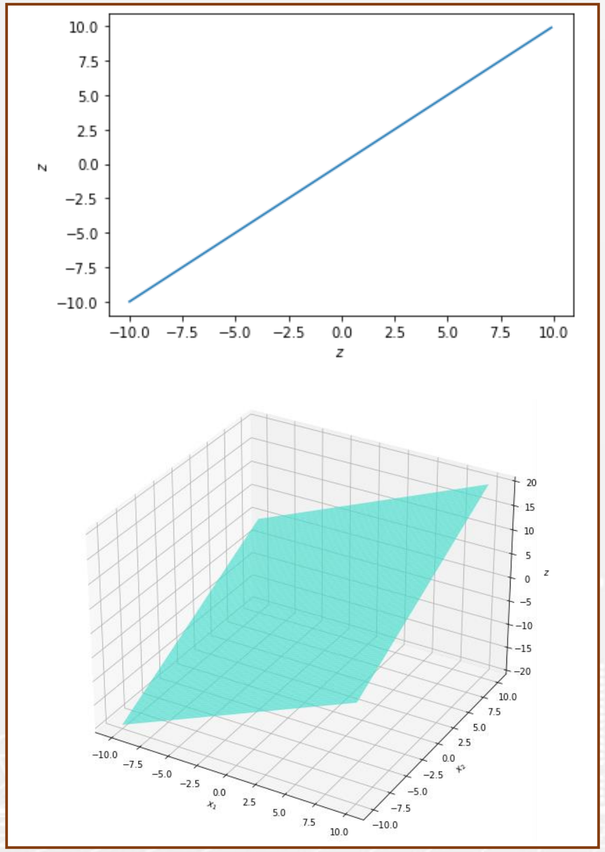
2. Parametric ReLU – สร้างจุดหักโดยใช้จุด 0 เป็นตัวกำหนด

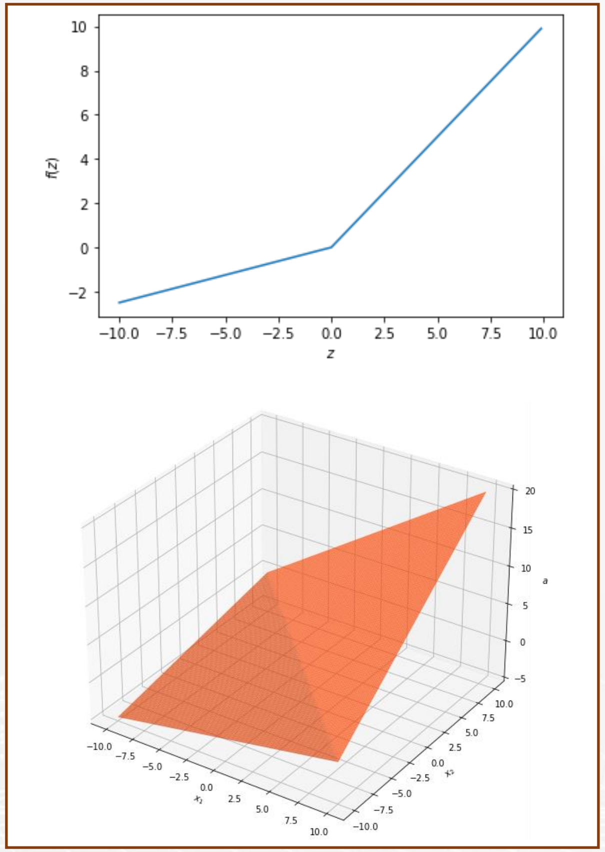
$$PReLU(z) = \begin{cases} z & ; \quad z > 0 \\ \alpha z & ; \quad z < 0, \alpha > 0 \end{cases}$$



List of Activation Function

2. Parametric ReLU





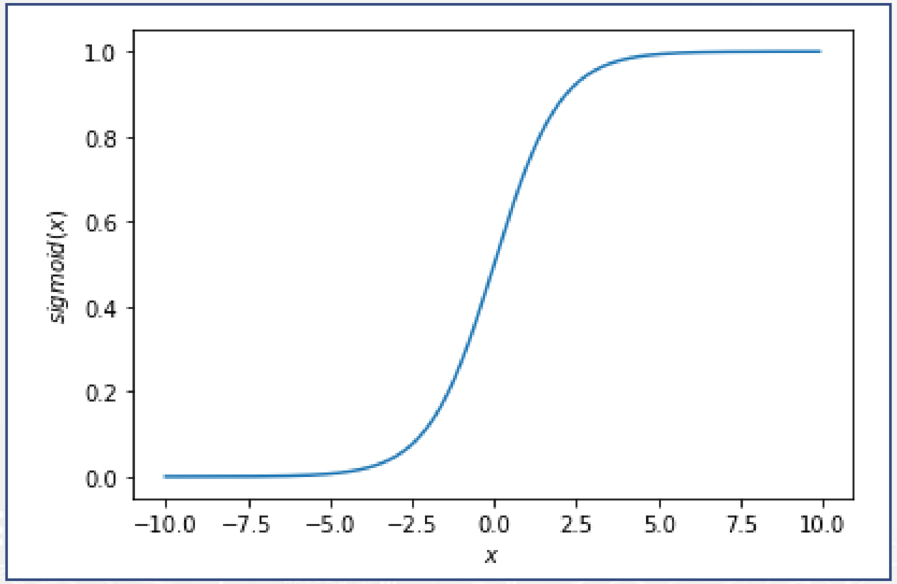
List of Activation Function

1. **ReLU ✓**
2. **Parametric ReLU ✓**
3. Sigmoid
4. Tanh
5. SELU
6. ELU
7. Softplus
8. Exponential
9. Gaussian
10. Swish

List of Activation Function

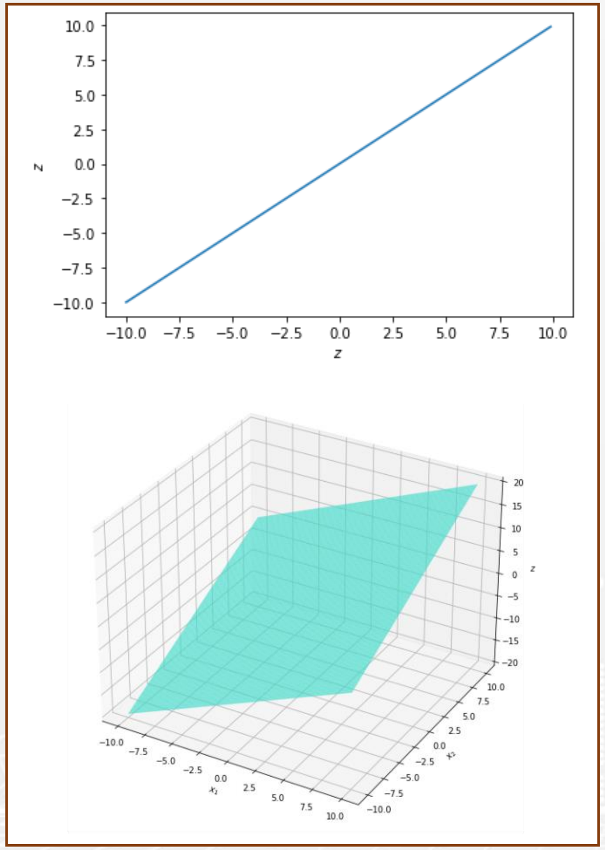
3. Sigmoid

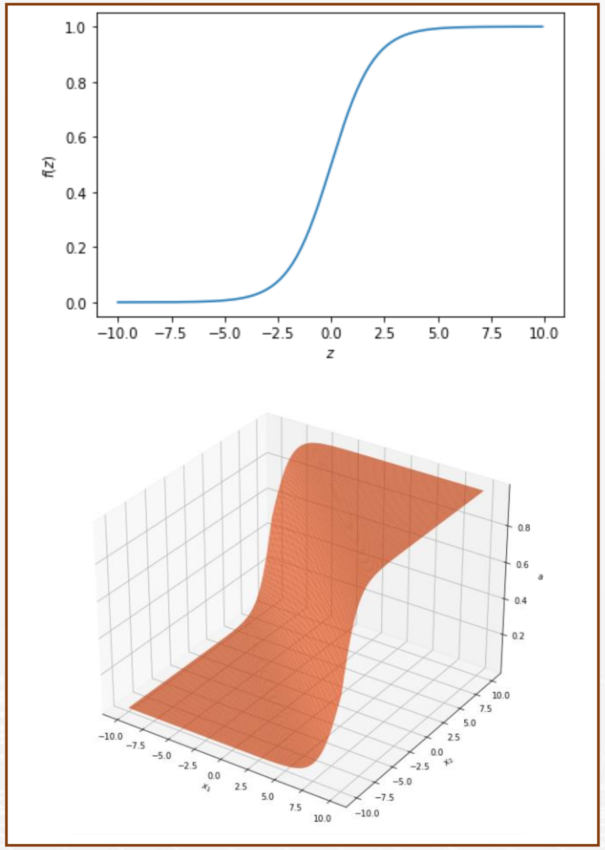
$$\sigma(z) = \frac{1}{1 + e^{-z}}$$



List of Activation Function

3. Sigmoid





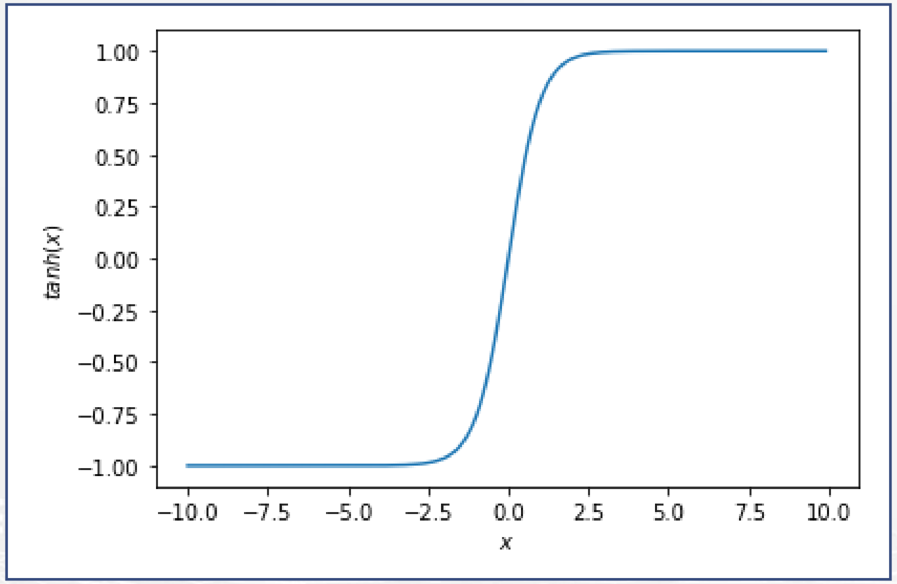
List of Activation Function

1. **ReLU ✓**
2. **Parametric ReLU ✓**
3. **Sigmoid ✓**
4. Tanh
5. SELU
6. ELU
7. Softplus
8. Exponential
9. Gaussian
10. Swish

List of Activation Function

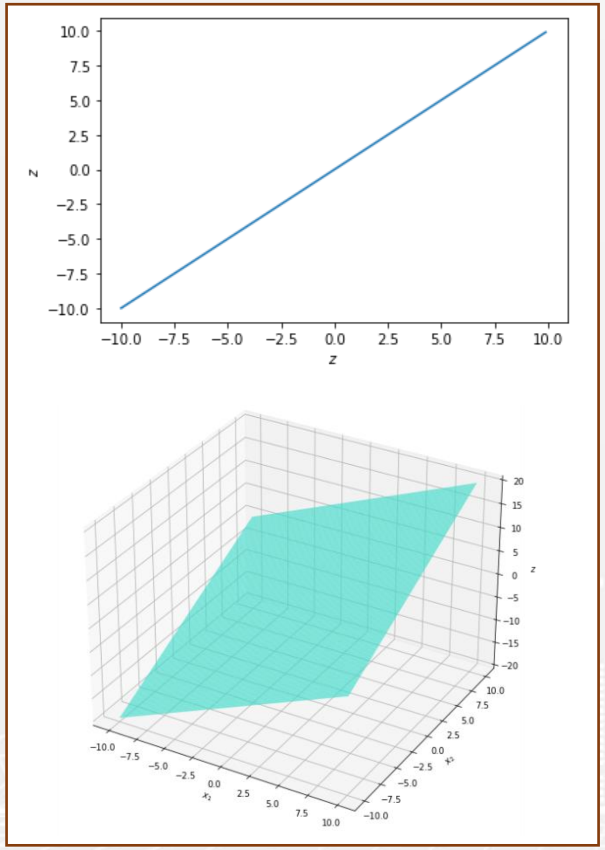
4. Tanh

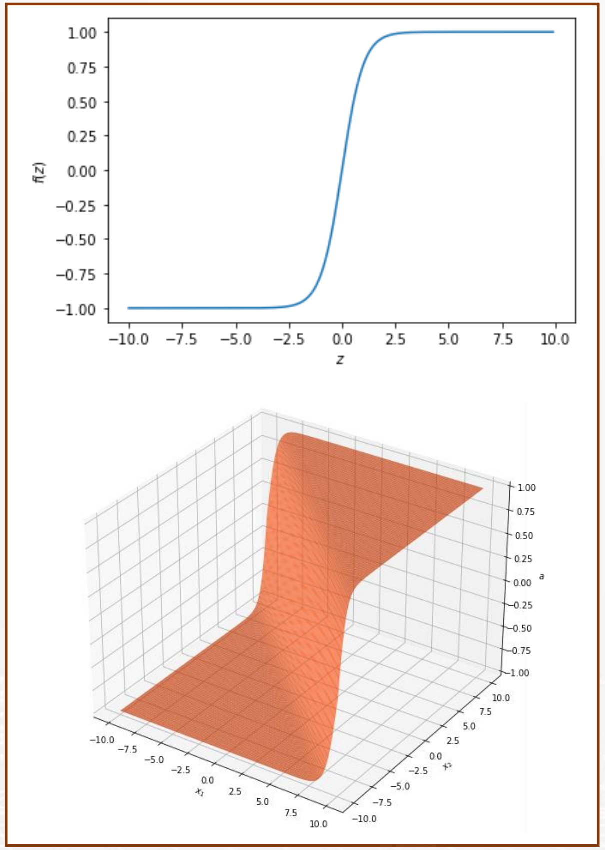
$$Tanh(x) = \frac{e^{z} - e^{-z}}{e^{z} + e^{-z}}$$



List of Activation Function

4. Tanh





List of Activation Function

1. **ReLU ✓**
2. **Parametric ReLU ✓**
3. **Sigmoid ✓**
4. **Tanh ✓**
5. SELU
6. ELU
7. Softplus
8. Exponential
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10. Swish

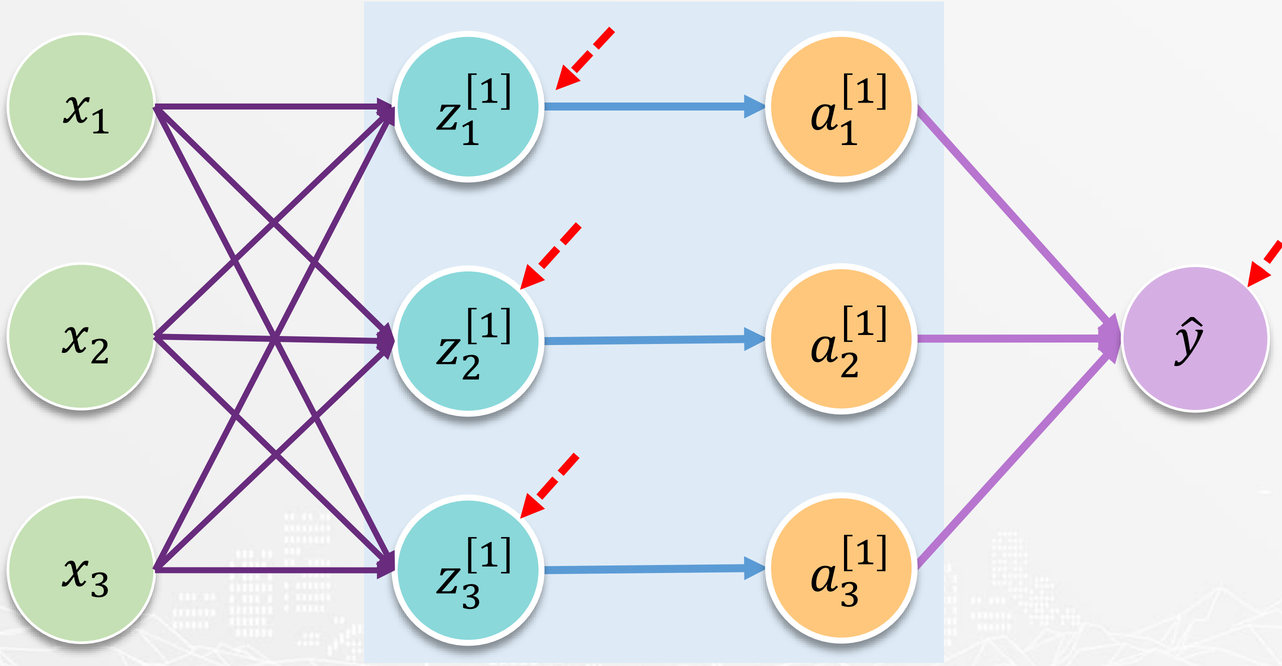
Activation Function

- ☑ **List of Activation Function**
- ☐ Comparison of Activation Function
- ☐ What if no Activation Function

Comparison of Activation Function

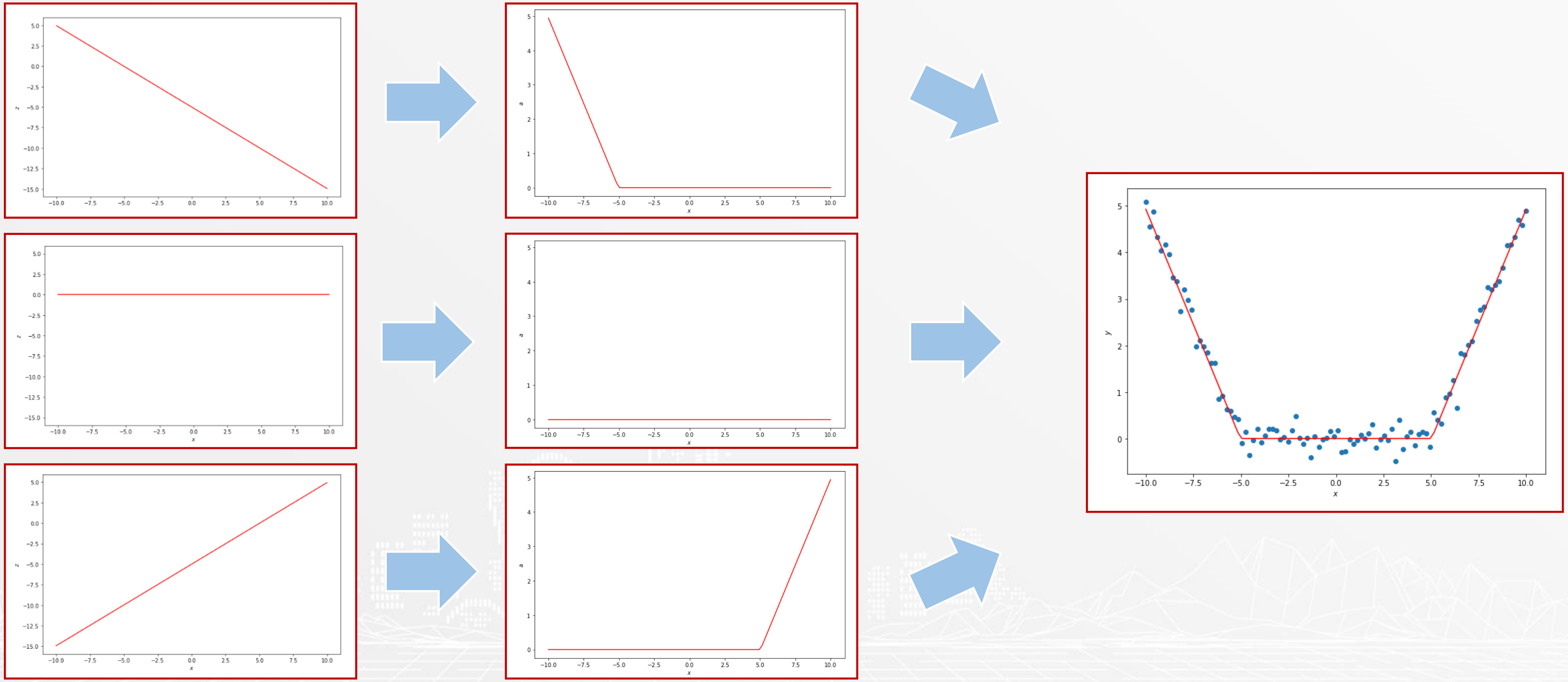
1. ReLU (Rectified Linear Unit)

$$f(z) = ReLU(z)$$



Comparison of Activation Function

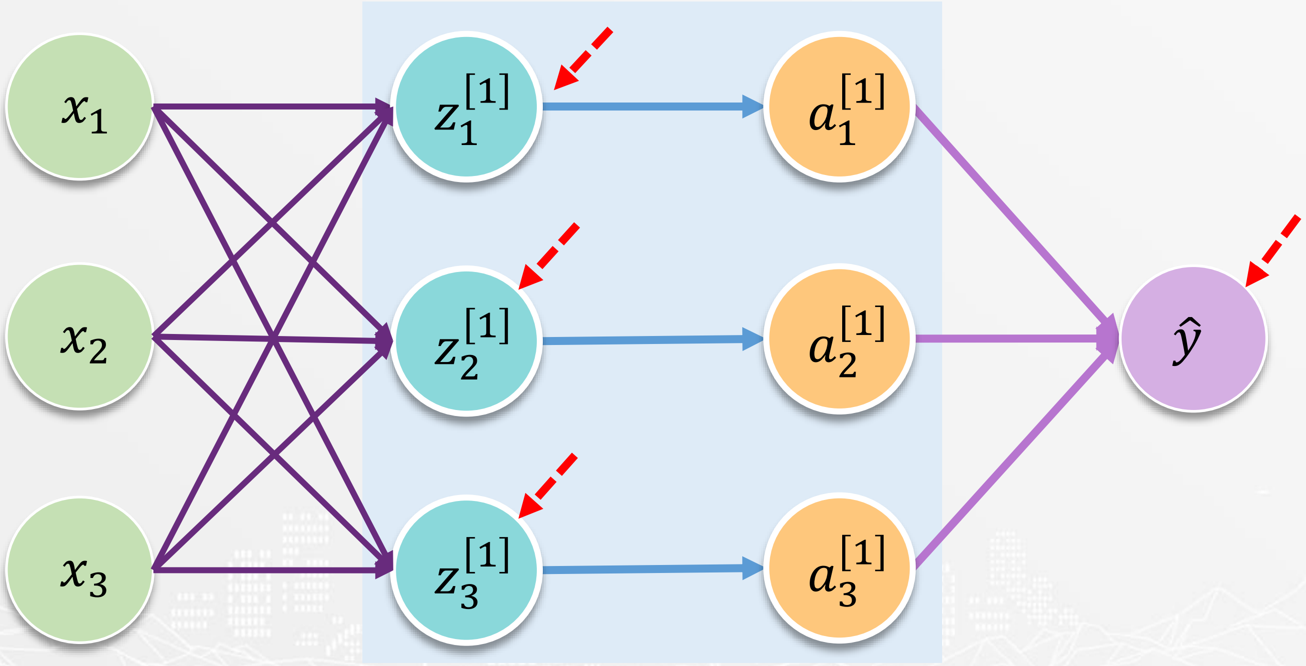
1. ReLU (Rectified Linear Unit)



Comparison of Activation Function

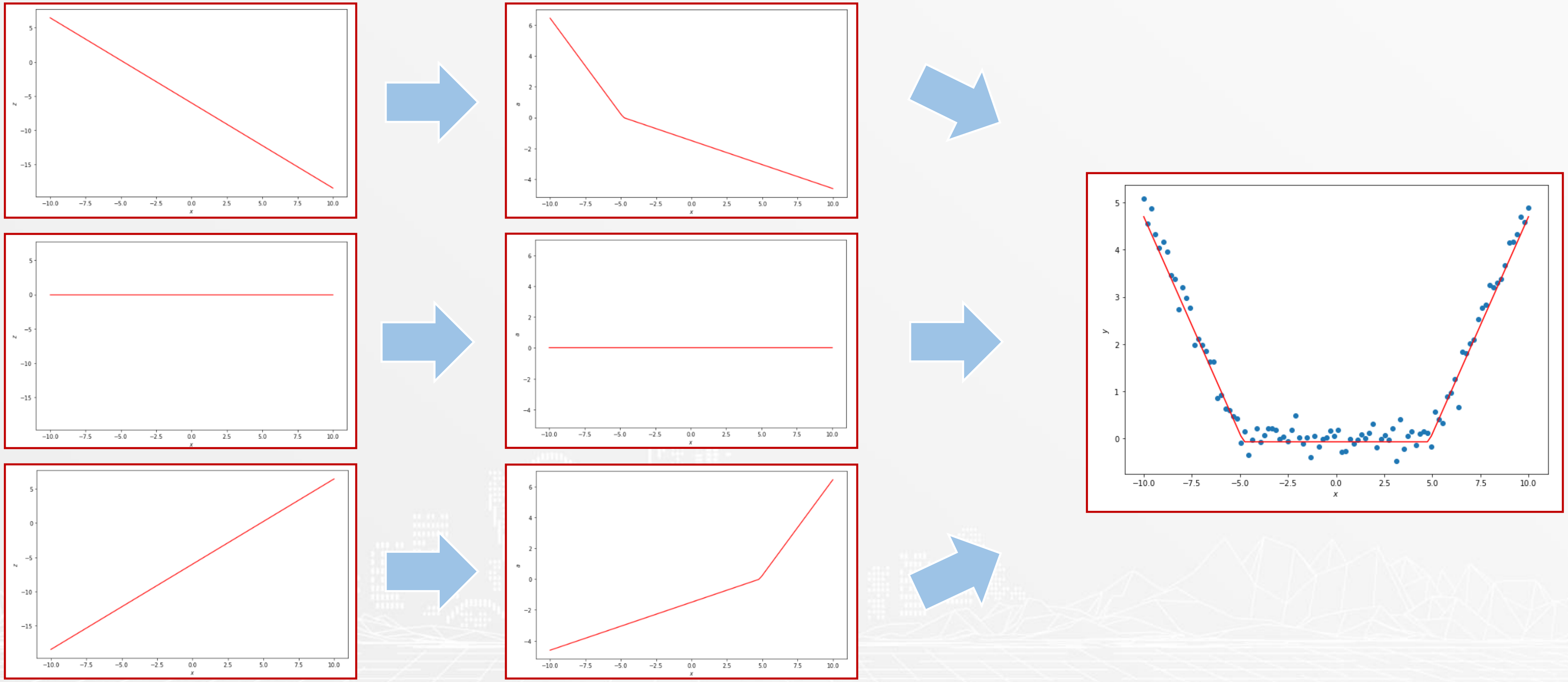
2. Parametric ReLU

$$f(z) = PReLU(z)$$



Comparison of Activation Function

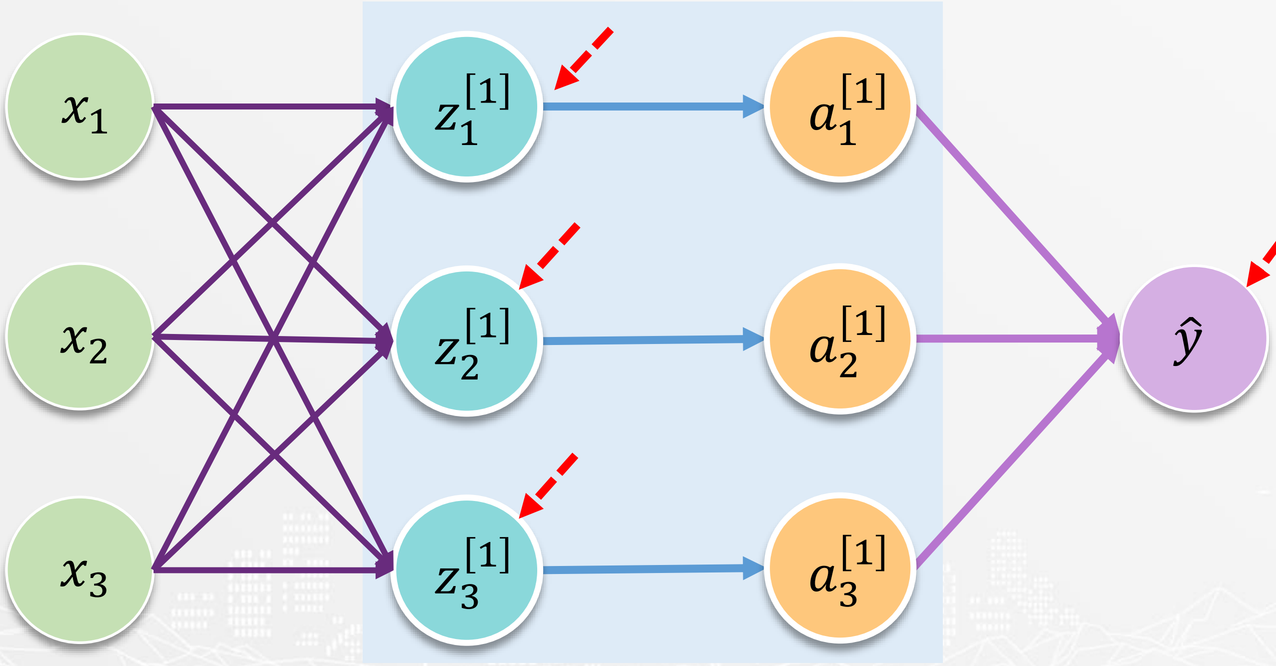
2. Parametric ReLU



Comparison of Activation Function

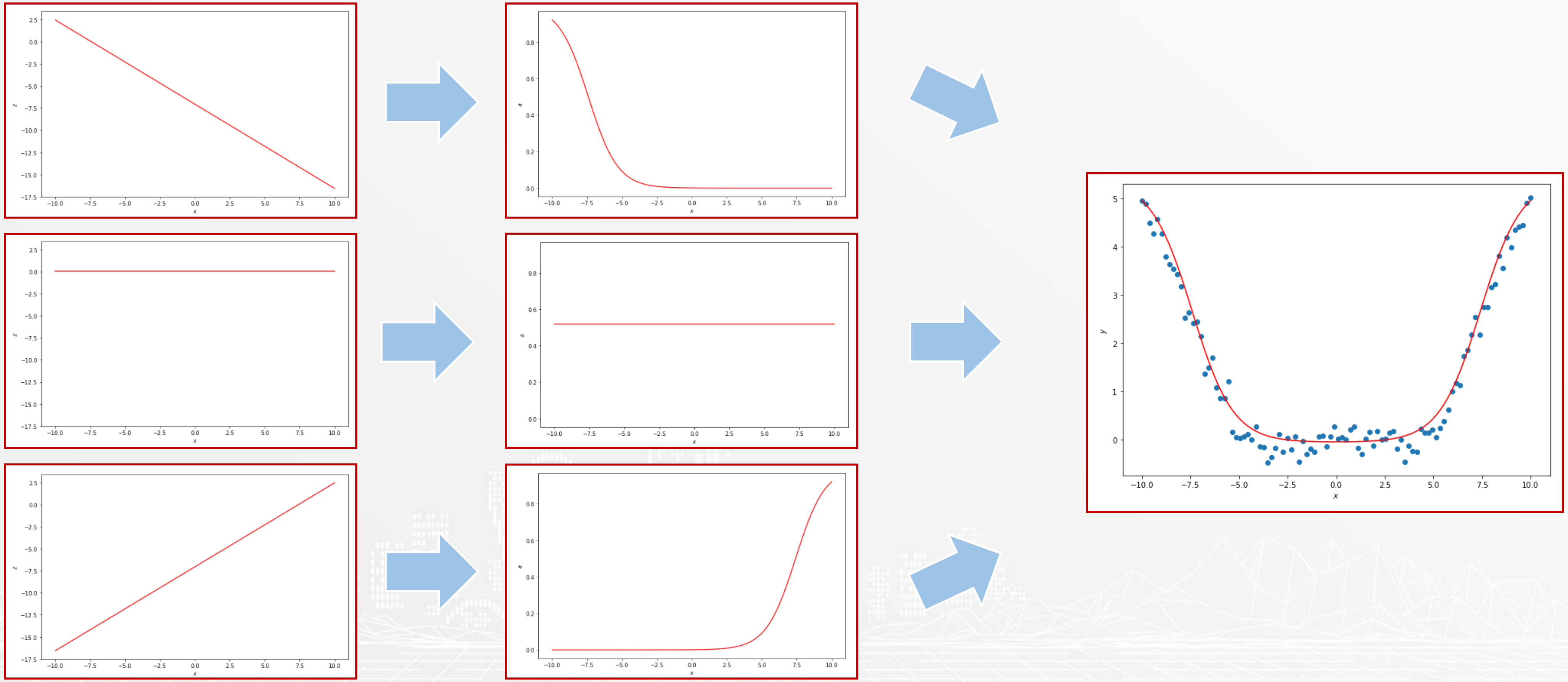
3. Sigmoid

$$f(z) = \sigma(z)$$



Comparison of Activation Function

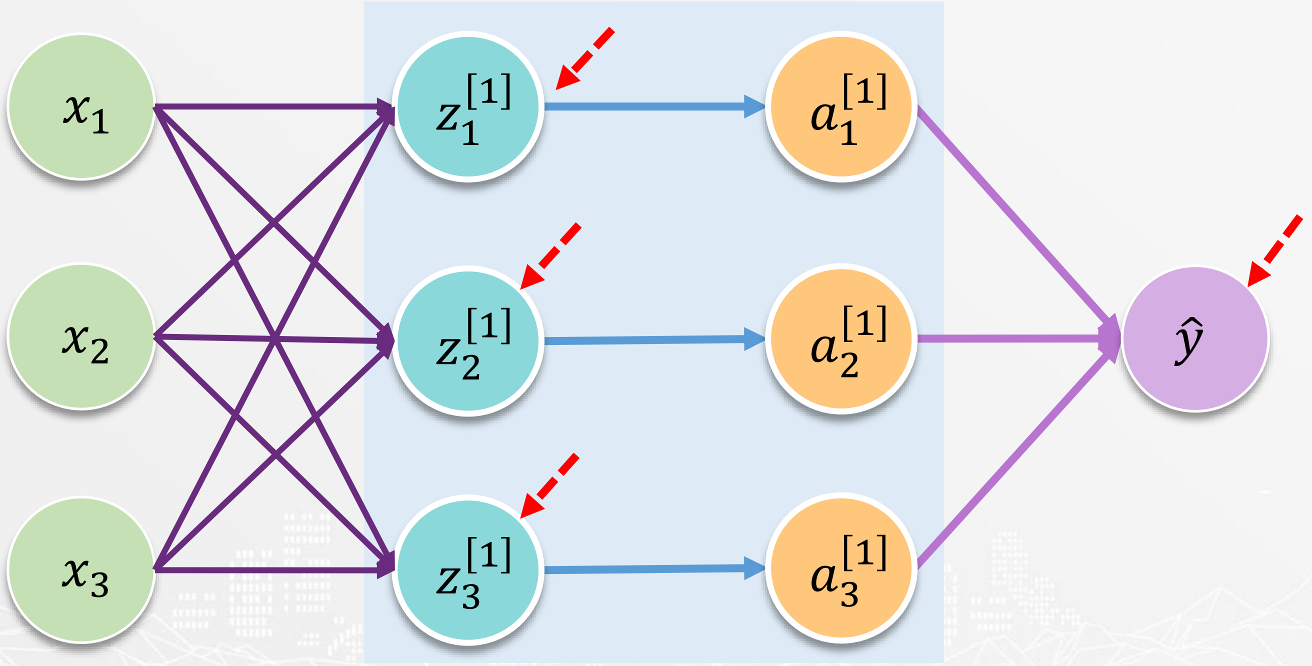
3. Sigmoid



Comparison of Activation Function

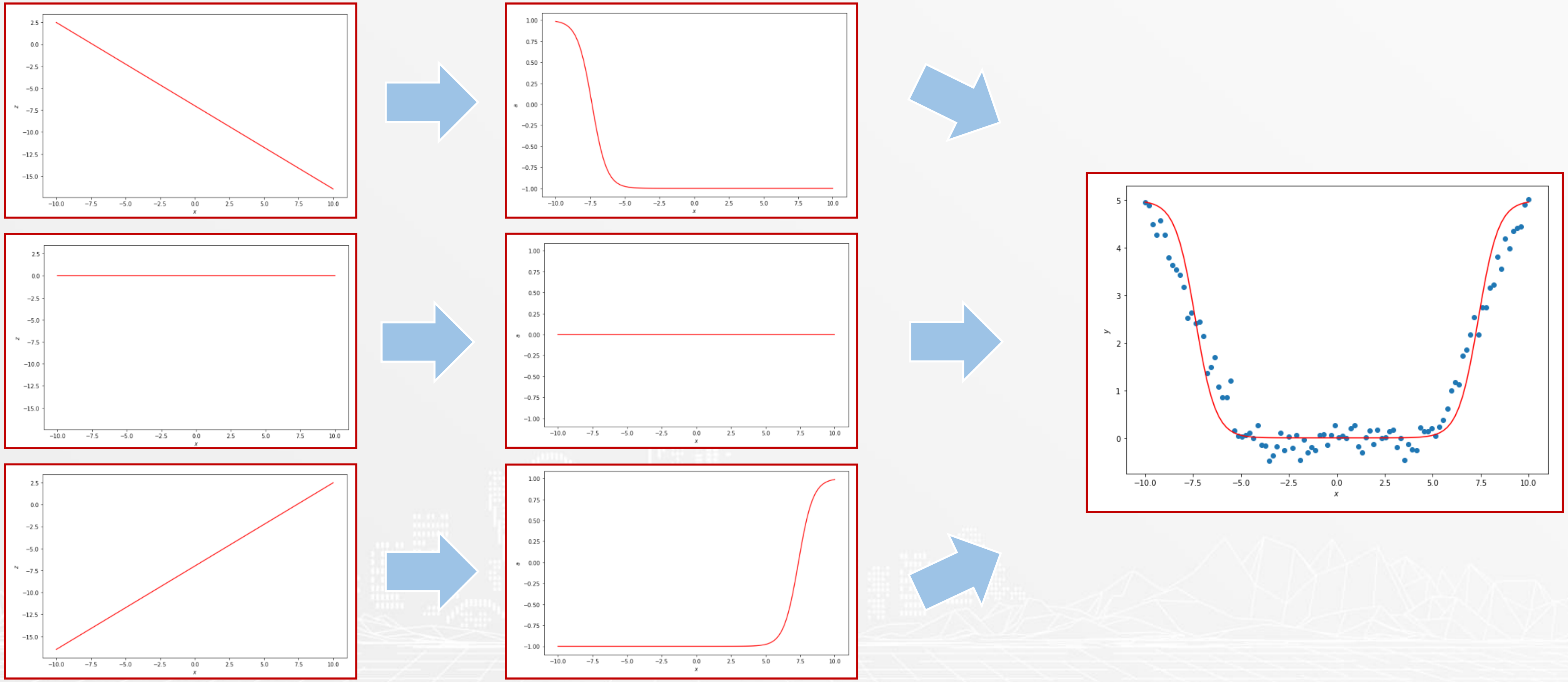
4. Tanh

$$f(z) = Tanh(z)$$



Comparison of Activation Function

4. Tanh



Comparison of Activation Function

Function	Range	บริเวณที่เกิดการเปลี่ยนแปลงความชัน	Cost per epoch	จำนวน epoch ที่ใช้ในการลู่เข้า
ReLU	[0, ∞)	เกิดรอยหัก	น้อยที่สุด	มากกว่า PReLU
PReLU	(−∞, ∞)	เกิดรอยหัก	มากกว่า ReLU	น้อยกว่า ReLU
Sigmoid	(0, 1)	smooth	มากกว่า ReLU, PReLU	มากกว่า Tanh
Tanh	(−1, 1)	smooth	มากที่สุด	น้อยกว่า Sigmoid

Activation Function

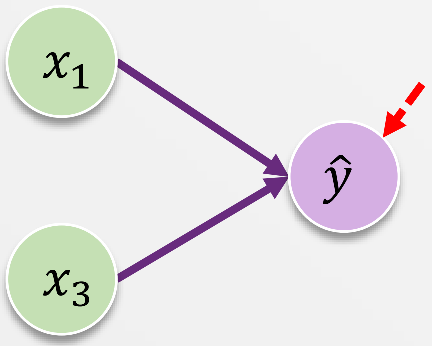
- ☑ **List of Activation Function**
- ☑ **Comparison of Activation Function**
- ☐ What if no Activation Function

What if no Activation Function

แล้วจะเกิดอะไรขึ้น ถ้าหากเราเพิ่ม hidden layer
เพียงอย่างเดียว โดยที่ไม่ใส่ activation function

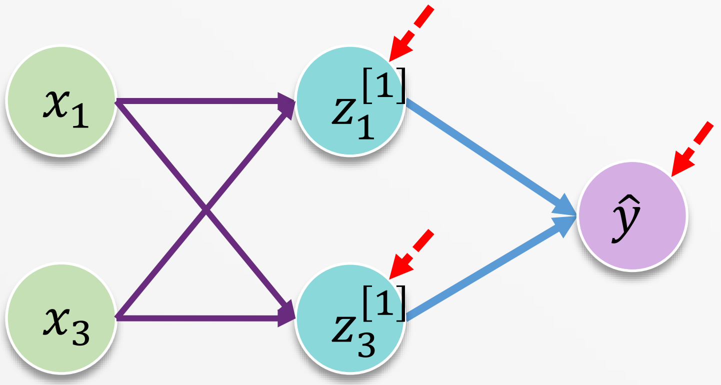
What if no Activation Function

Linear Regression



$$\hat{y} = w_0 + w_1 x_1 + w_2 x_2$$

Neural Network Regression



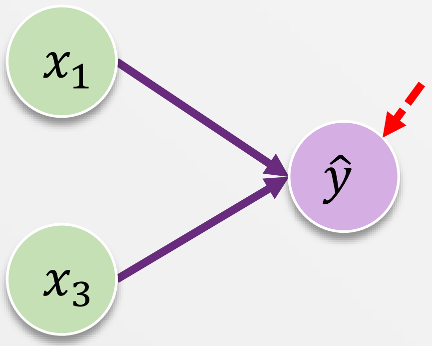
$$\hat{y} = b^{[out]} + w_1^{[out]} z_1 + w_2^{[out]} z_2 \qquad (1)$$

$$z_1 = b_1^{[1]} + w_{1,1}^{[1]} x_1 + w_{2,1}^{[1]} x_2 \qquad (2)$$

$$z_2 = b_2^{[1]} + w_{1,2}^{[1]} x_1 + w_{2,2}^{[1]} x_2 \qquad (3)$$

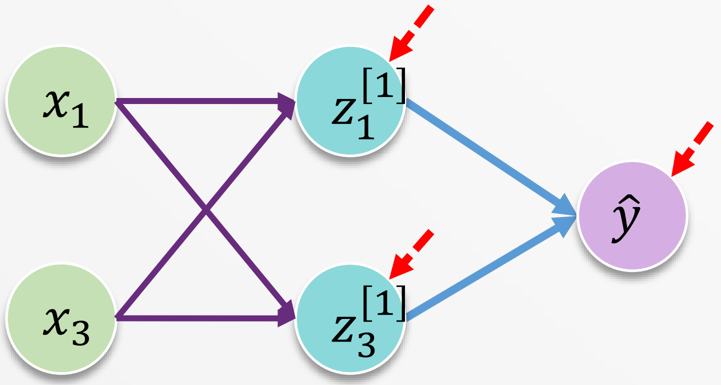
What if no Activation Function

Linear Regression



$$\hat{y} = w_0 + w_1 x_1 + w_2 x_2$$

Neural Network Regression



แทนค่า (2), (3) ใน (1)

$$\hat{y} = b^{[out]} + w_1^{[out]}(2) + w_2^{[out]}(3)$$

$$\downarrow$$

$$\hat{y} = c_0 + c_1 x_1 + c_2 x_2$$

What if no Activation Function

" Linear + Linear ➡ Linear "

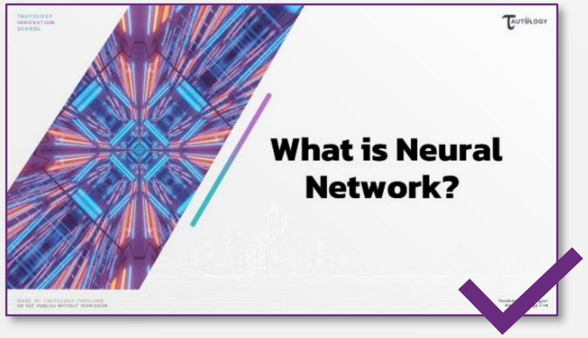
Activation Function

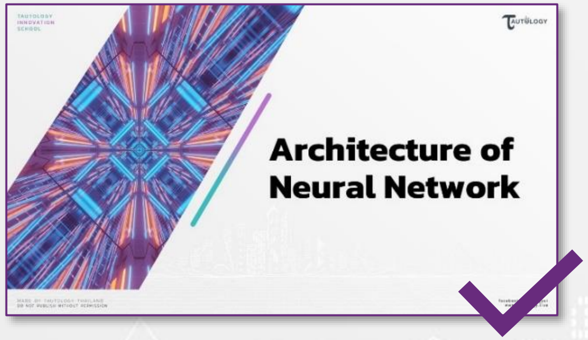
- ☑ List of Activation Function
- ☑ Comparison of Activation Function
- ☑ What if no Activation Function

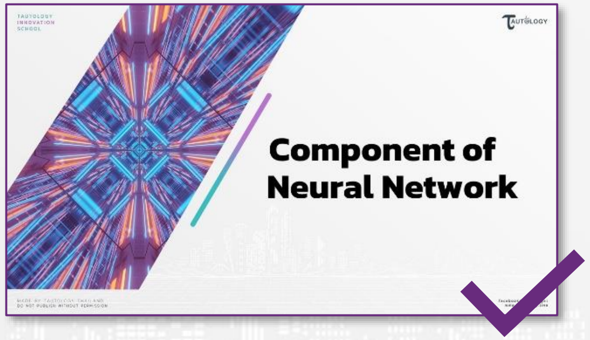
Component of Neural Network

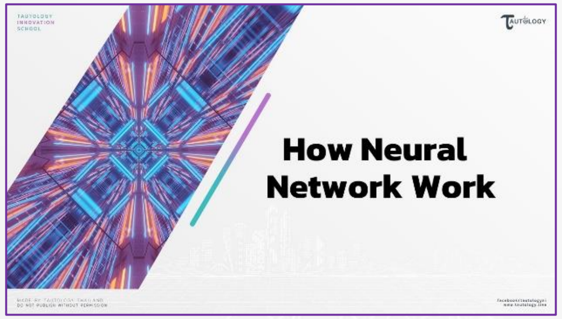
- Hidden Node
- Hidden Layer
- Weight & Bias
- Activation Function

Neural Network









How Neural Network Work

How Neural Network Work

Regression

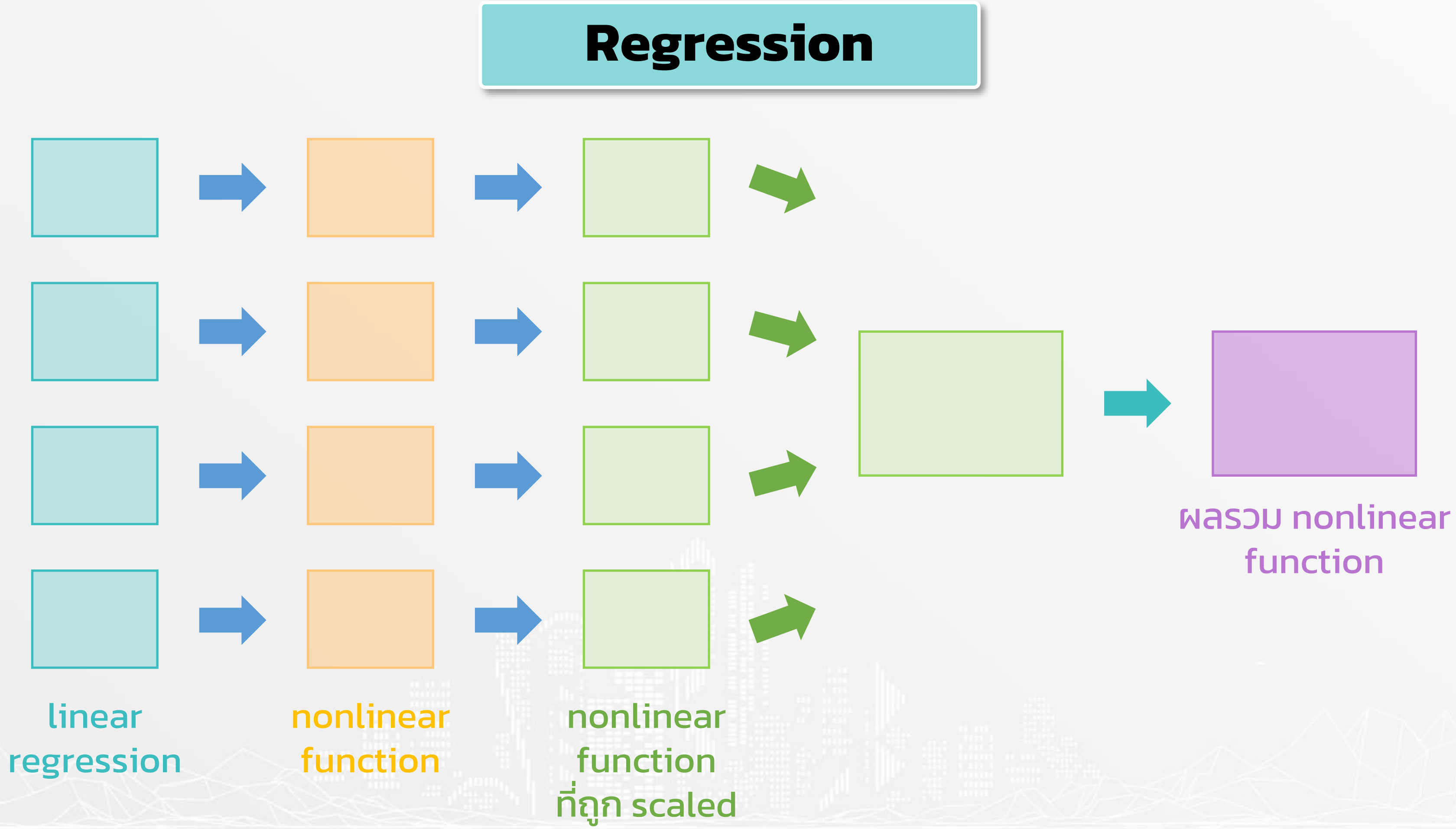
Classification

How Neural Network Work

Regression

Classification

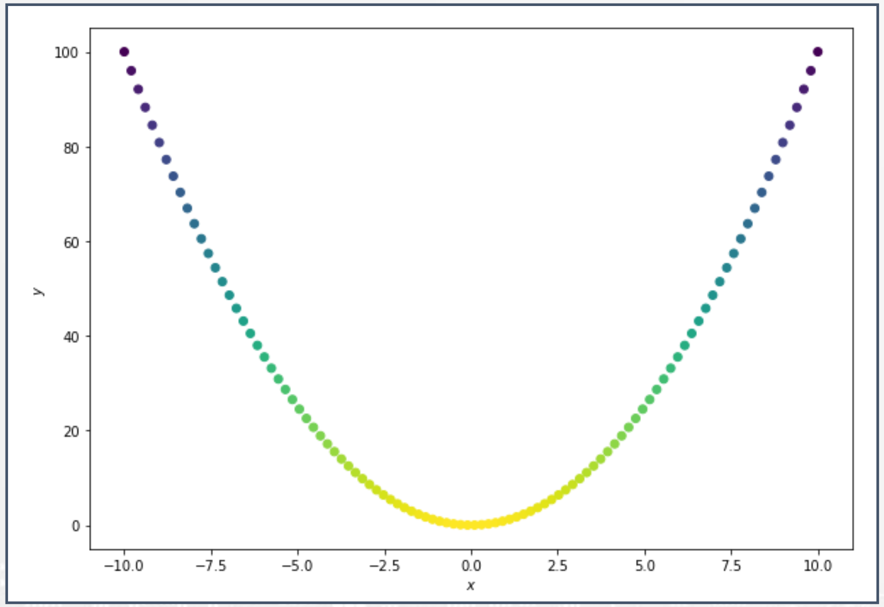
How Neural Network Work



How Neural Network Work

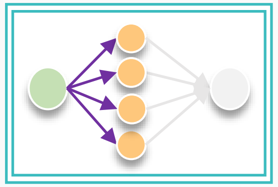
Regression

Example 1

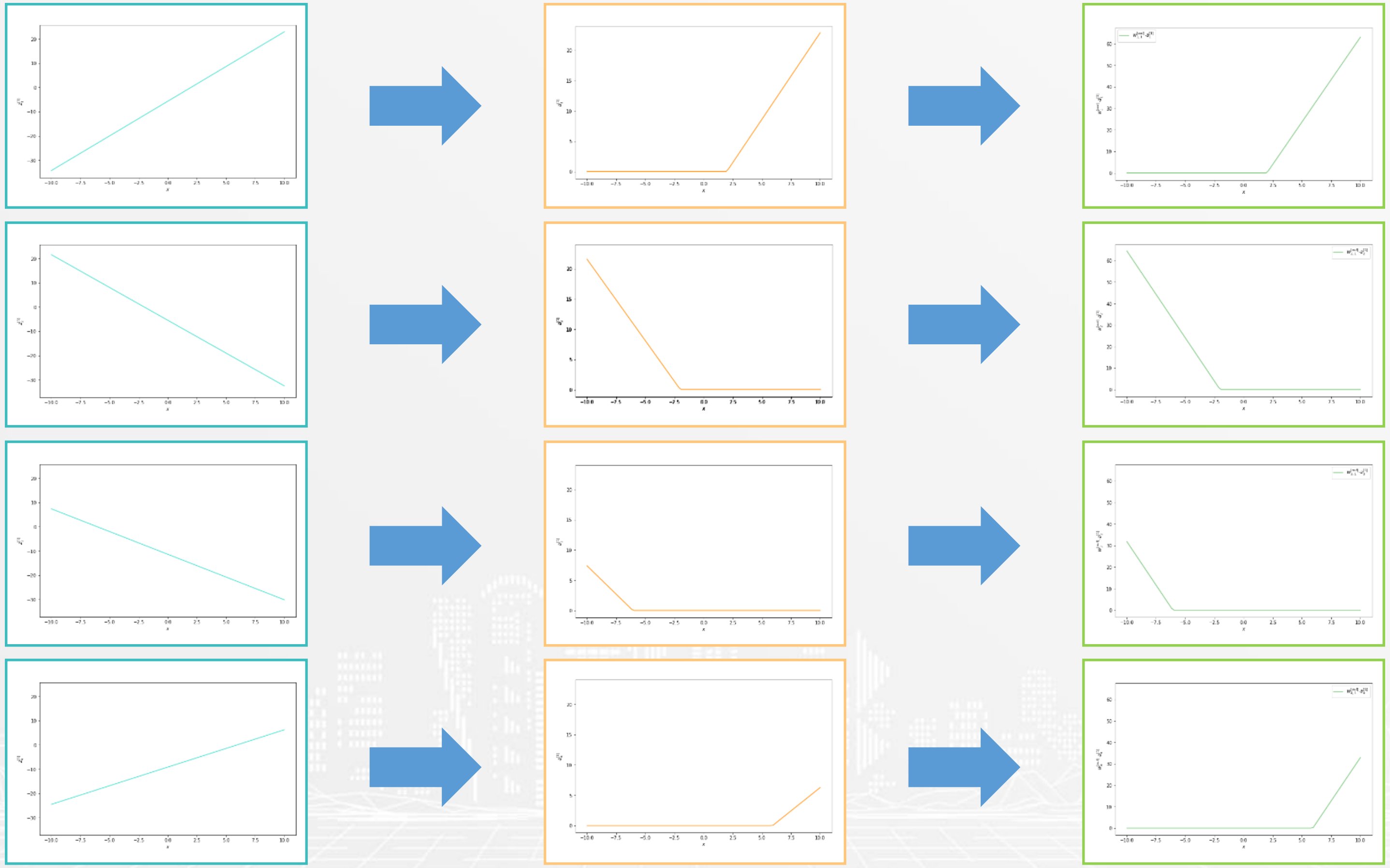


TAUTOLOGY

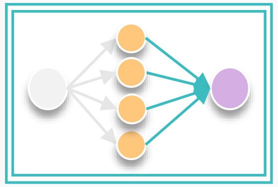
How Neural Network Work



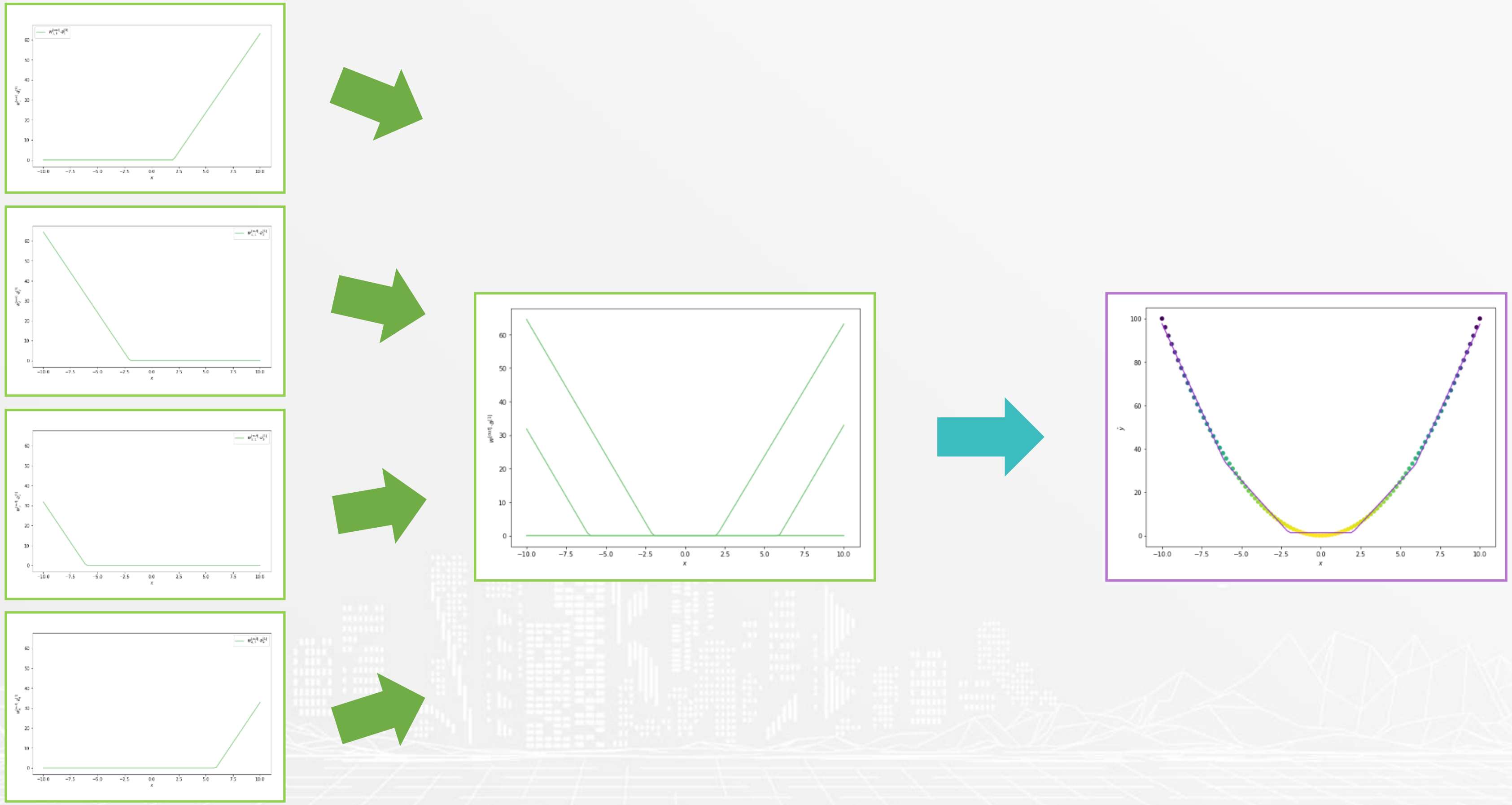
Regression Example 1



How Neural Network Work



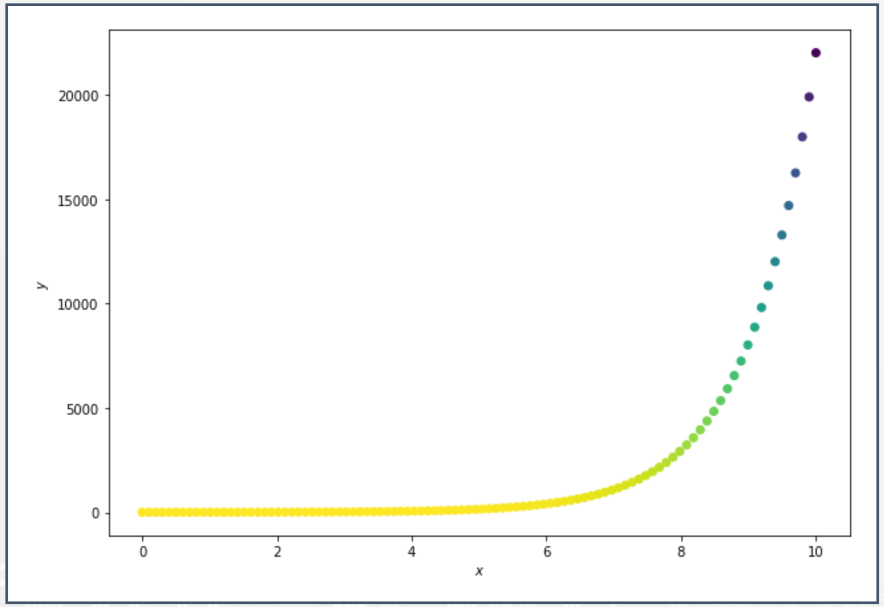
Regression Example 1



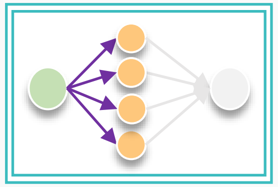
How Neural Network Work

Regression

Example 2



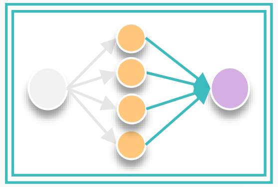
How Neural Network Work

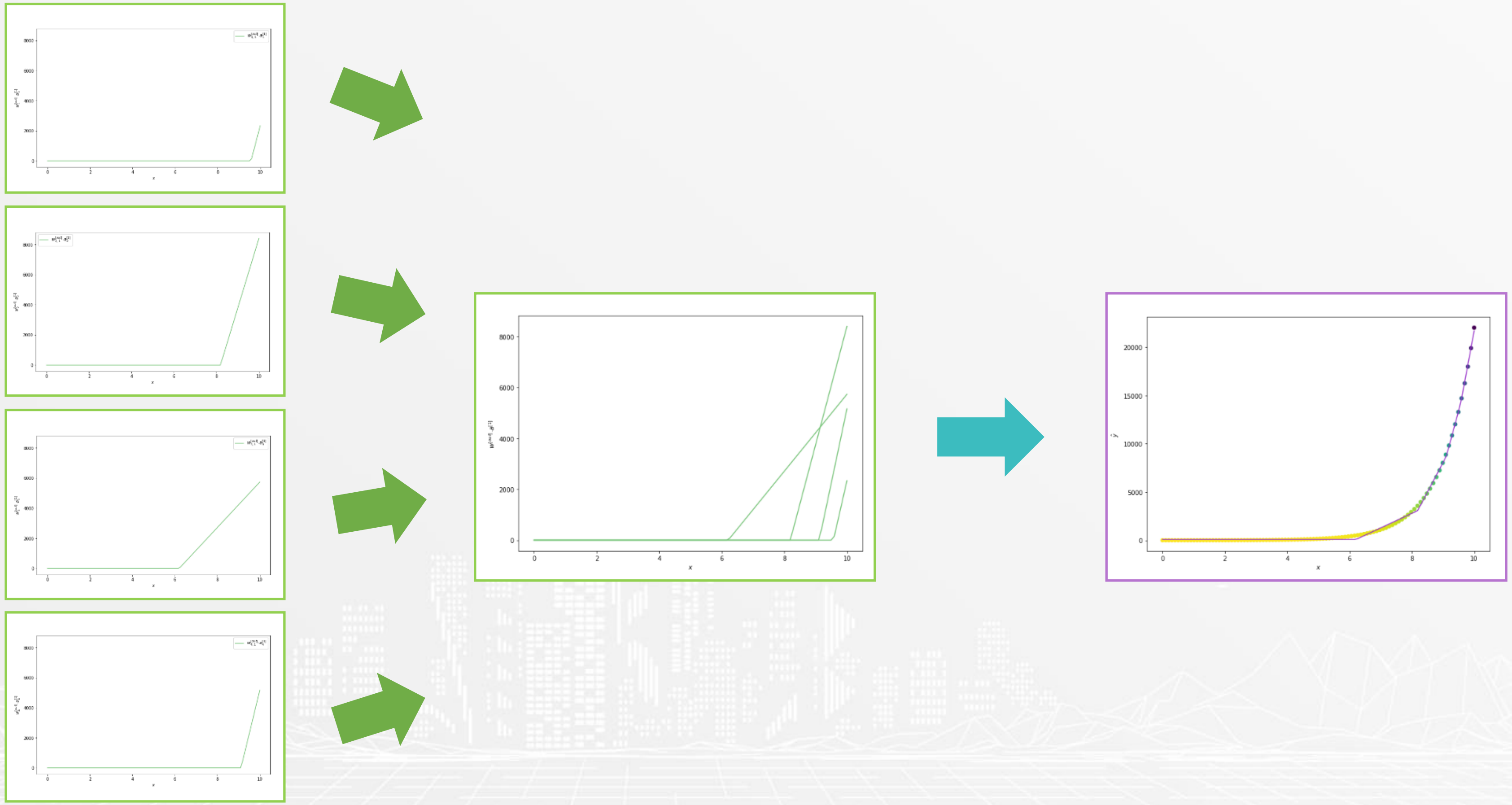


Regression Example 2

How Neural Network Work

Regression Example 2

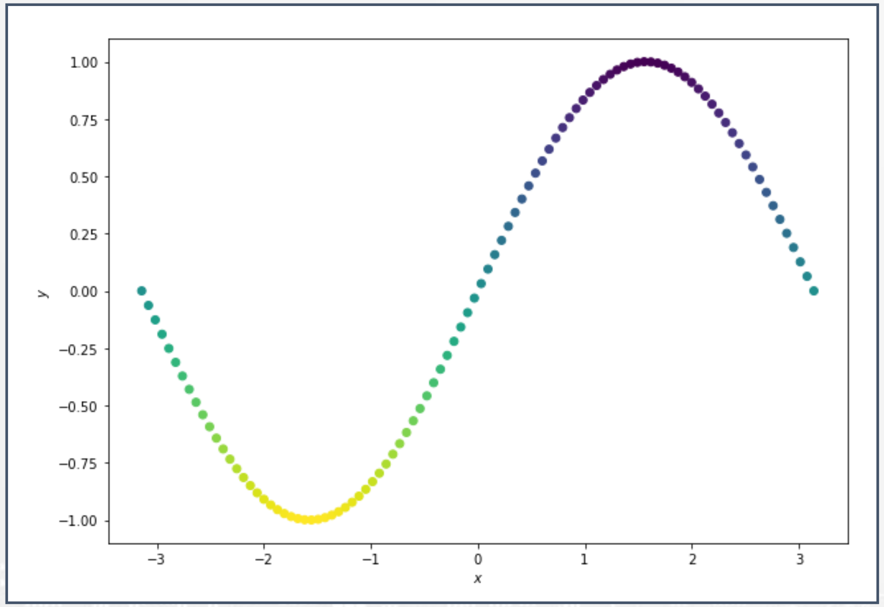




How Neural Network Work

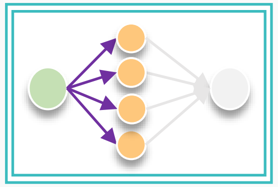
Regression

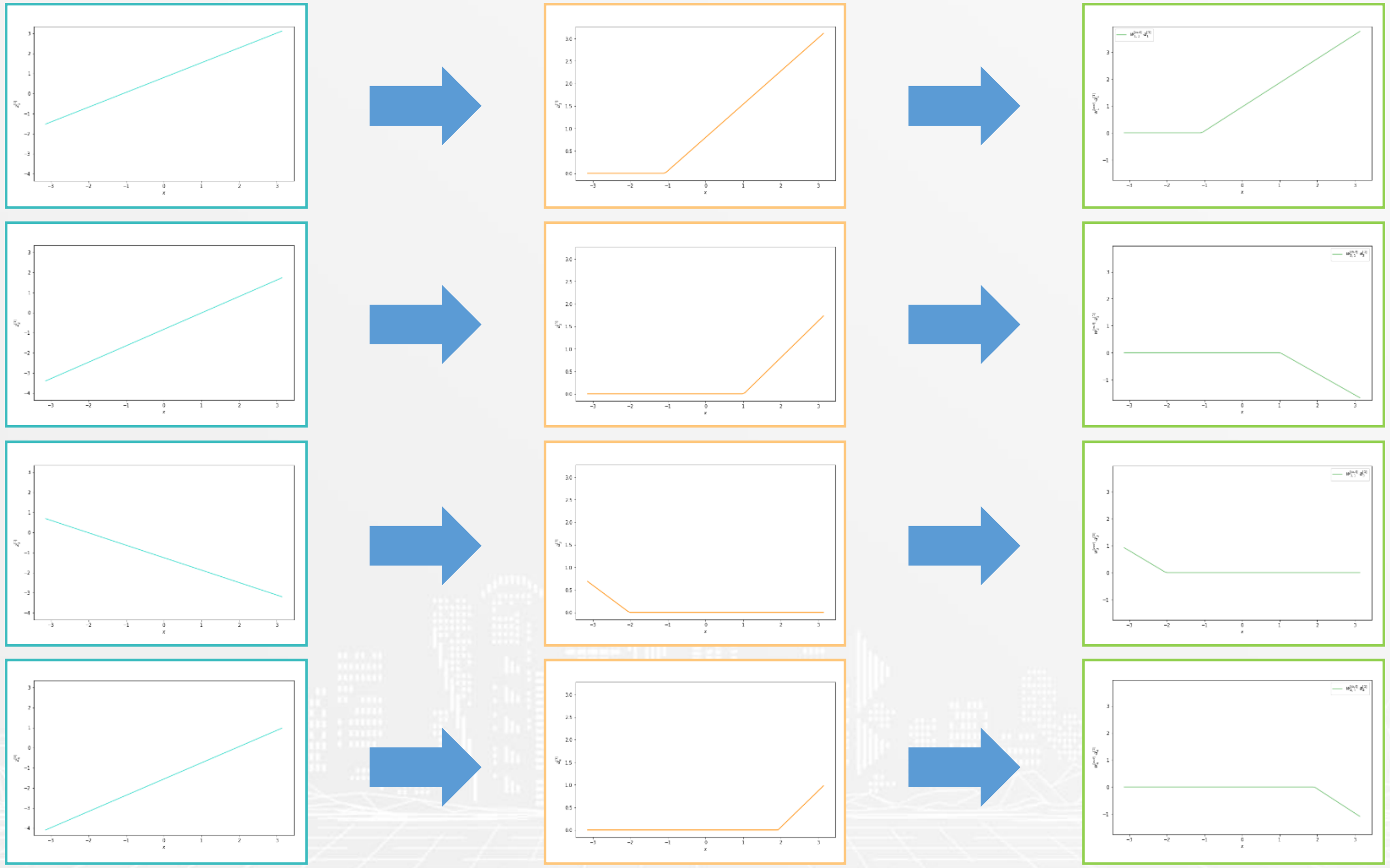
Example 3



How Neural Network Work

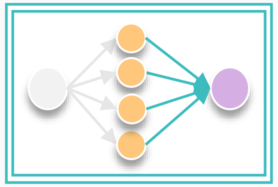
Regression Example 3

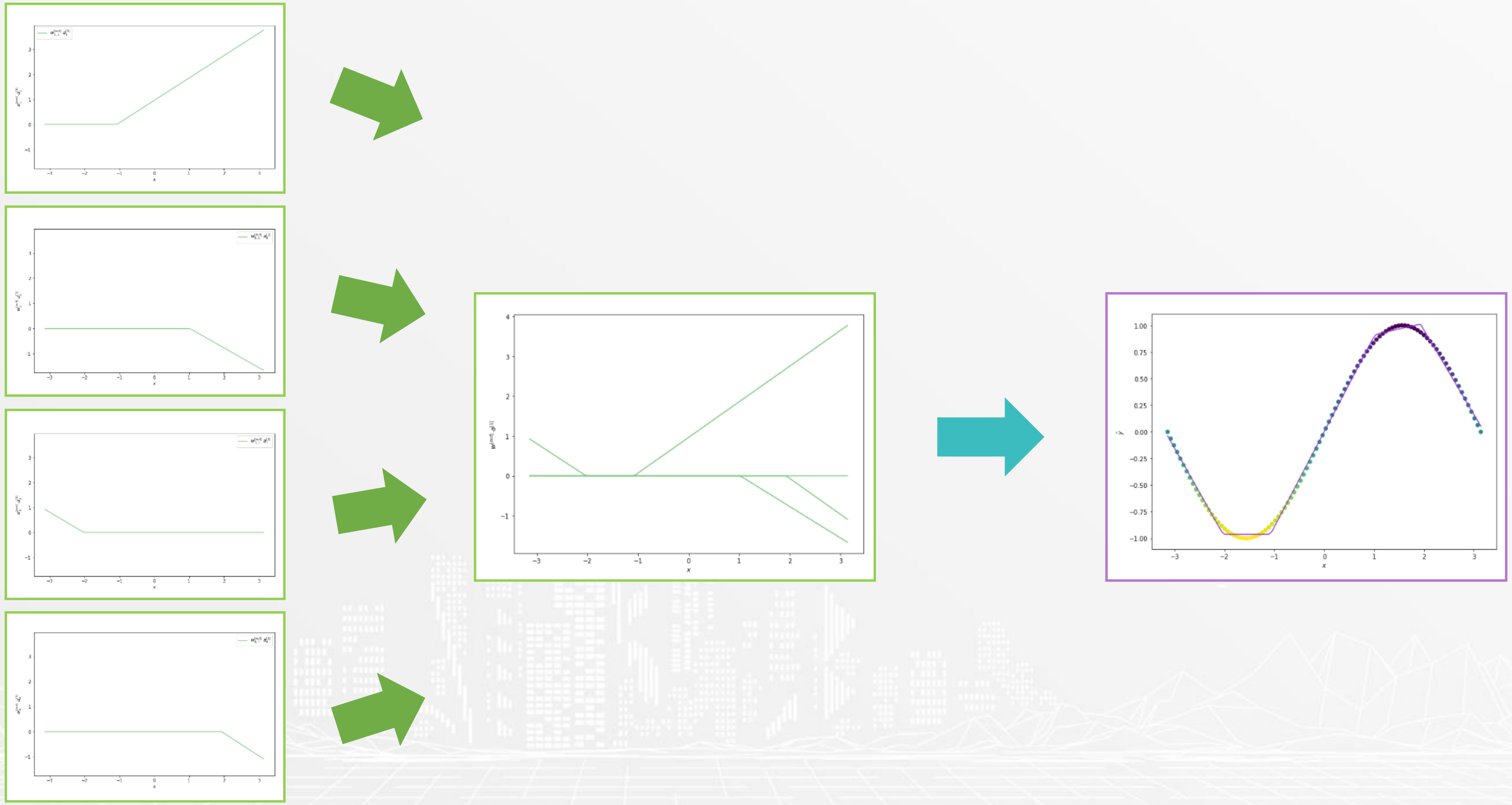




How Neural Network Work

Regression Example 3

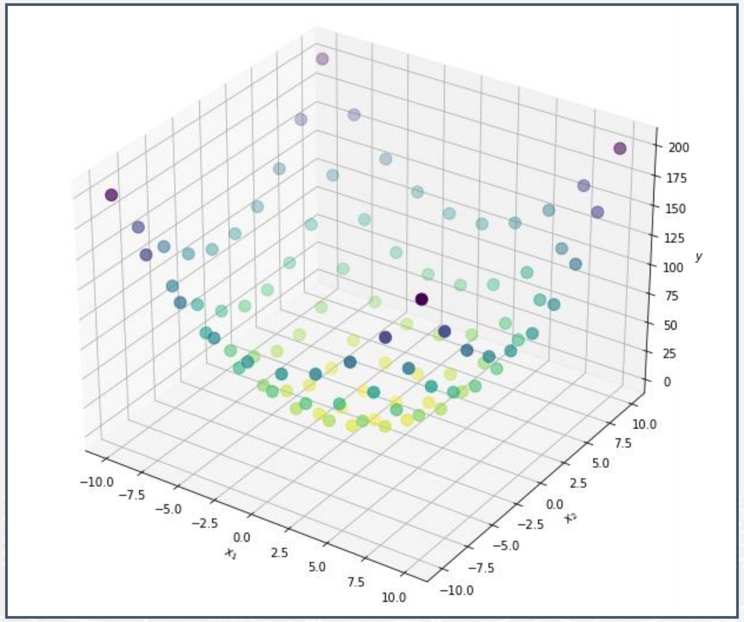




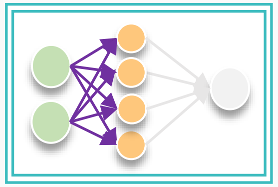
How Neural Network Work

Regression

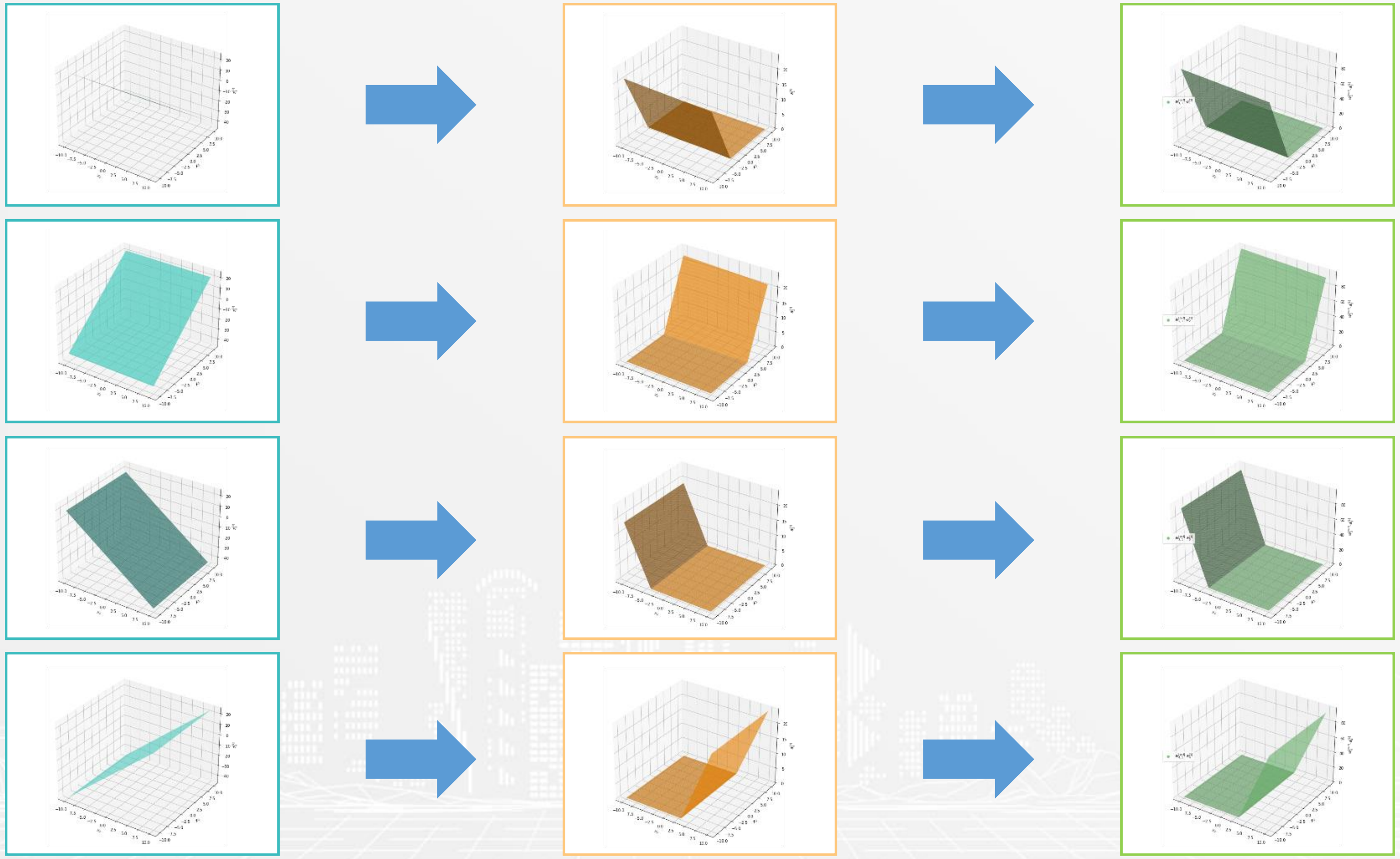
Example 4



How Neural Network Work

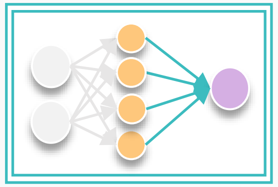


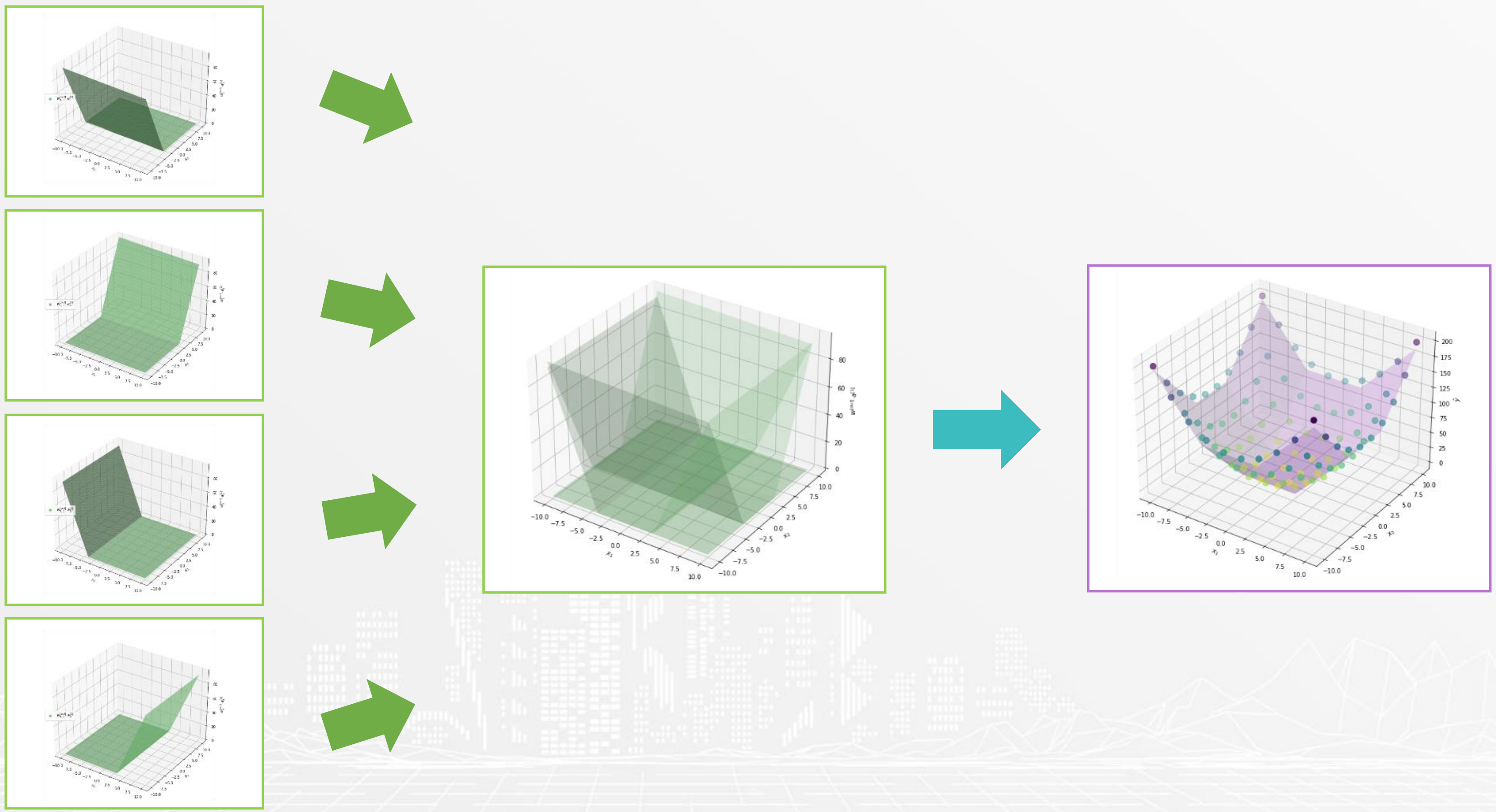
Regression Example 4



How Neural Network Work

Regression Example 4

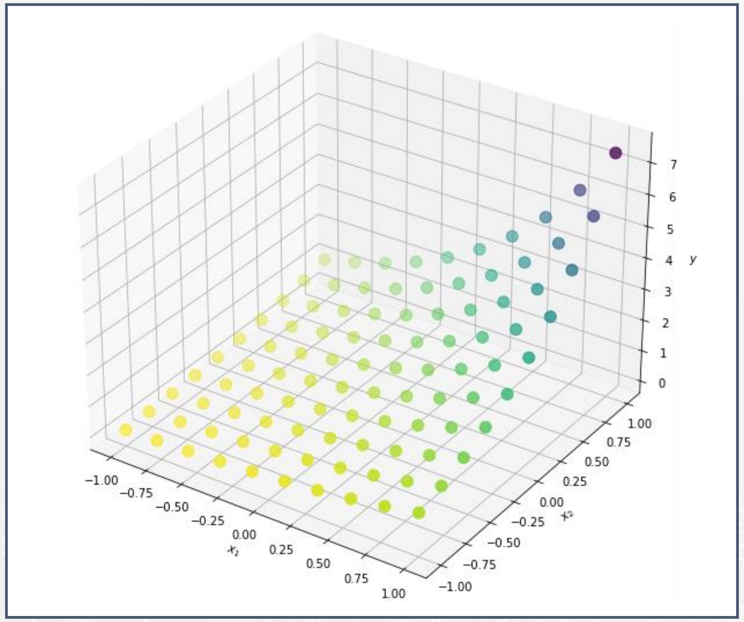




How Neural Network Work

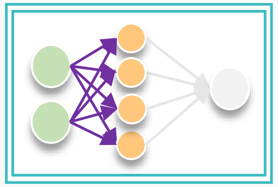
Regression

Example 5

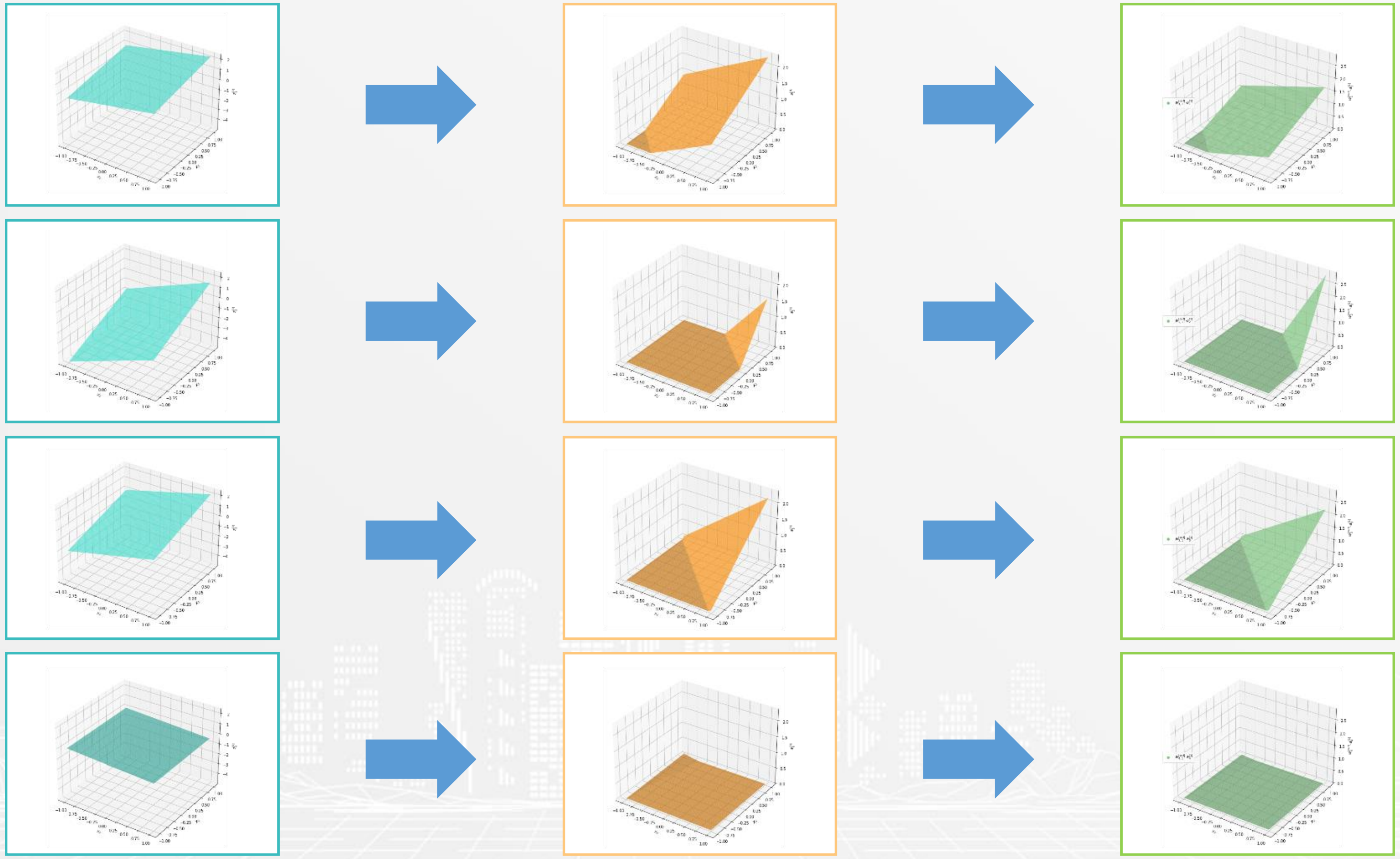


TAUTOLOGY

How Neural Network Work

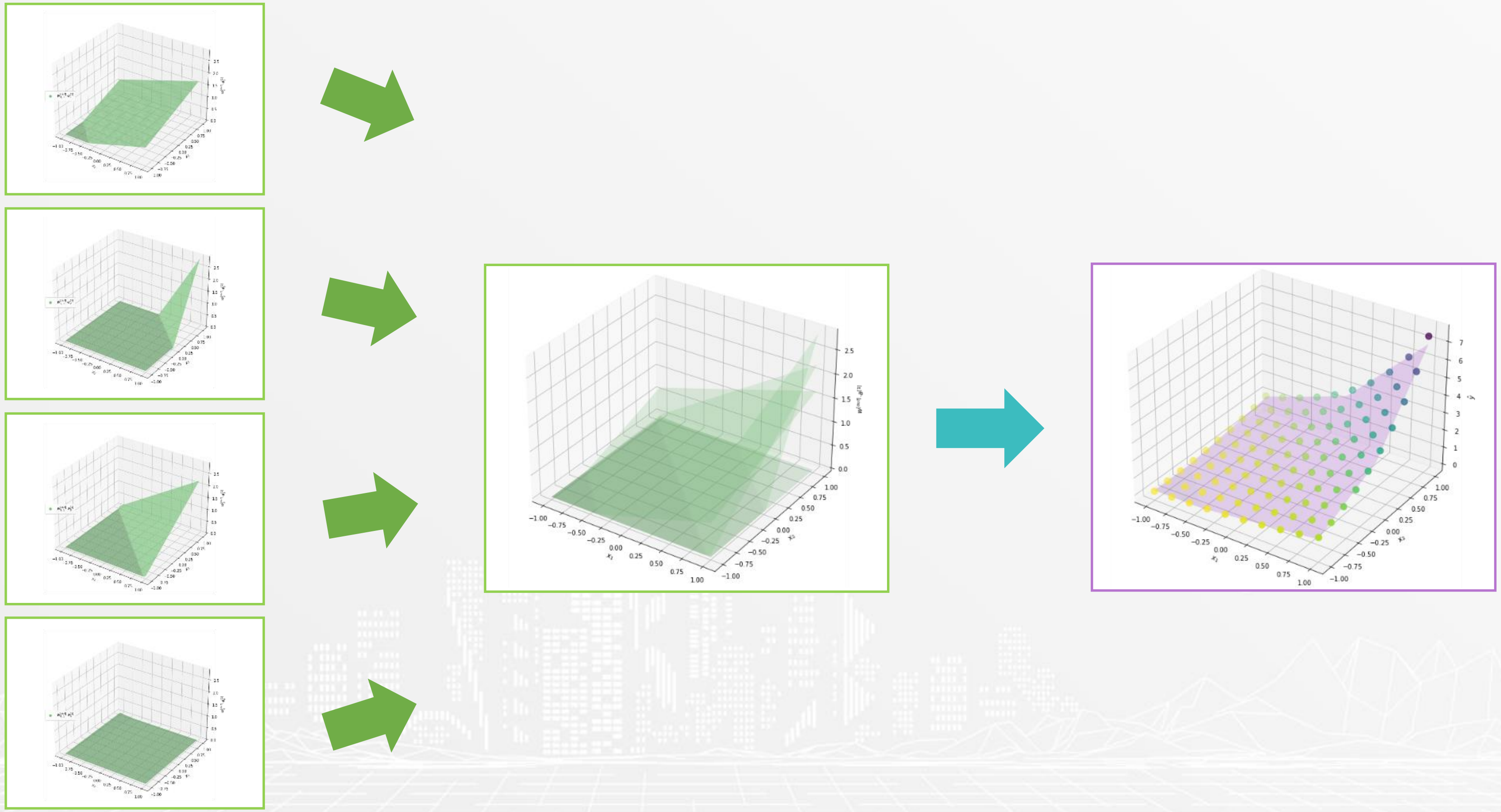


Regression | Example 5



How Neural Network Work

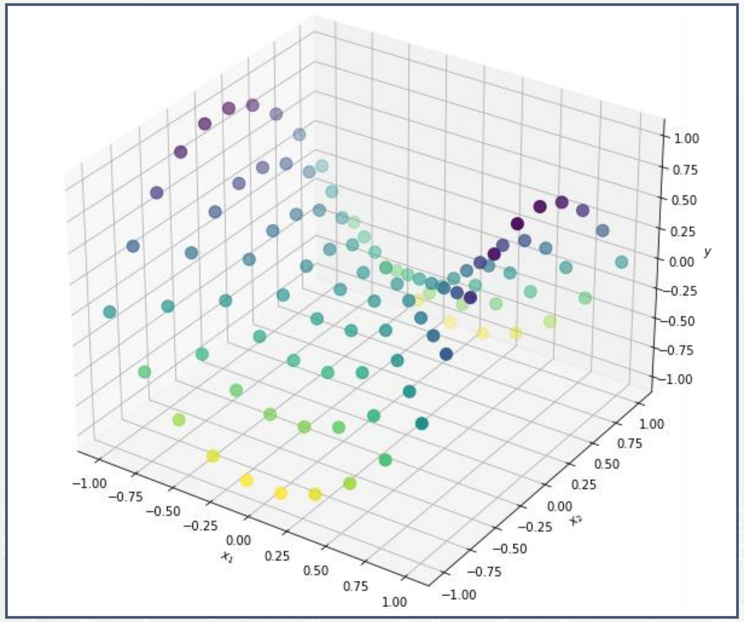
Regression | **Example 5**



How Neural Network Work

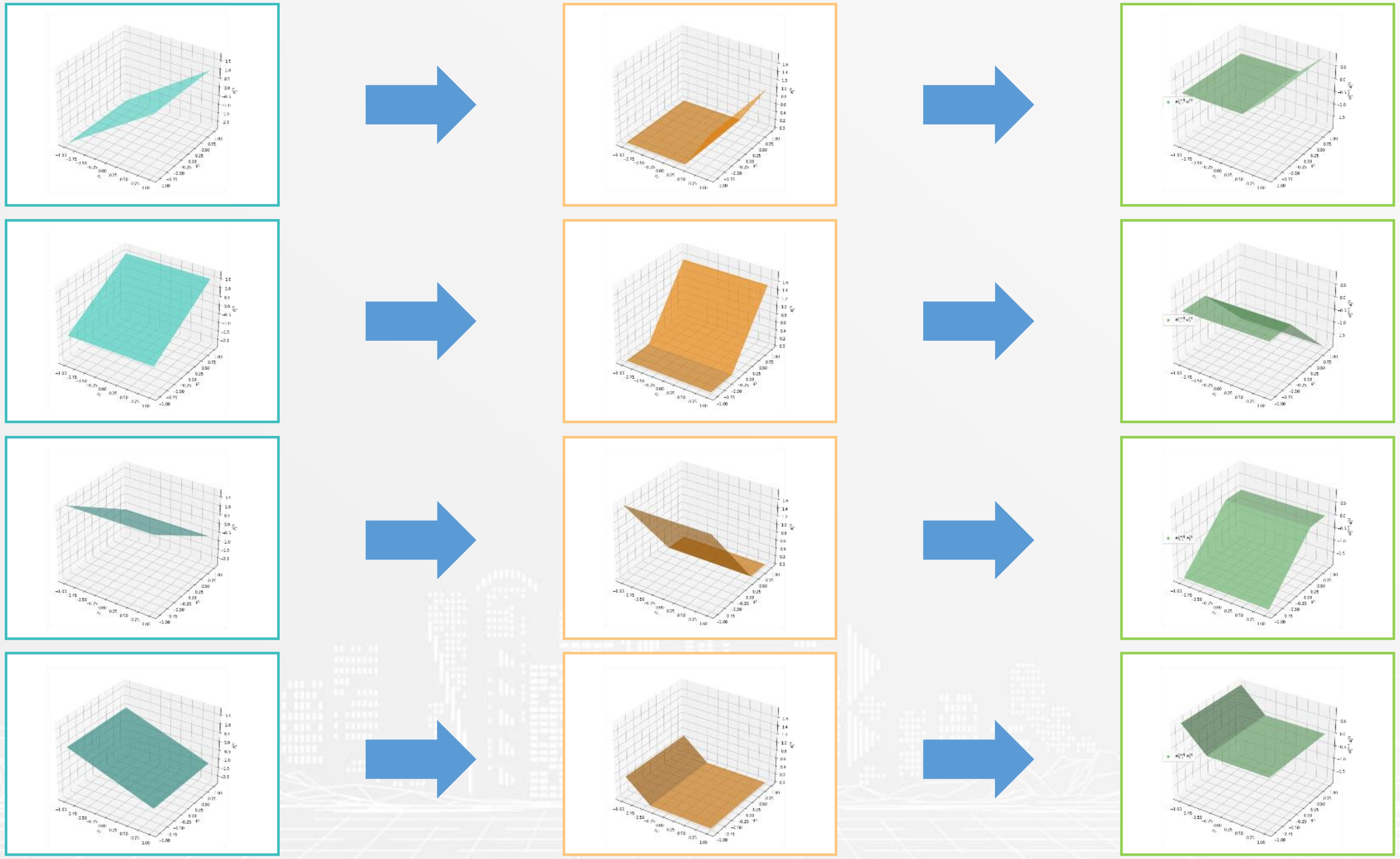
Regression

Example 6



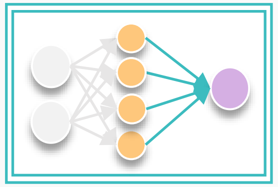
How Neural Network Work

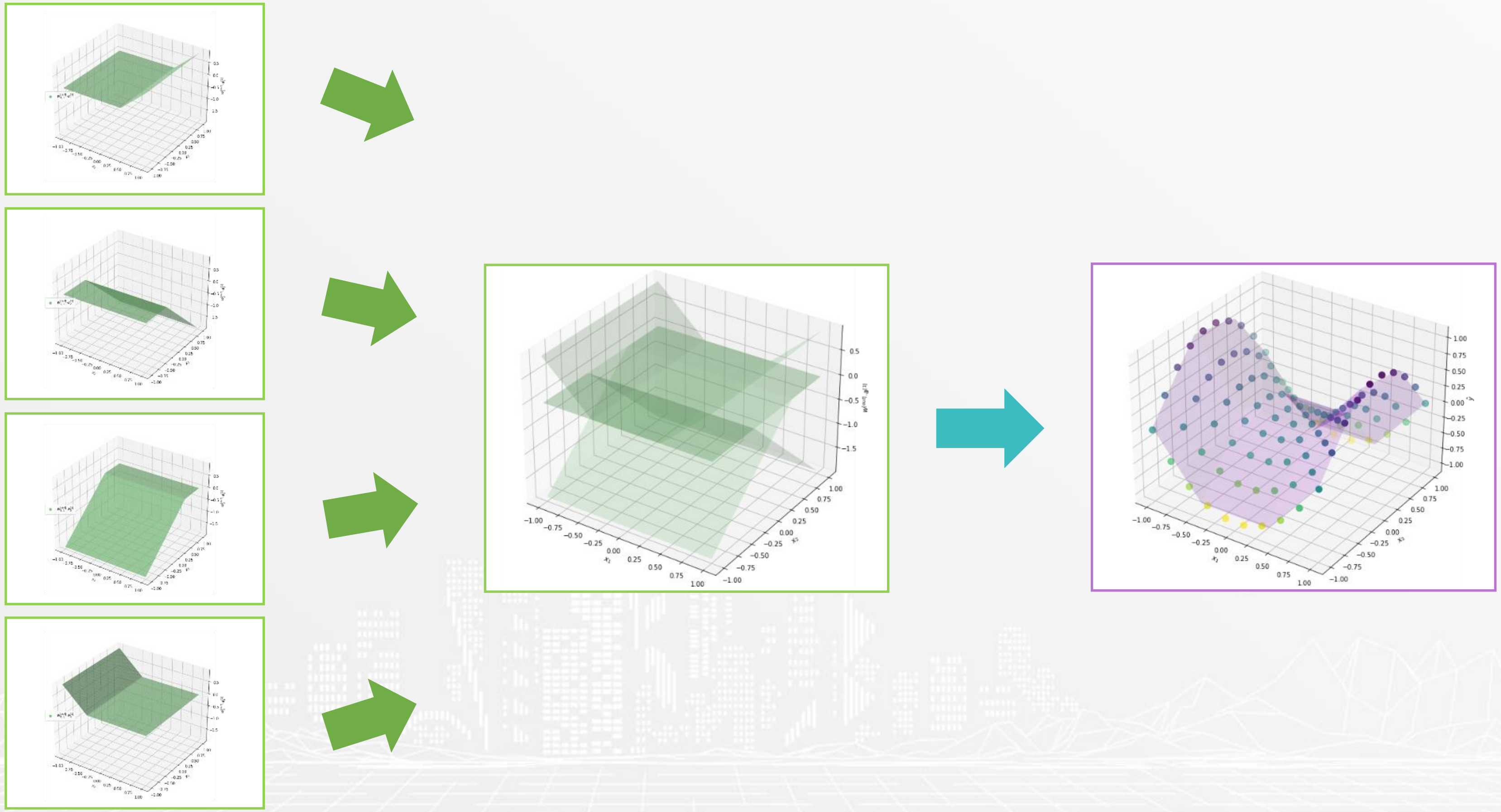
Regression Example 6



How Neural Network Work

Regression Example 6





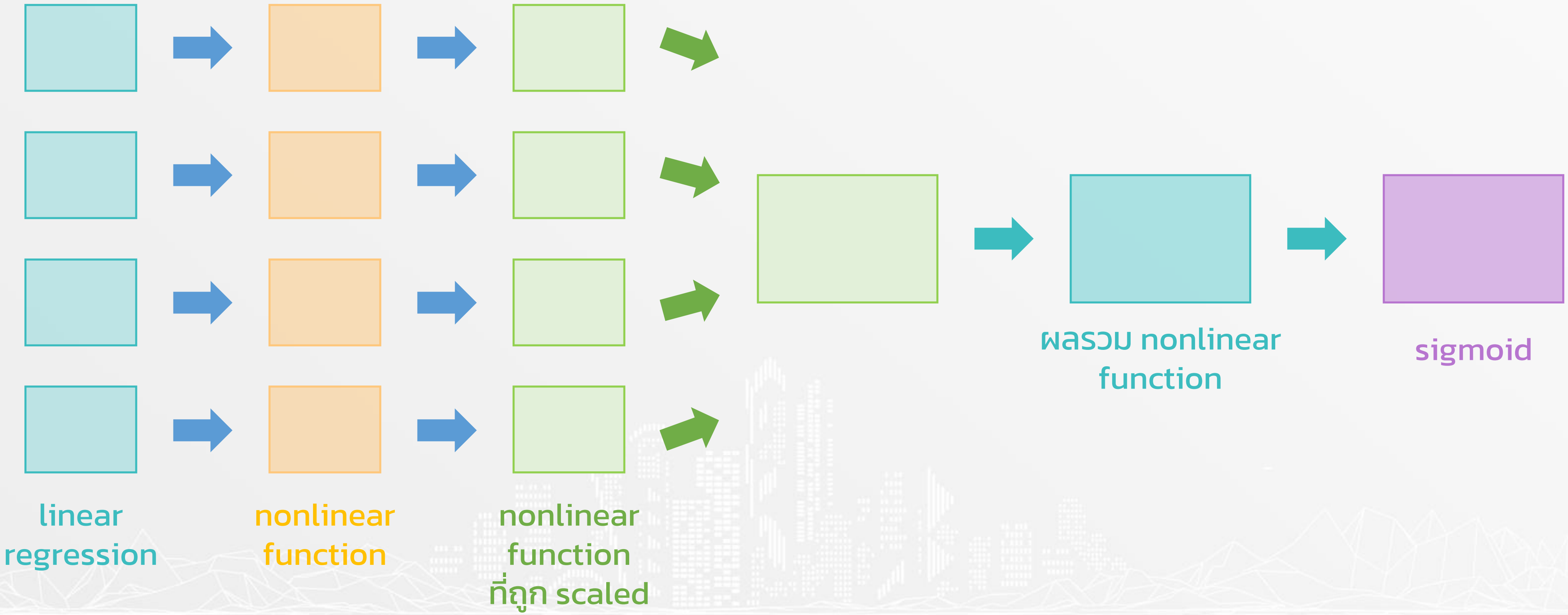
How Neural Network Work

Regression

Classification

How Neural Network Work

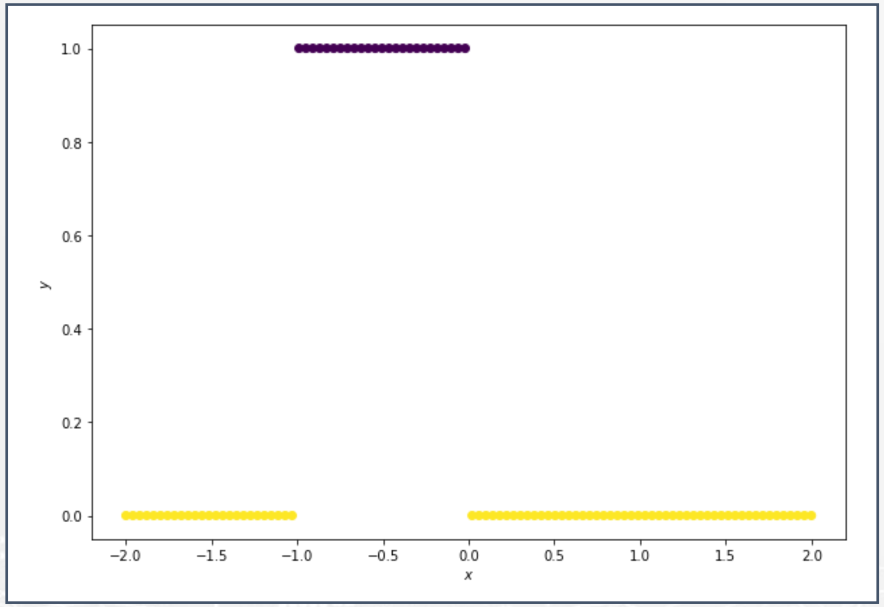
Binary Classification



How Neural Network Work

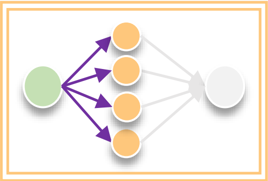
Classification

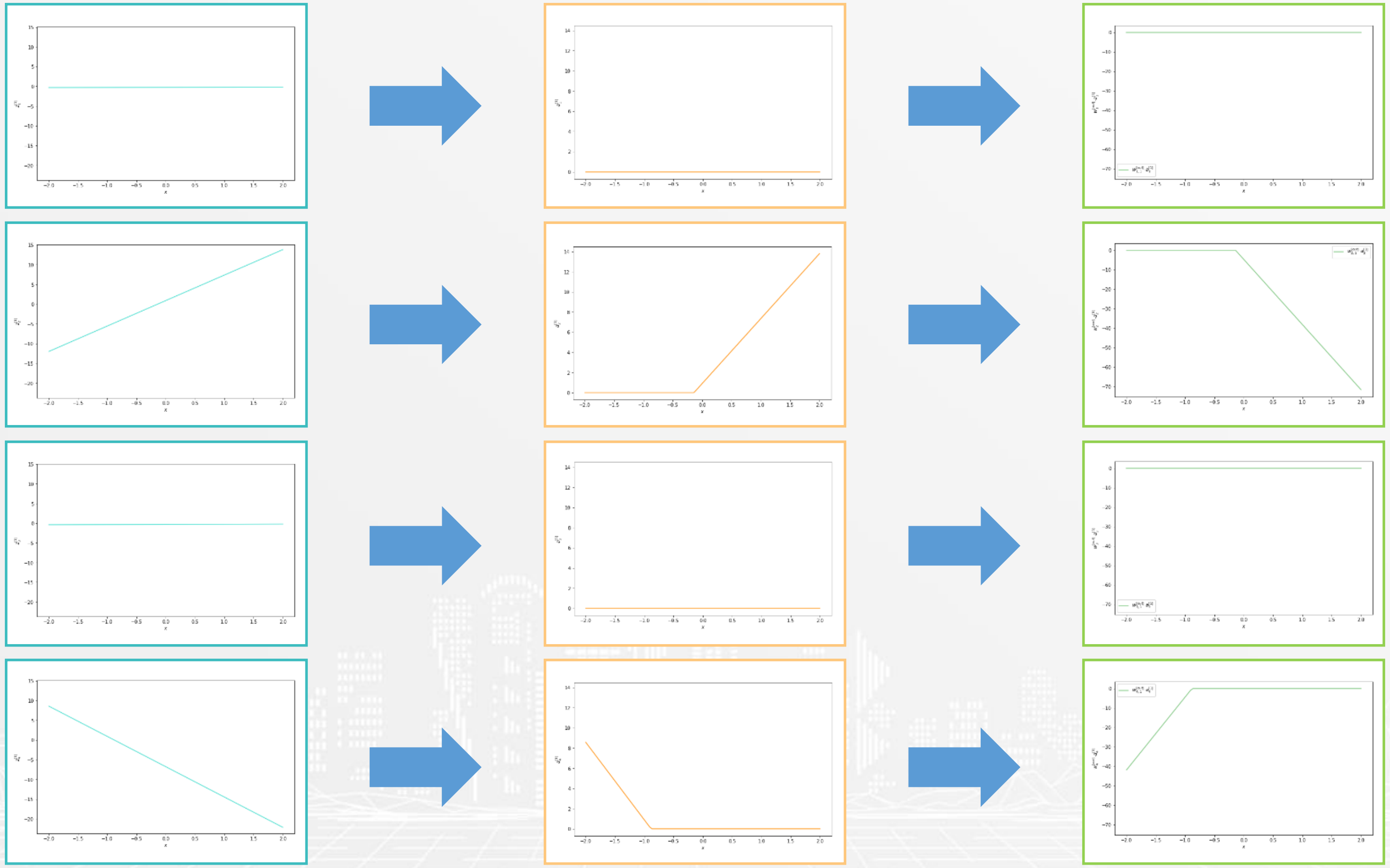
Example 1 : Binary Classification



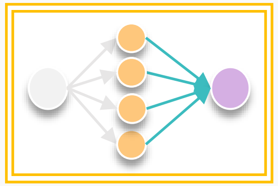
How Neural Network Work

Classification Example 1

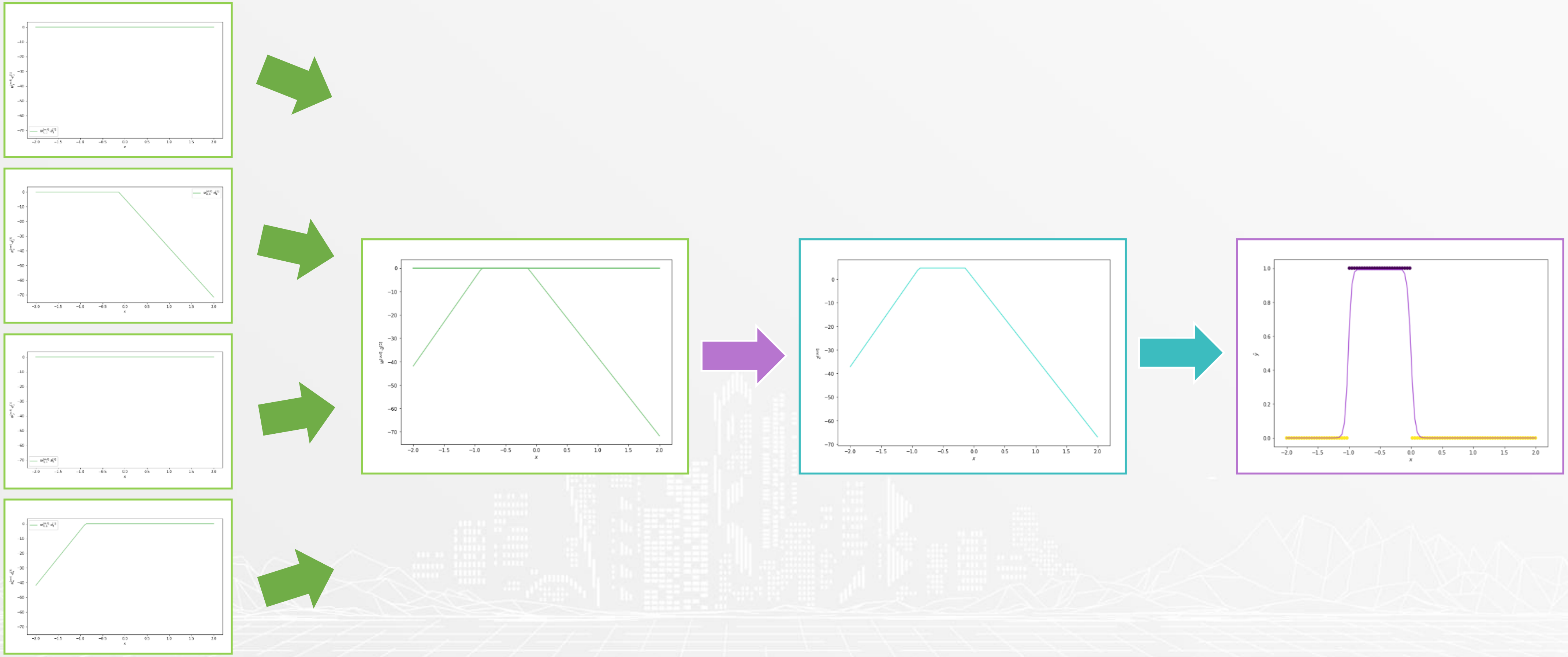




How Neural Network Work



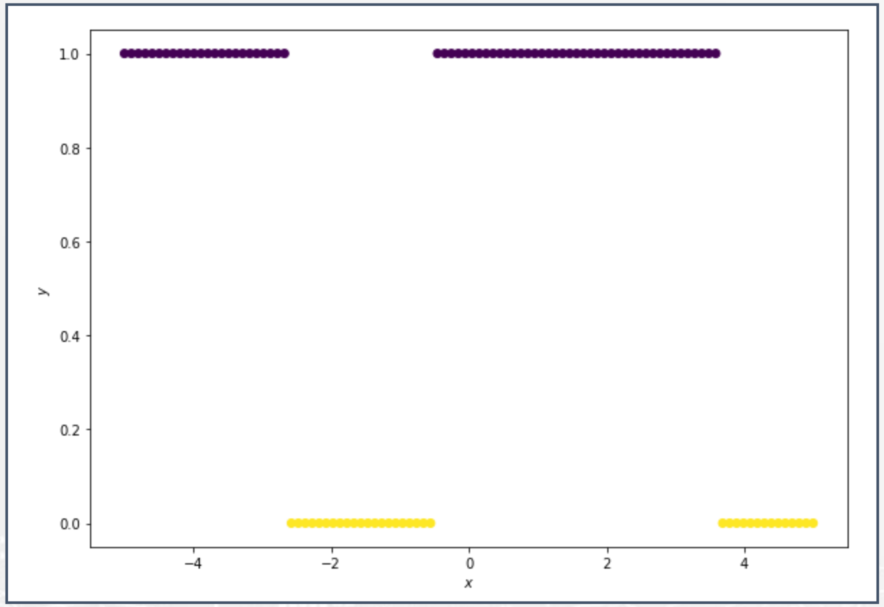
Classification Example 1



How Neural Network Work

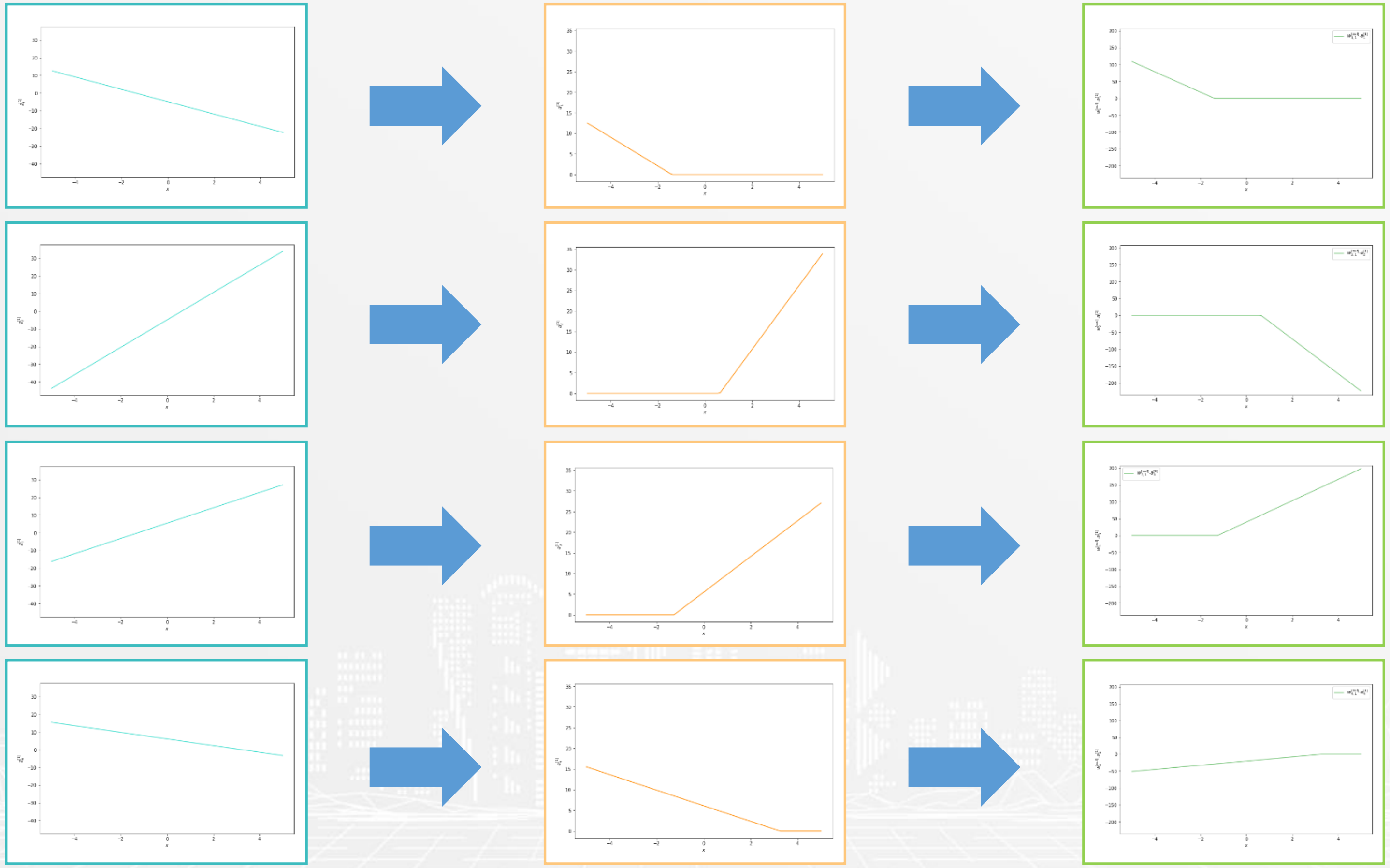
Classification

Example 2 : Binary Classification



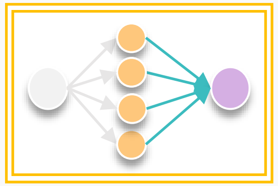
How Neural Network Work

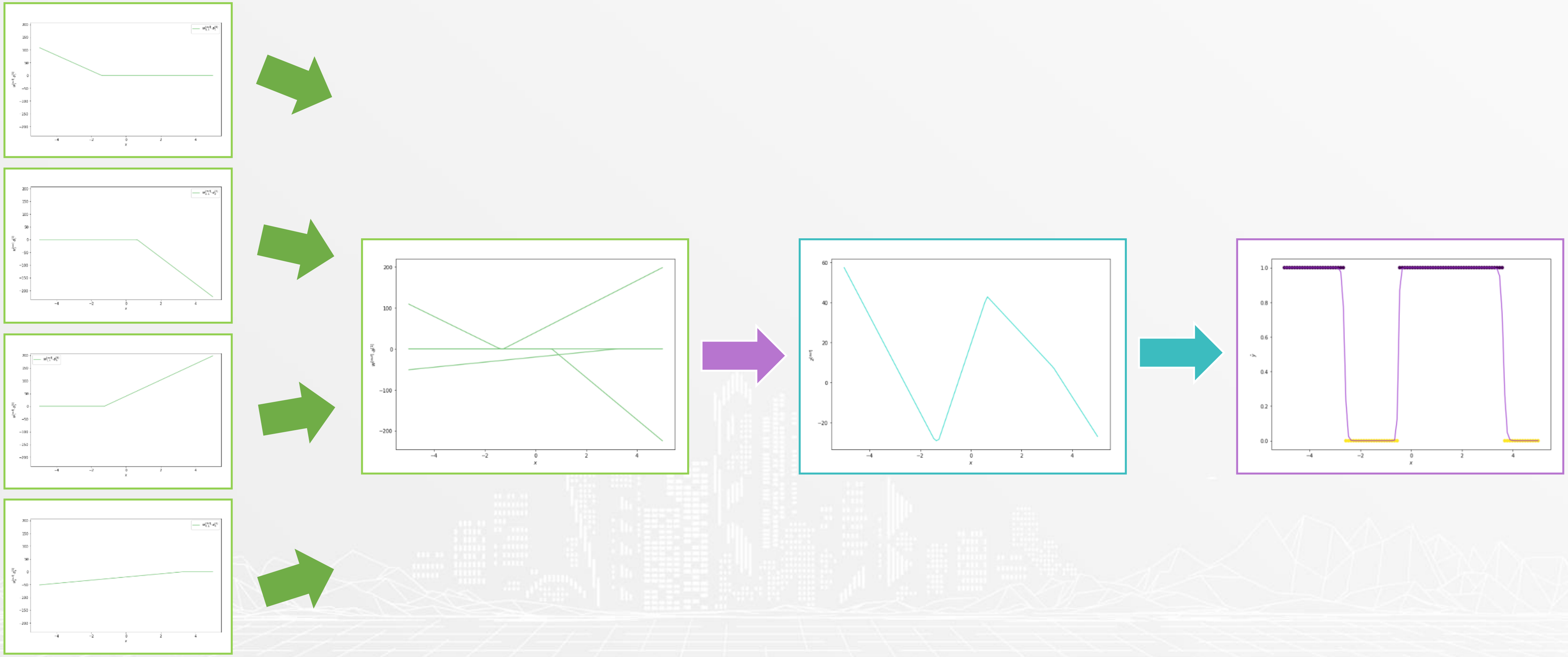
Classification Example 2



How Neural Network Work

Classification Example 2

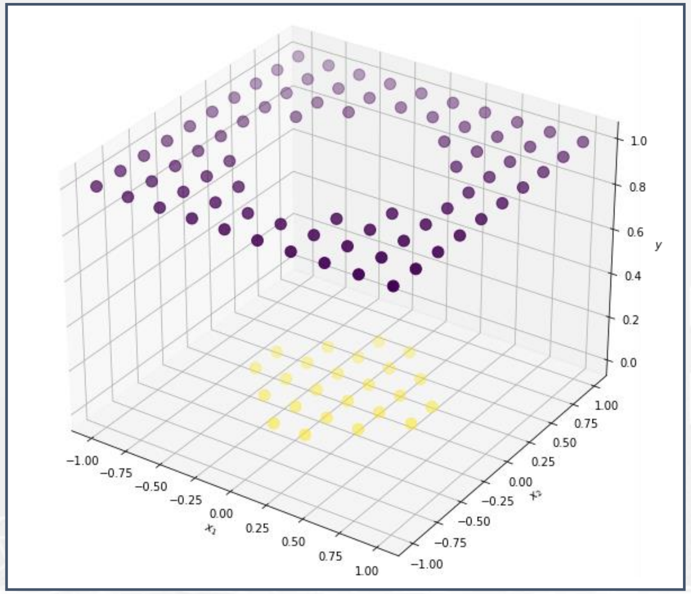


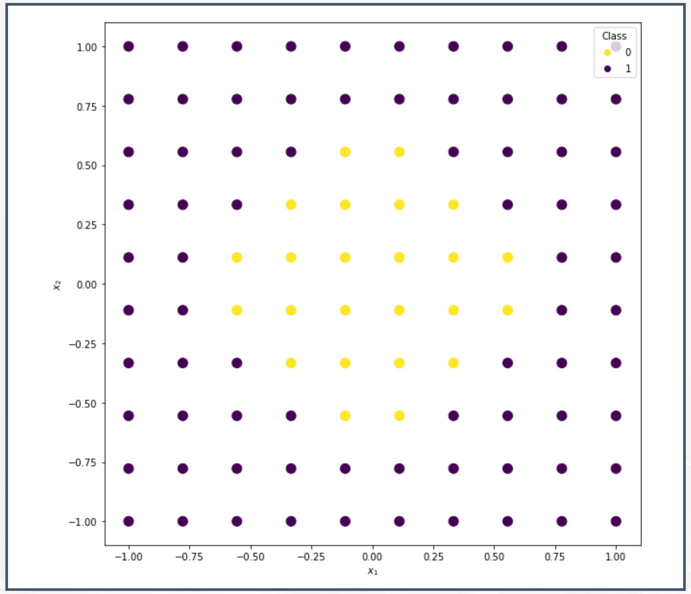


How Neural Network Work

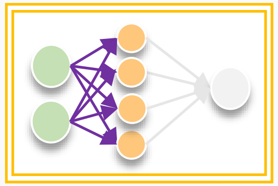
Classification

Example 3 : Binary Classification

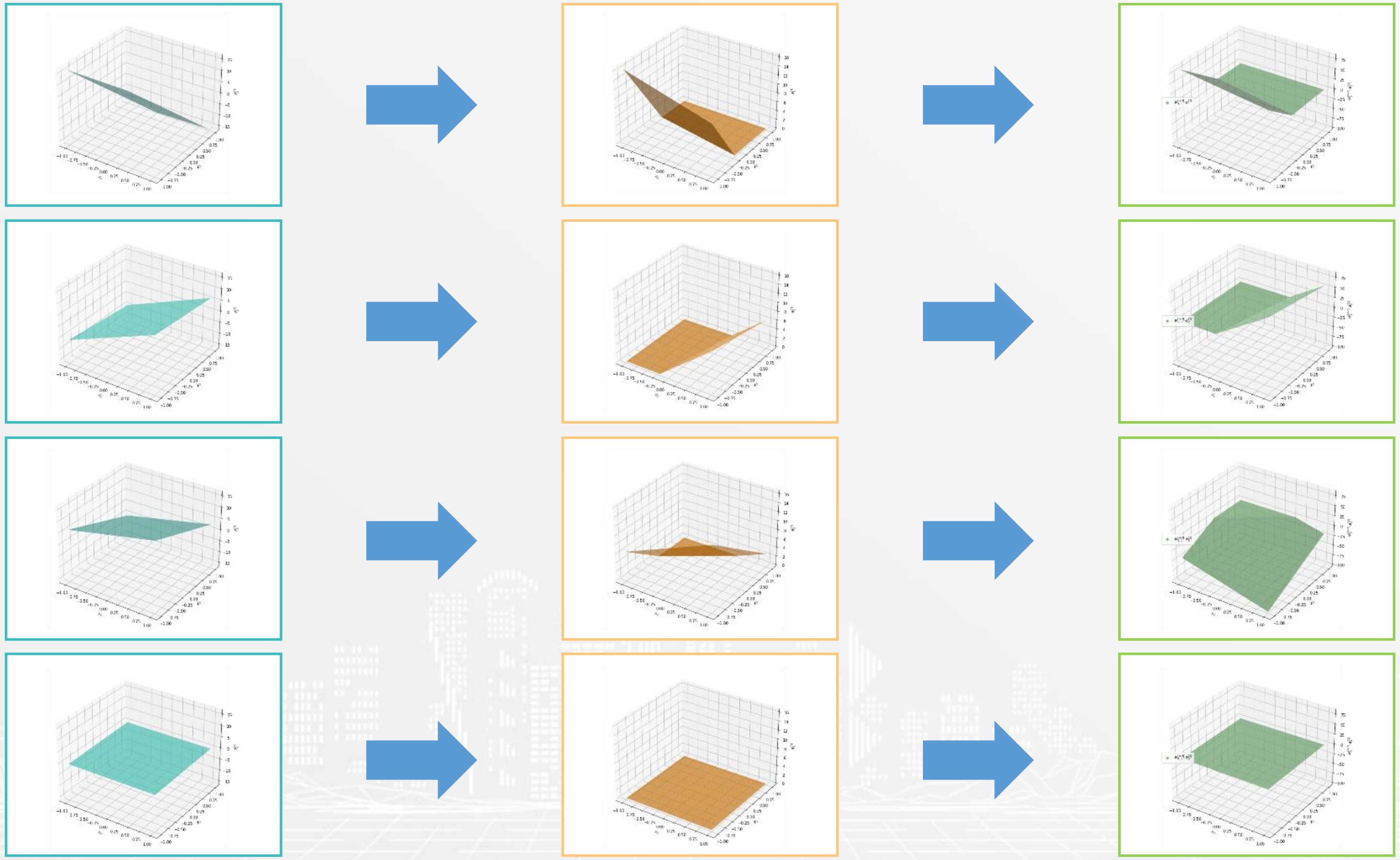




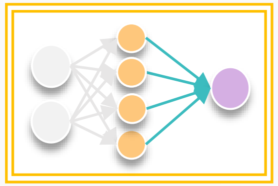
How Neural Network Work



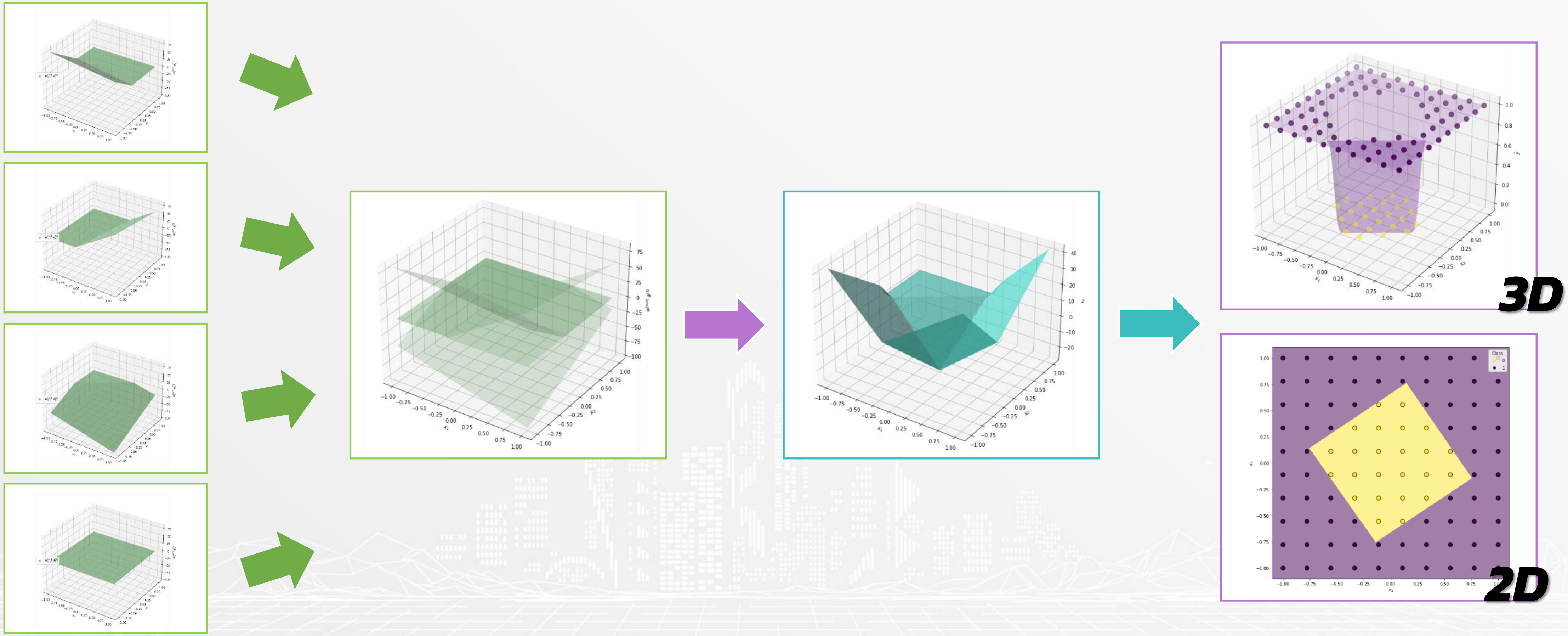
Classification Example 3



How Neural Network Work



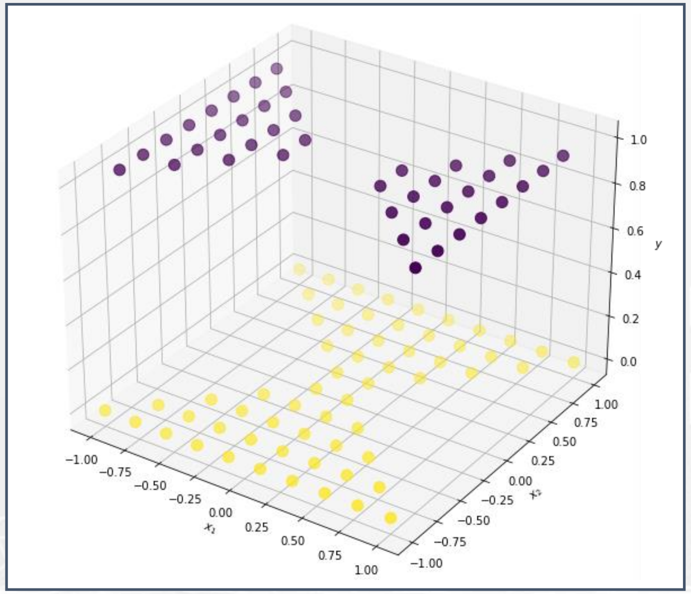
Classification Example 3

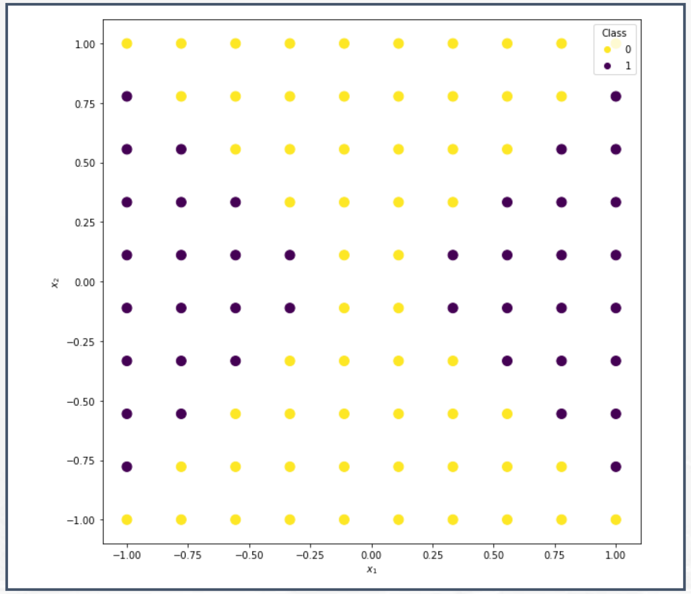


How Neural Network Work

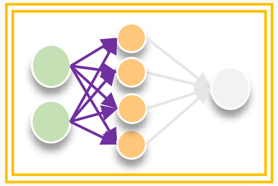
Classification

Example 4 : Binary Classification

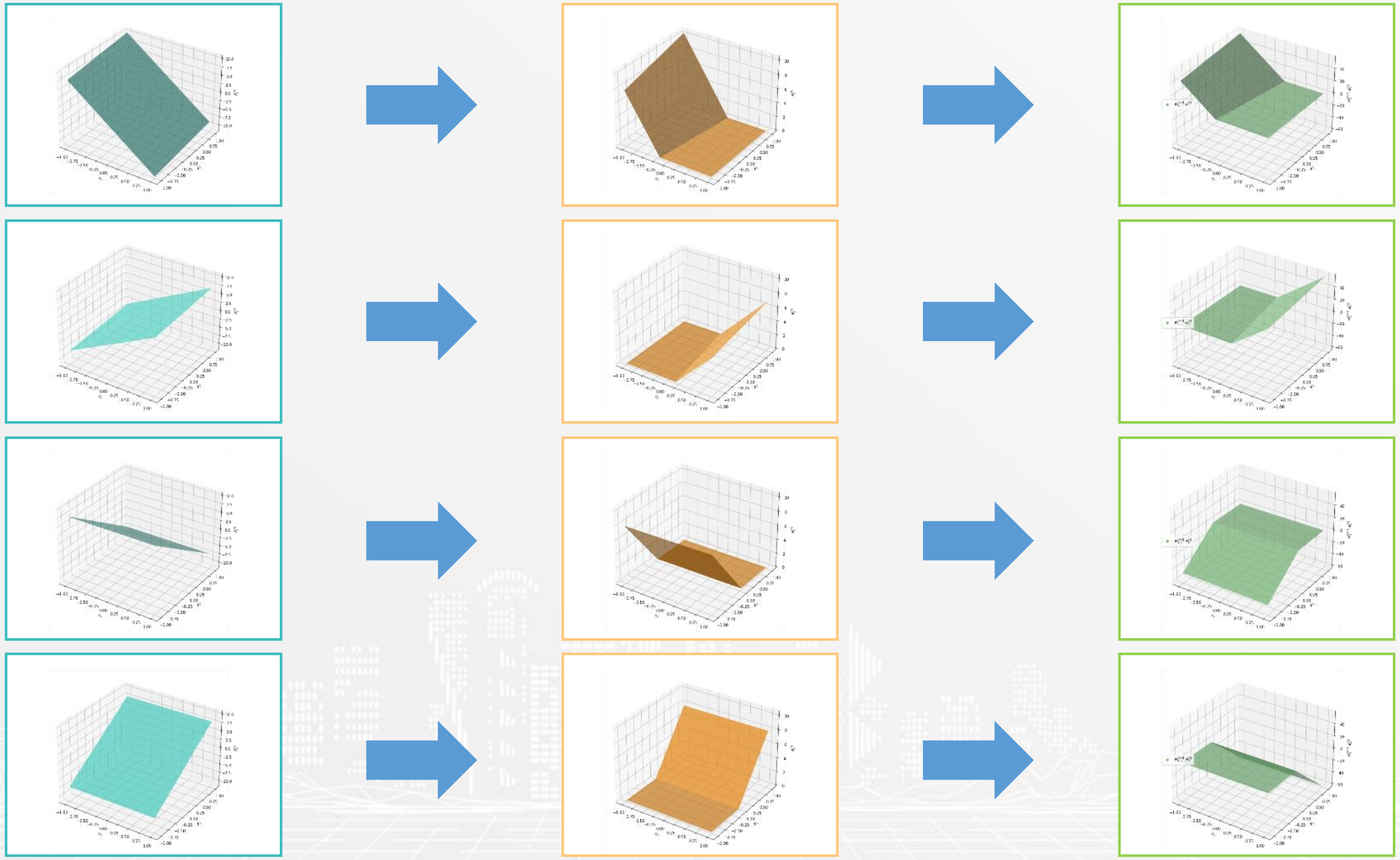




How Neural Network Work

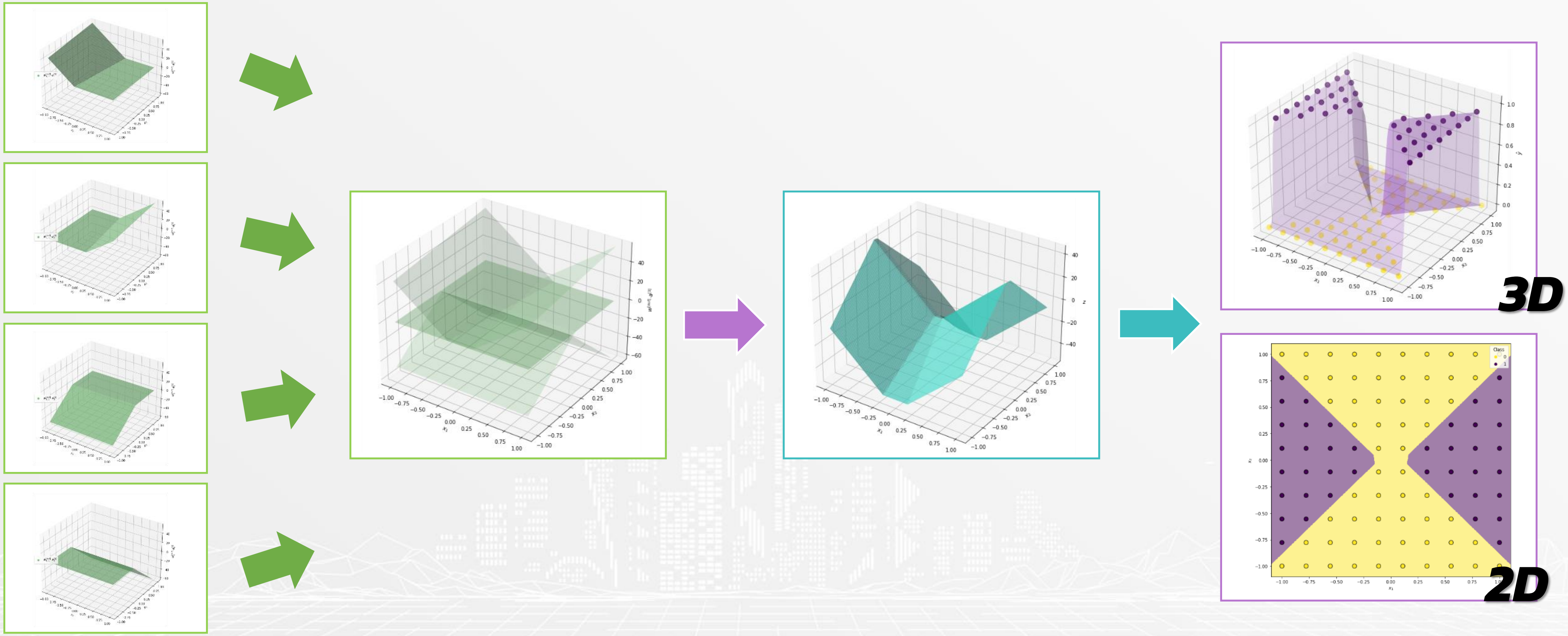


Classification Example 4



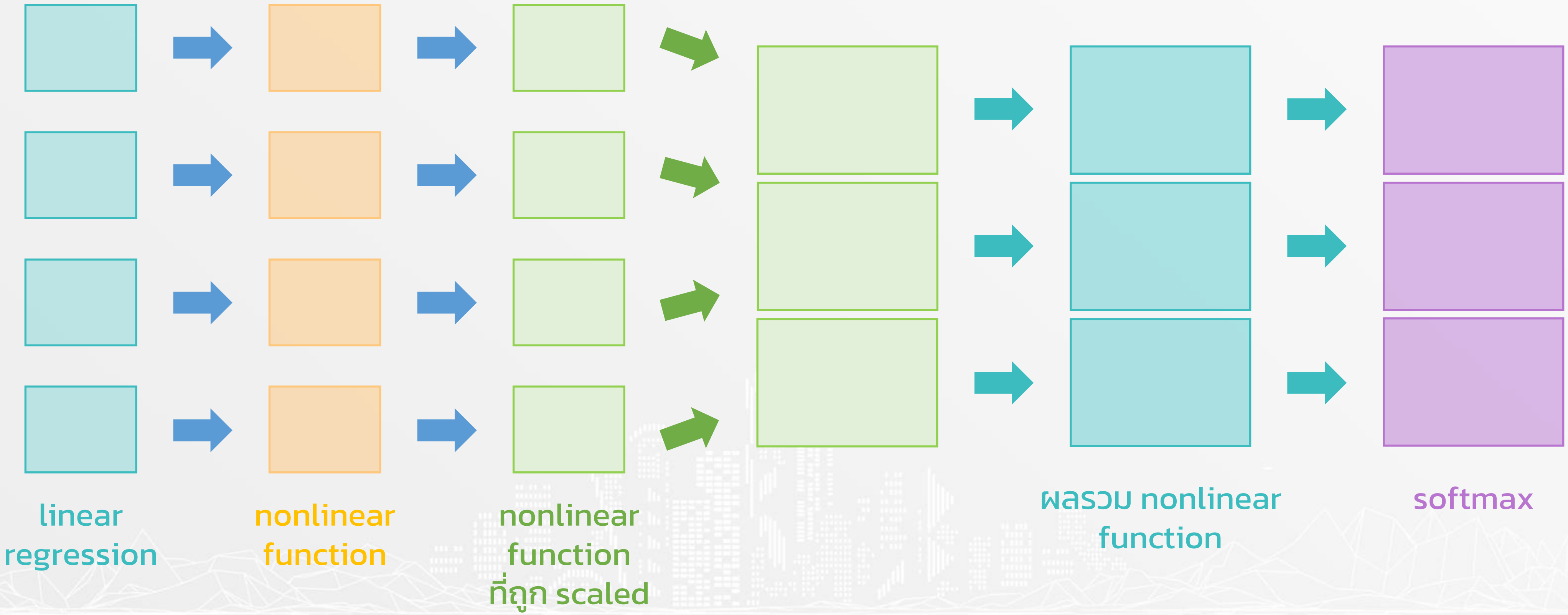
How Neural Network Work

Classification Example 4



How Neural Network Work

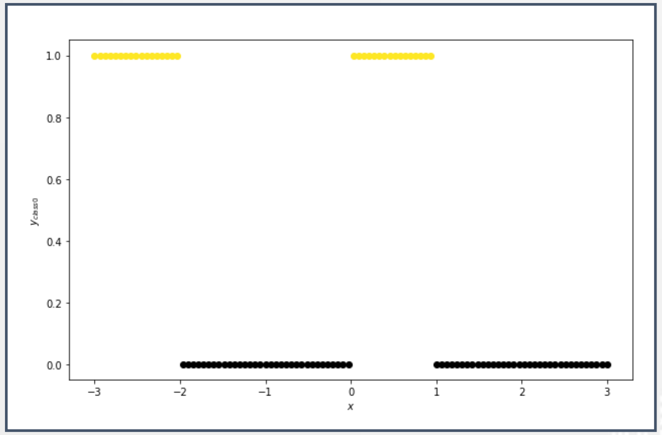
Multi-Class Classification

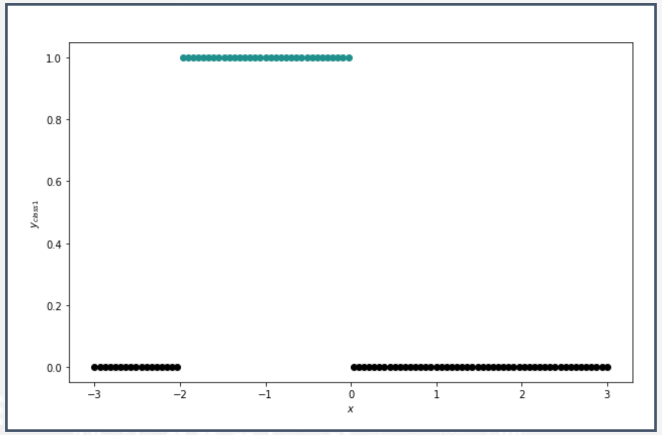


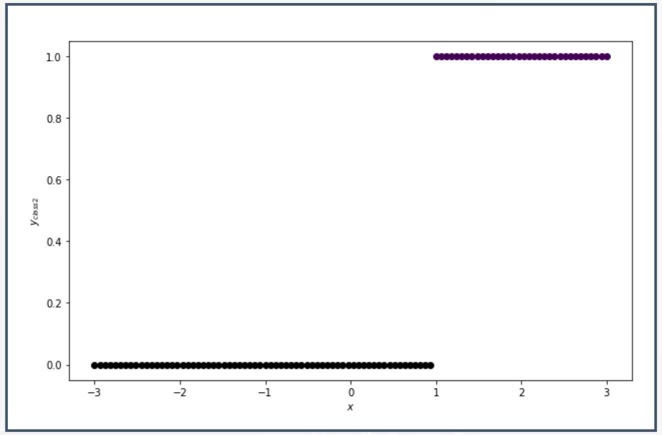
How Neural Network Work

Classification

Example 5 : Multi-Class Classification

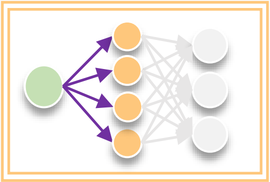


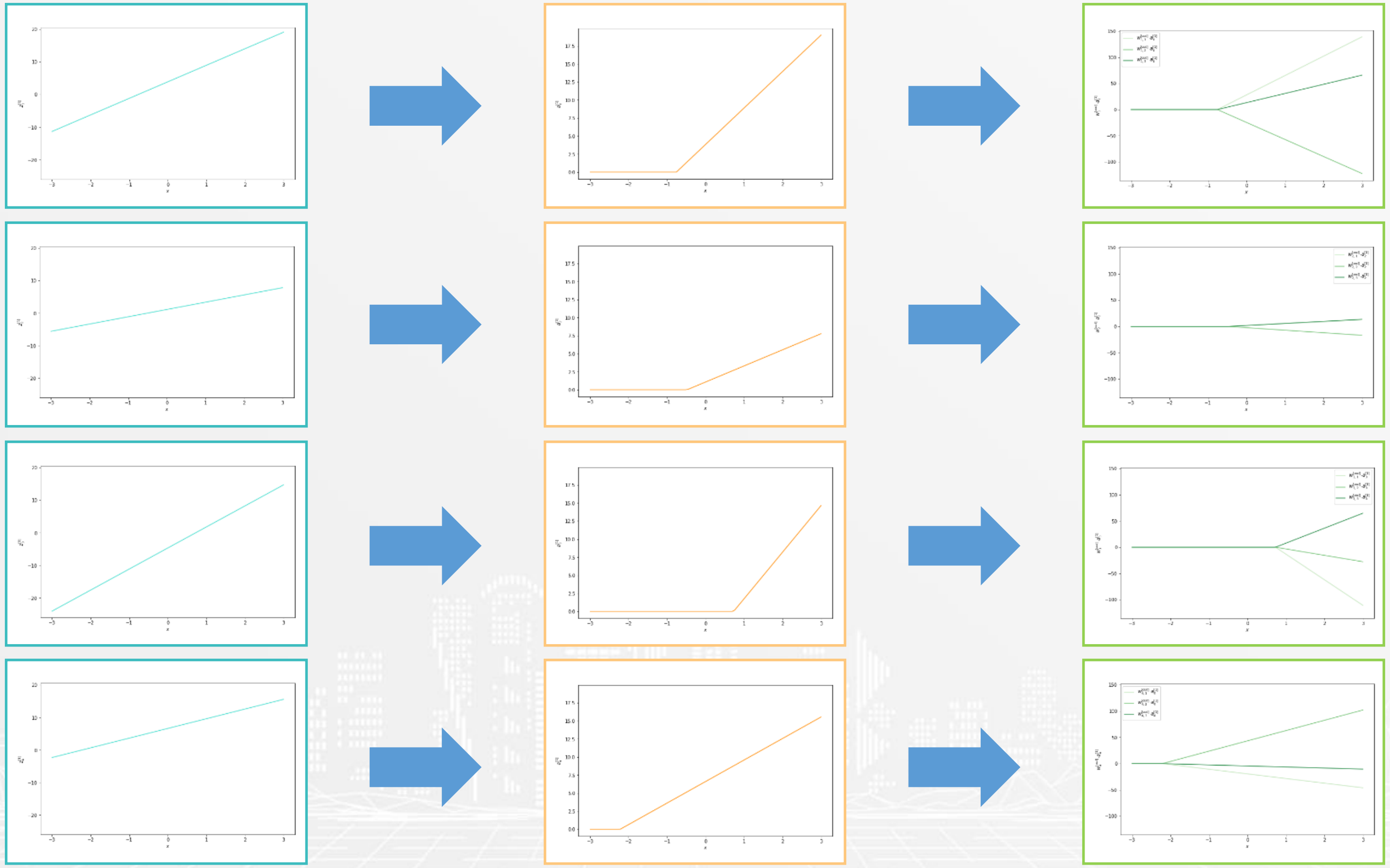




How Neural Network Work

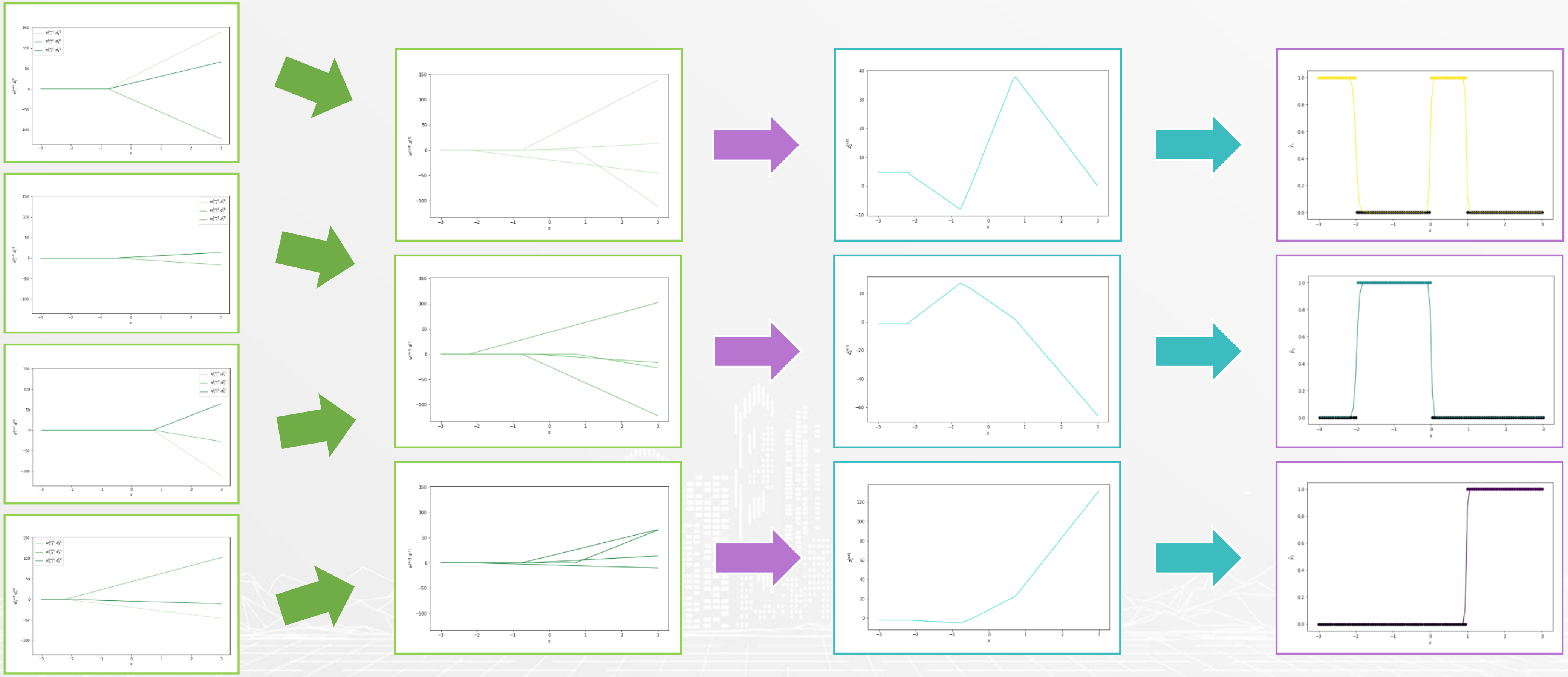
Classification Example 5





How Neural Network Work

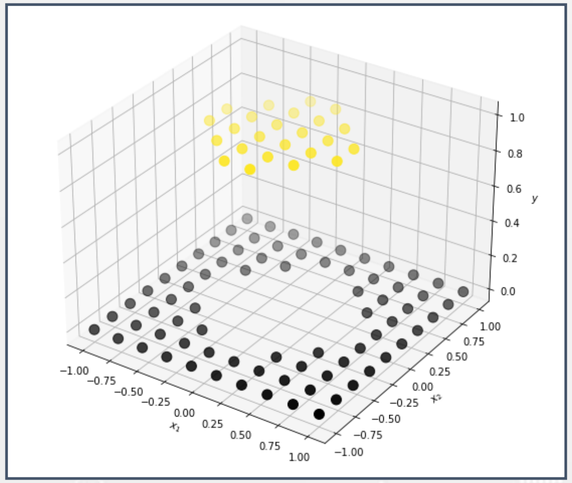
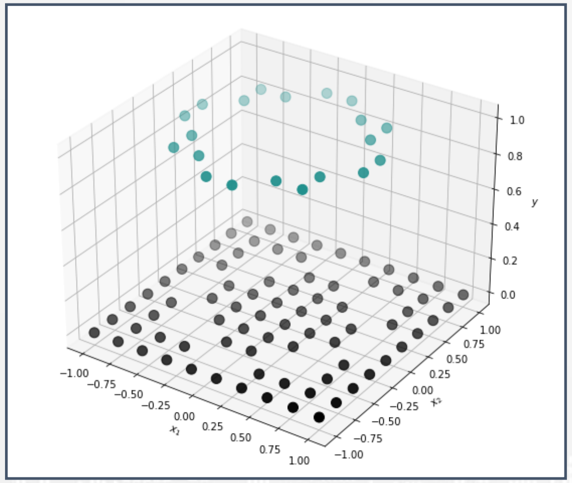
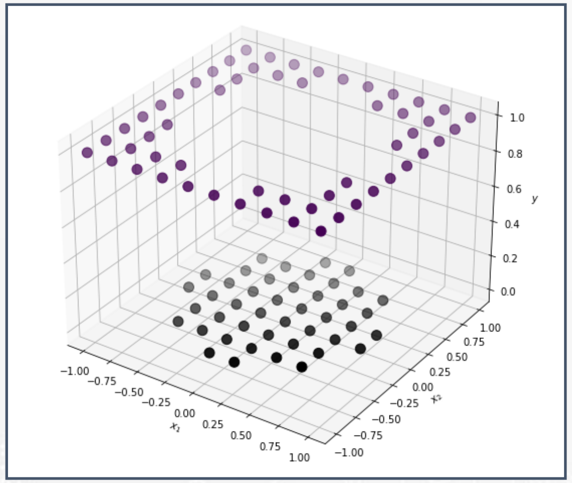
Classification Example 5



How Neural Network Work

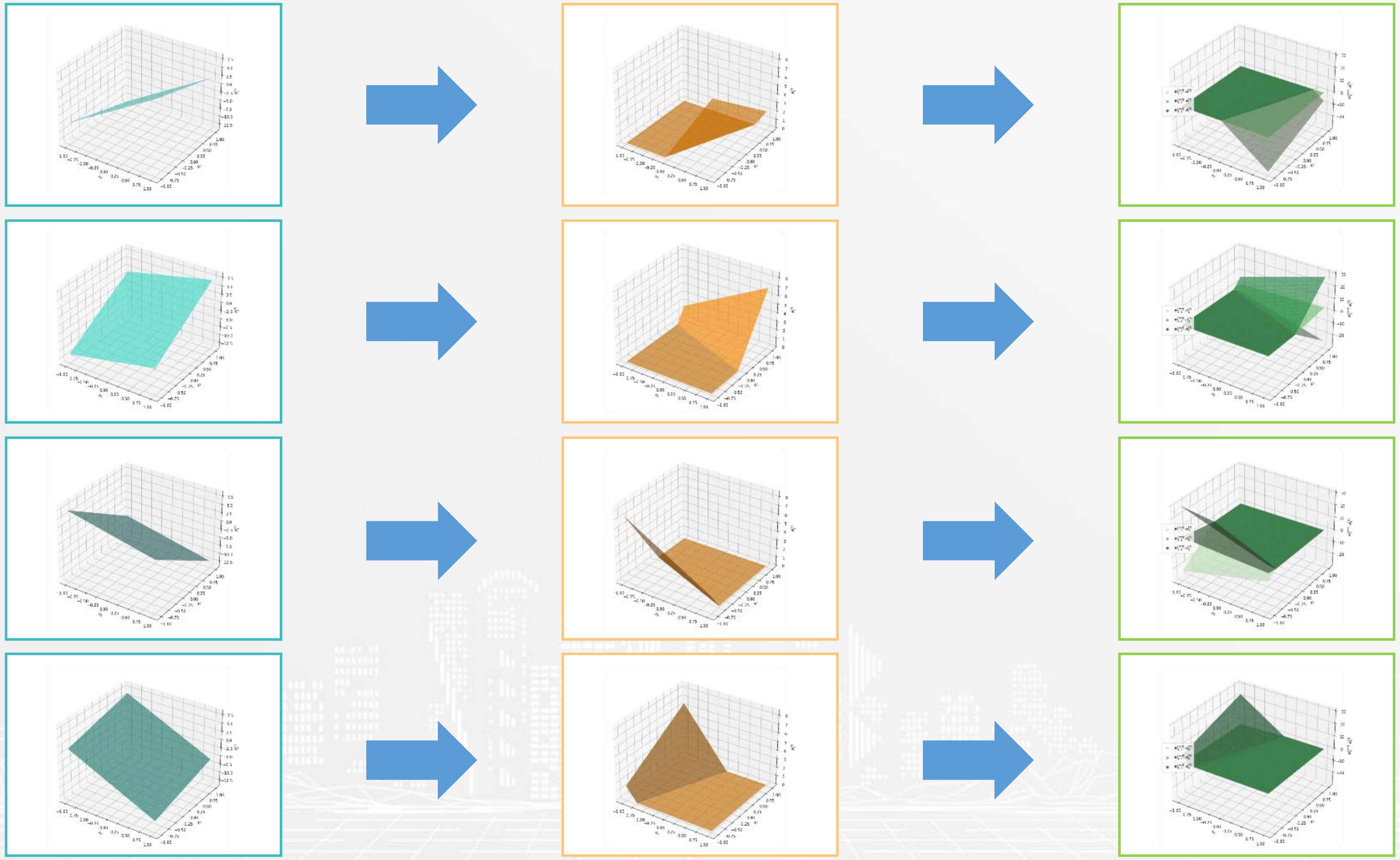
Classification

Example 6 : Multi-Class Classification

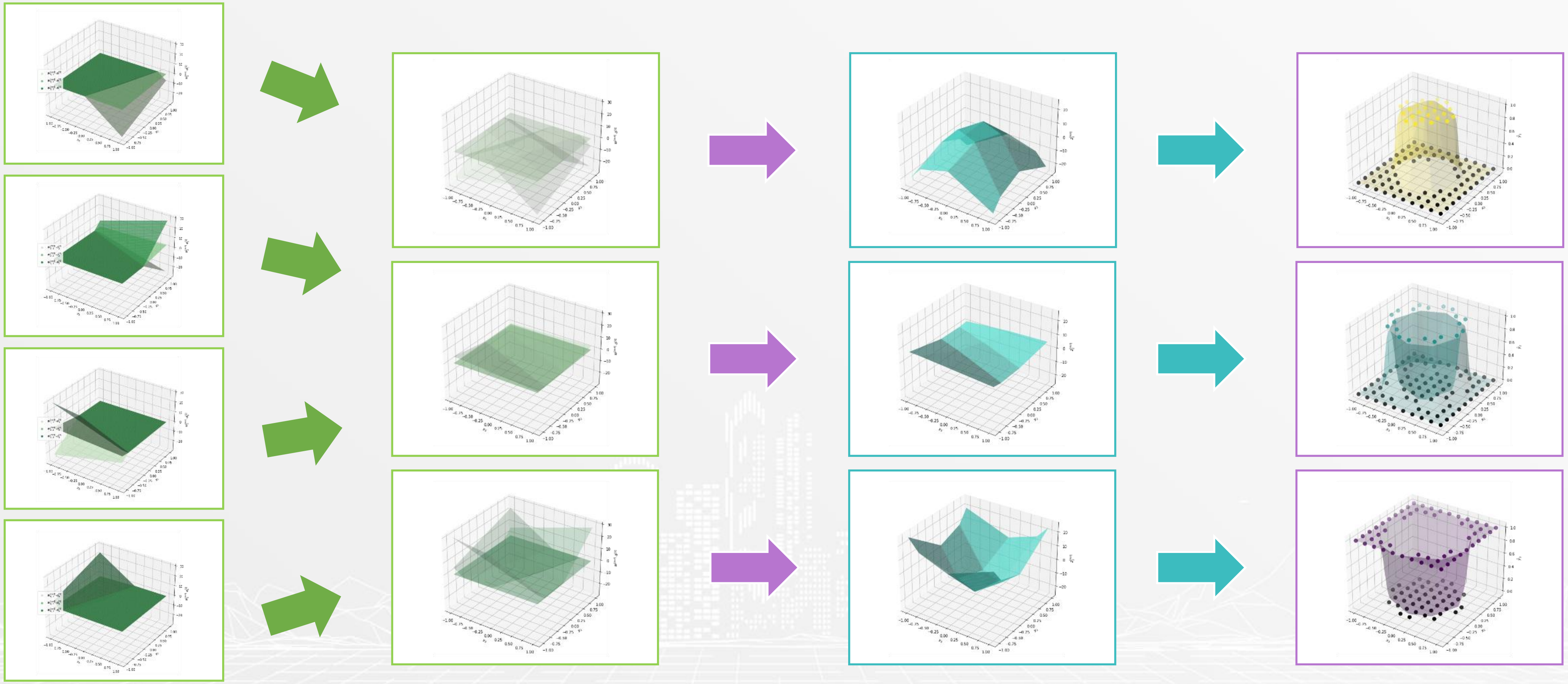
How Neural Network Work

Classification Example 6



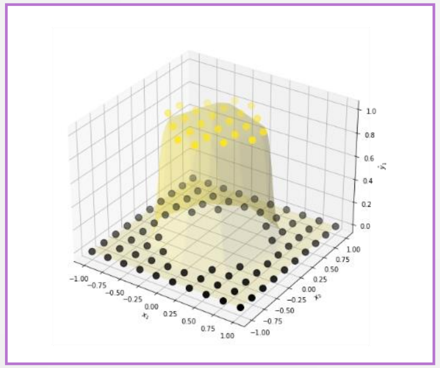
How Neural Network Work

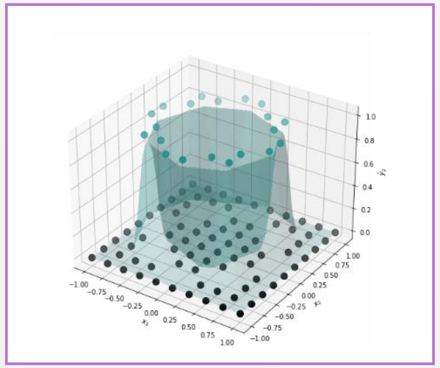
Classification Example 6

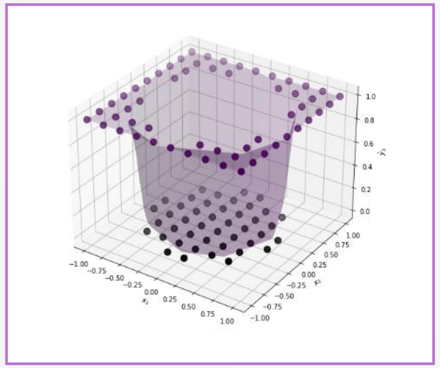


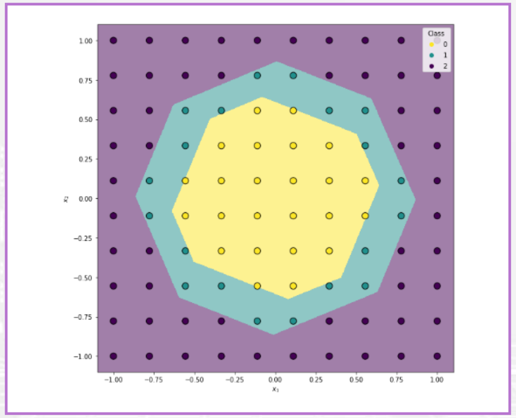
How Neural Network Work

Classification Example 6

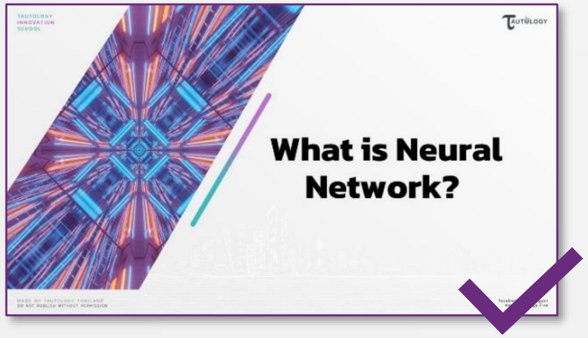


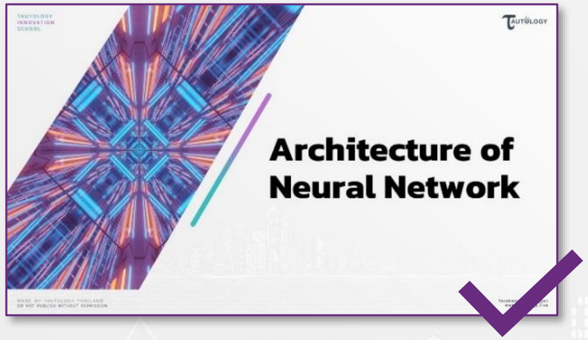


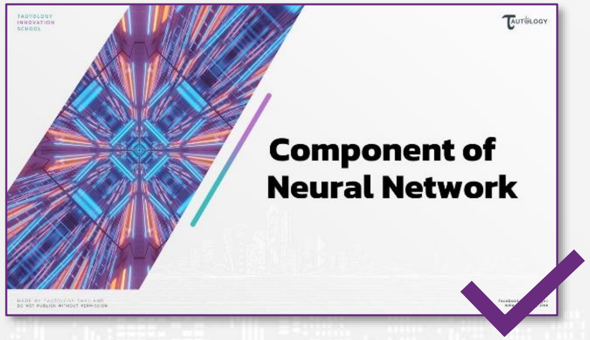


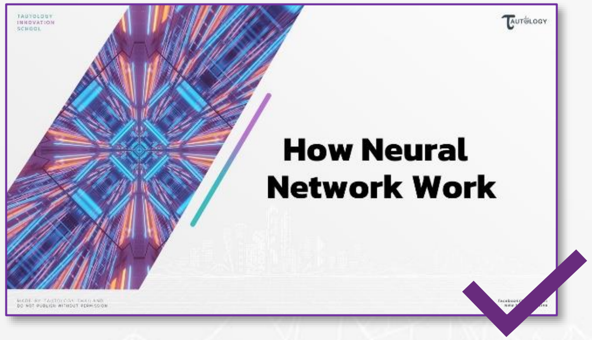


Neural Network









Neural Network & Deep Learning

Neural Network

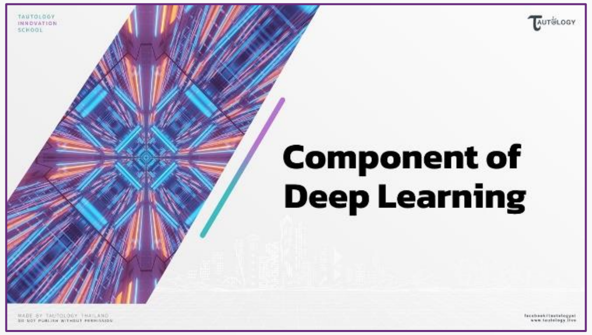
Deep Learning

Deep Learning for Regression

Deep Learning for Classification

Workshop

Deep Learning

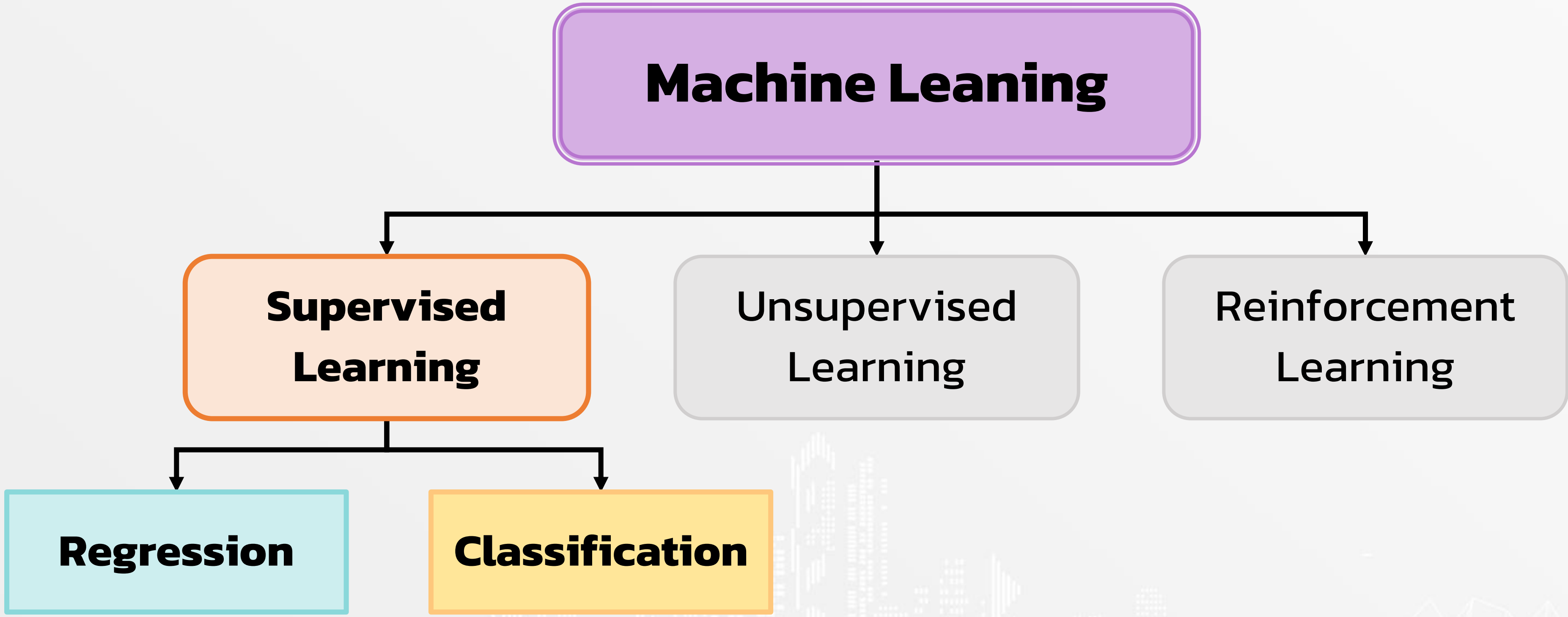


What is Deep Learning?

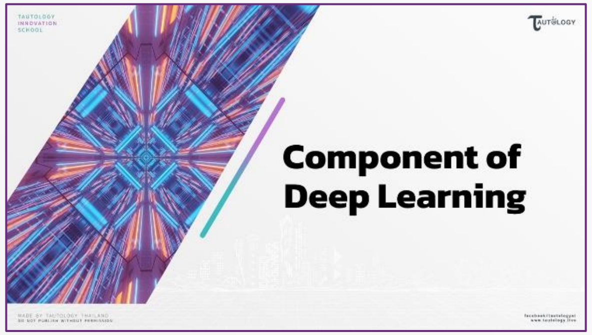
What is Deep Learning?

Deep Learning คือ Neural Network ที่มี**การเพิ่มจำนวน hidden layer** เข้าไป **เพื่อเพิ่มประสิทธิภาพ**การทำงานในด้าน **computational cost** และยังคงรักษาความสามารถในการประมาณ nonlinear function ที่ซับซ้อนไว้ด้วย

What is Deep Learning?



Deep Learning



Architecture of Deep Learning

Architecture of Deep Learning

Regression

Classification

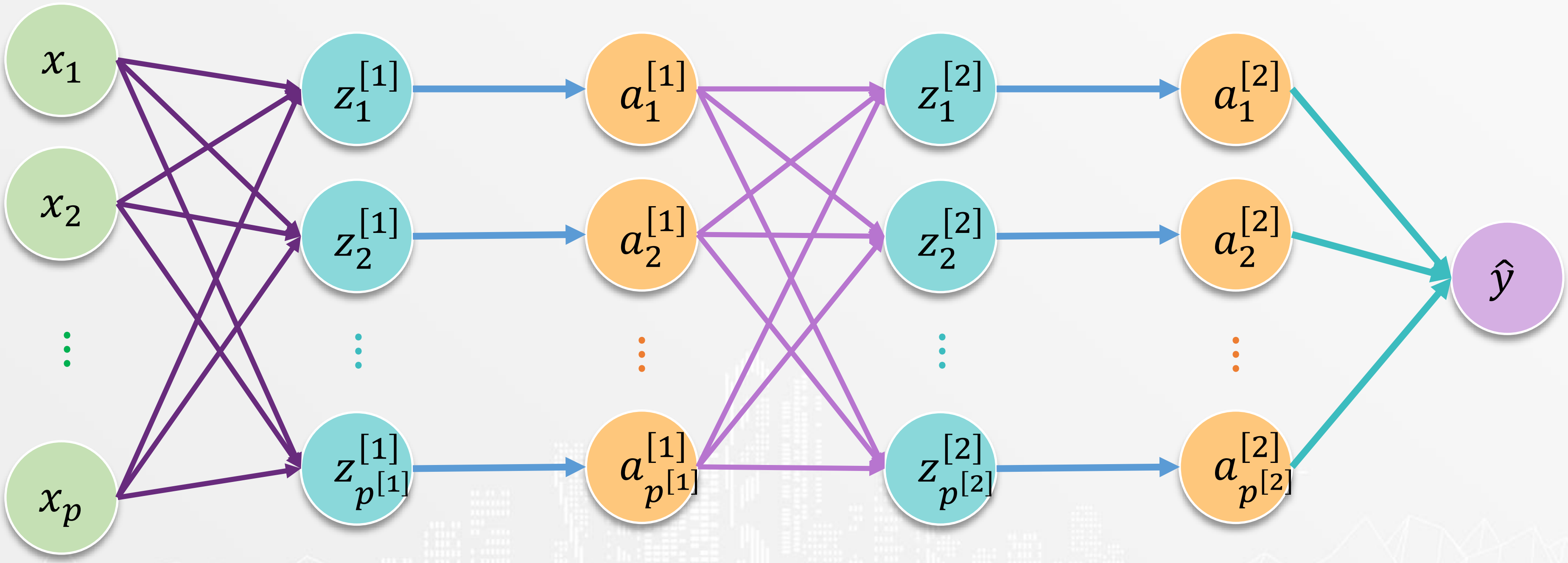
Architecture of Deep Learning

Regression

Classification

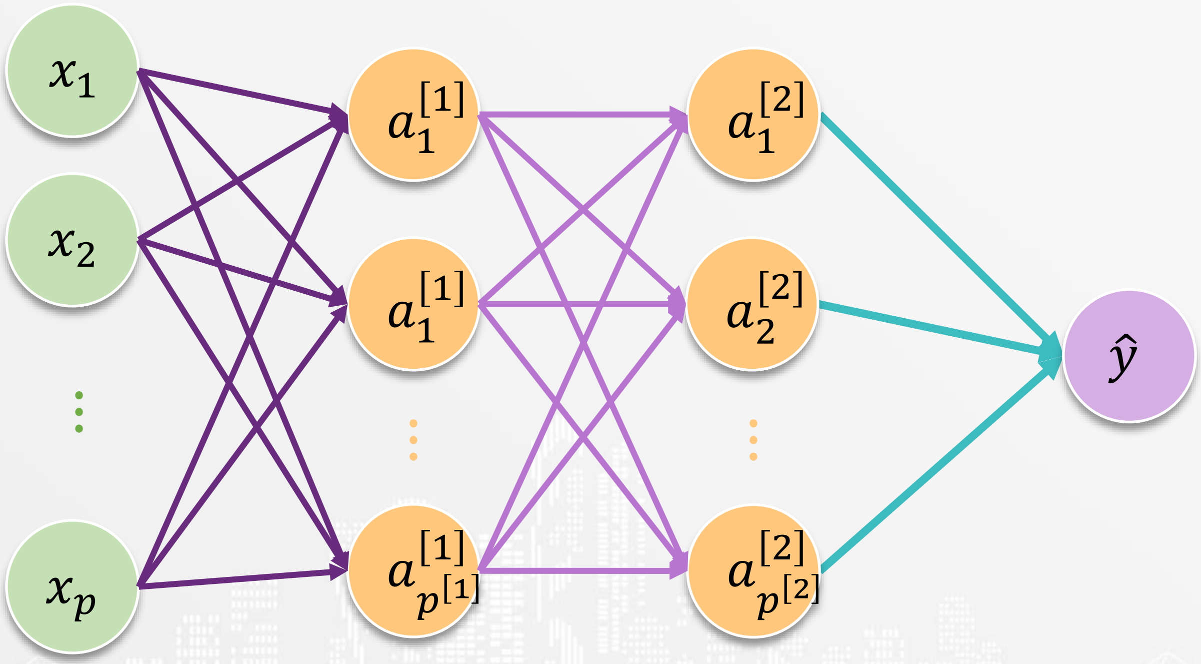
Architecture of Deep Learning

Regression



Architecture of Deep Learning

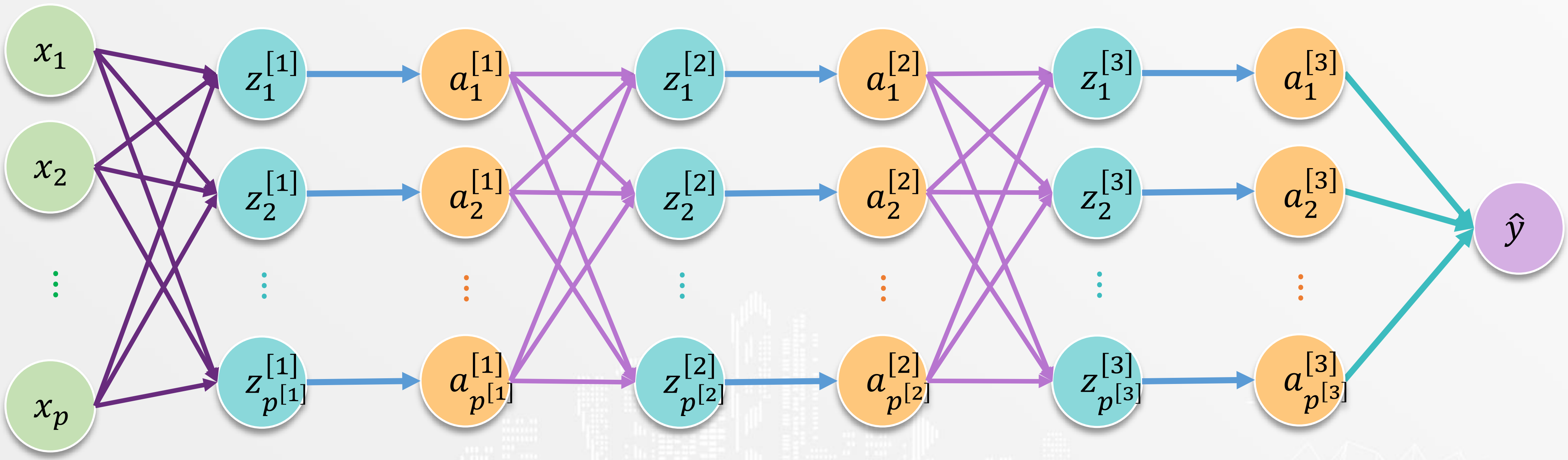
Regression



TAUTOLOGY

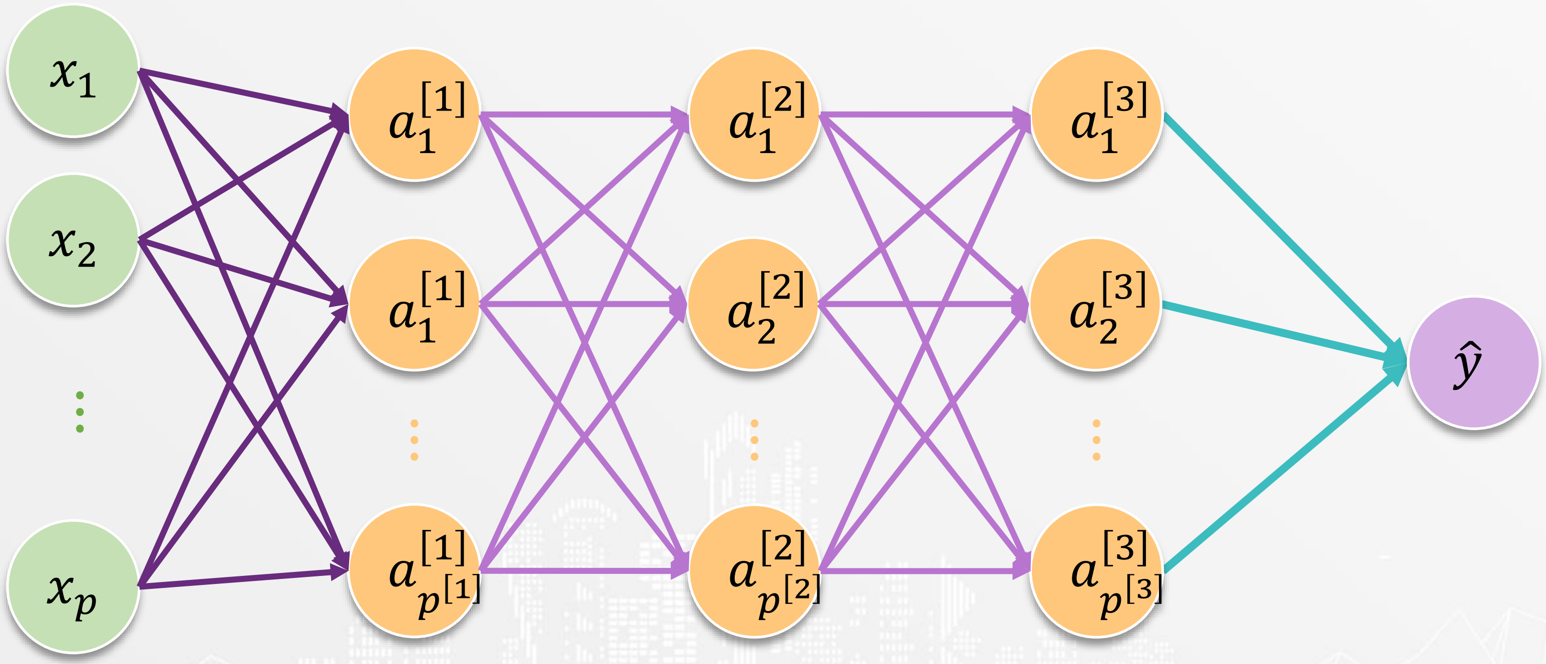
Architecture of Deep Learning

Regression



Architecture of Deep Learning

Regression



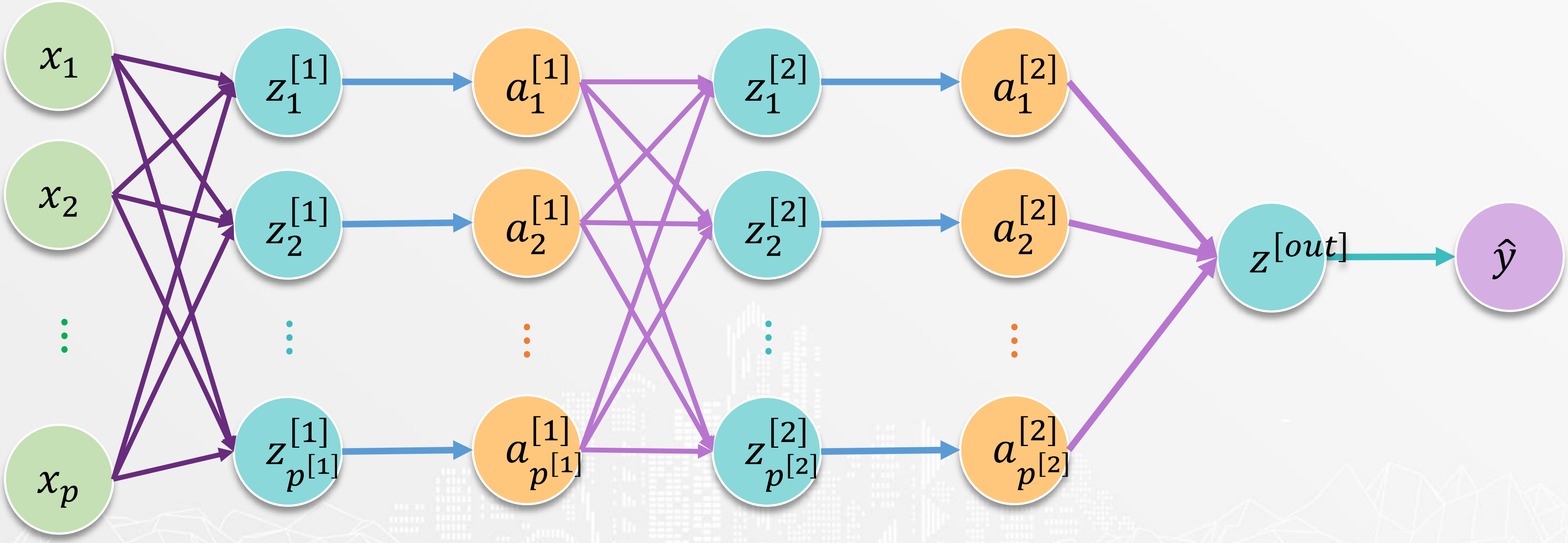
Architecture of Deep Learning

Regression

Classification

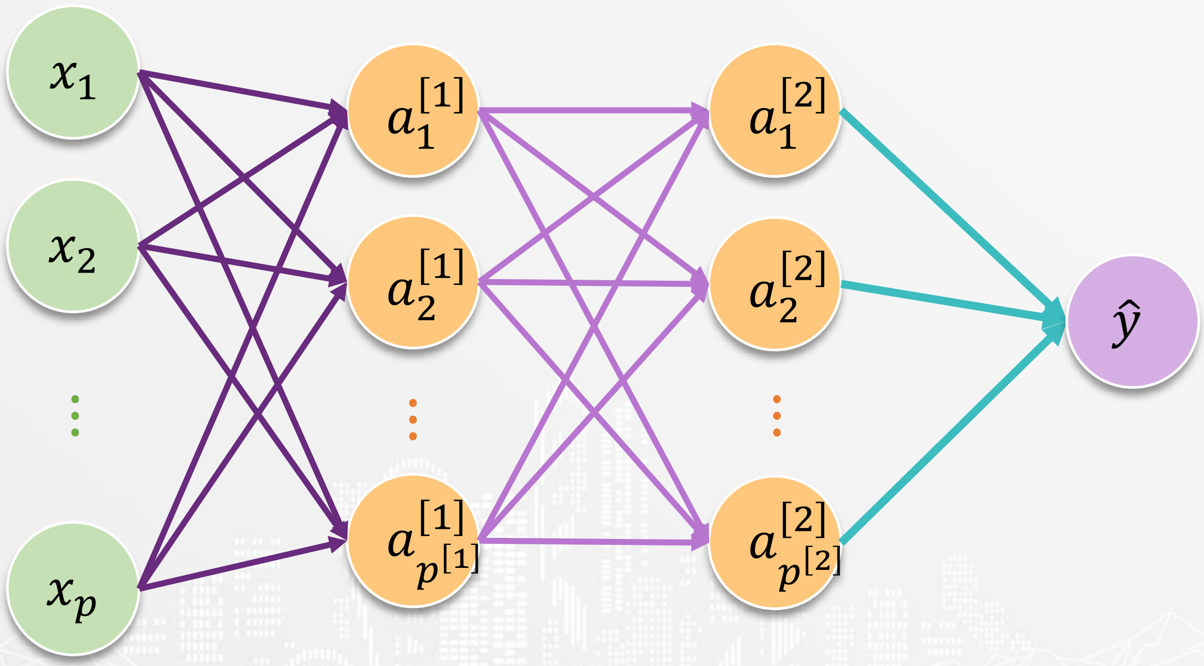
Architecture of Deep Learning

Binary Classification



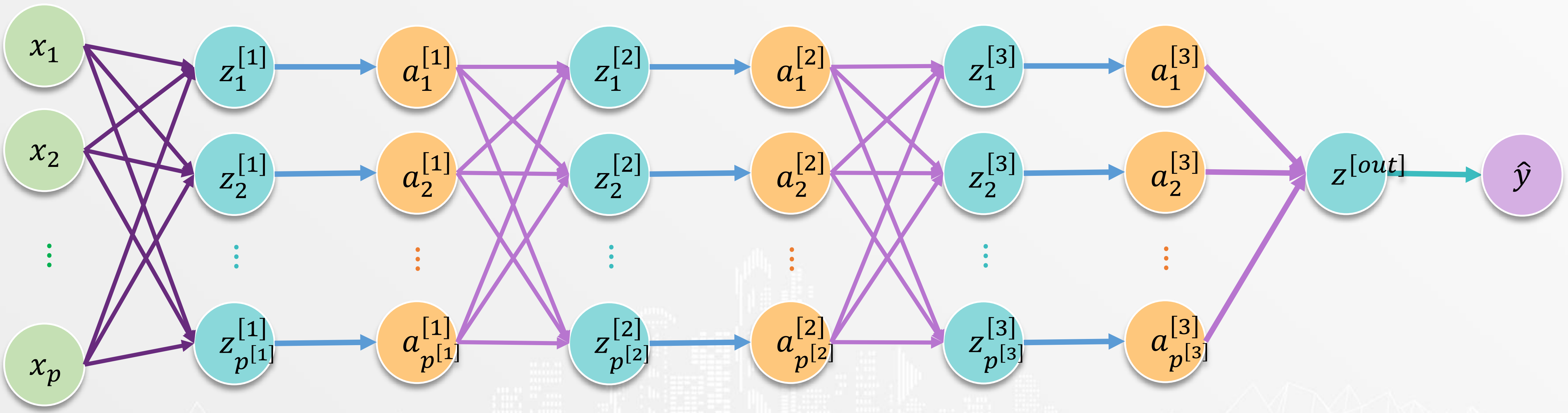
Architecture of Deep Learning

Binary Classification



Architecture of Deep Learning

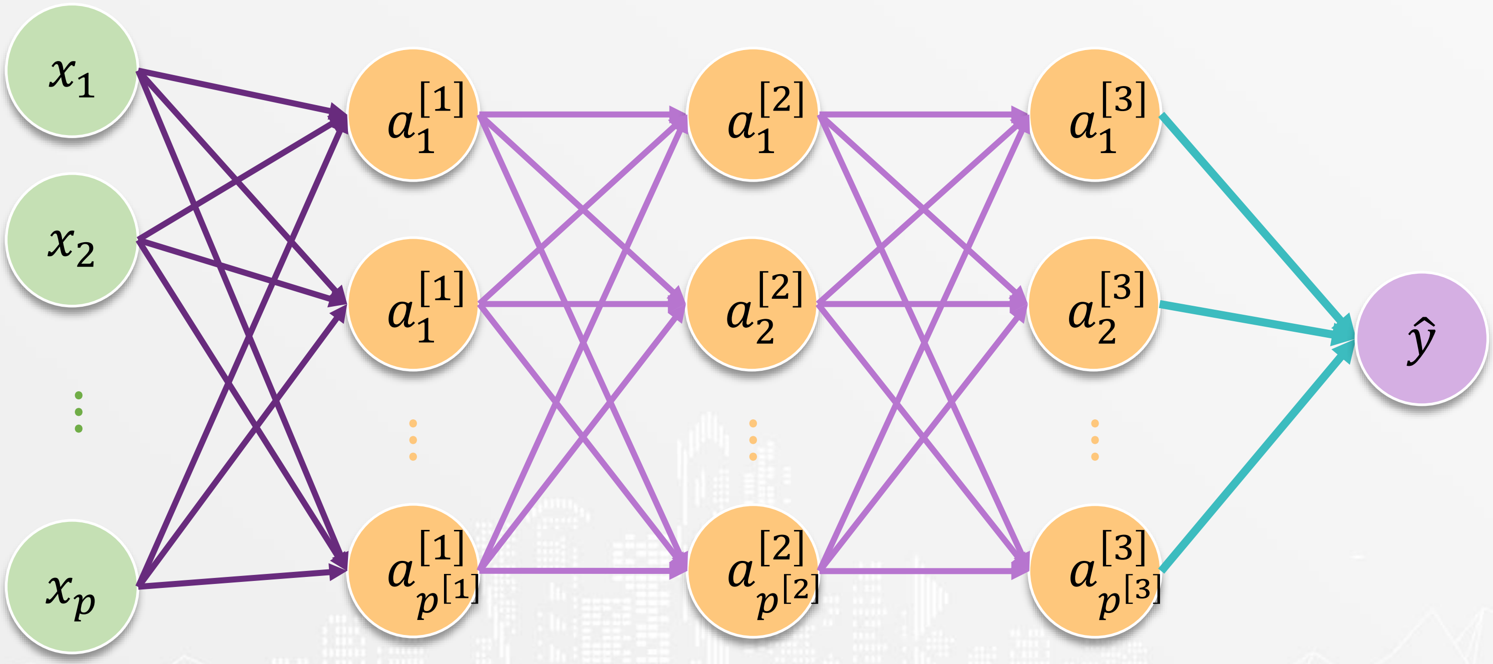
Binary Classification



TAUTOLOGY

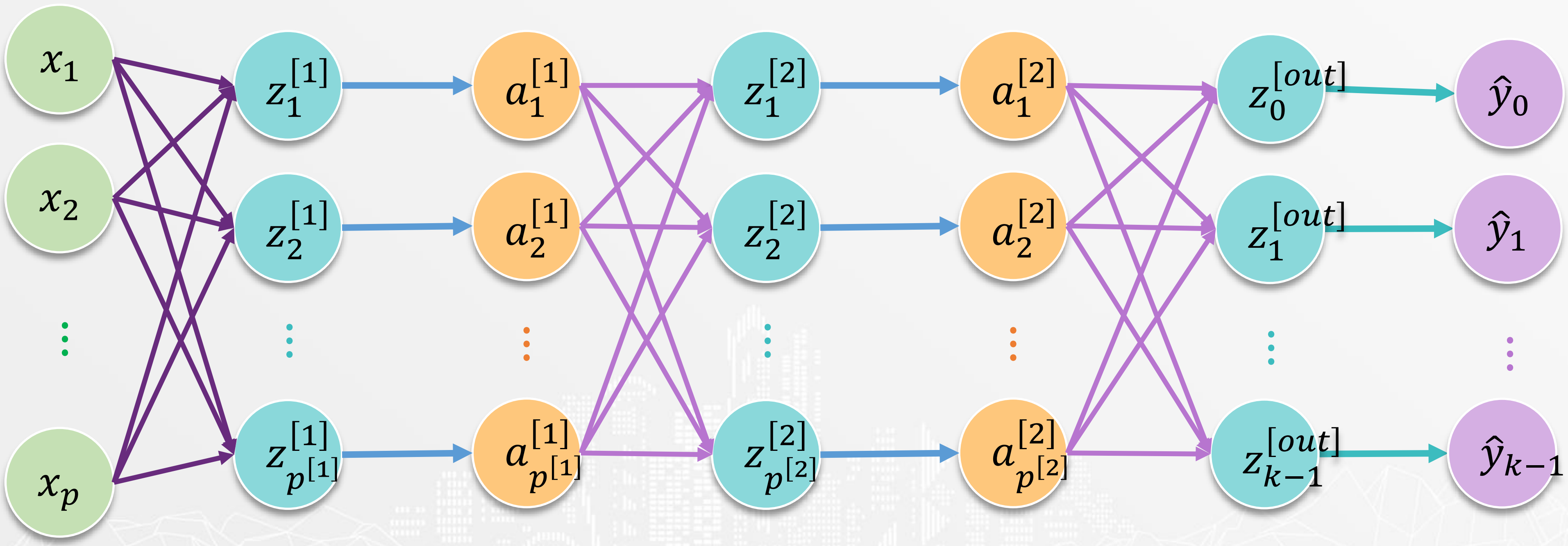
Architecture of Deep Learning

Binary Classification



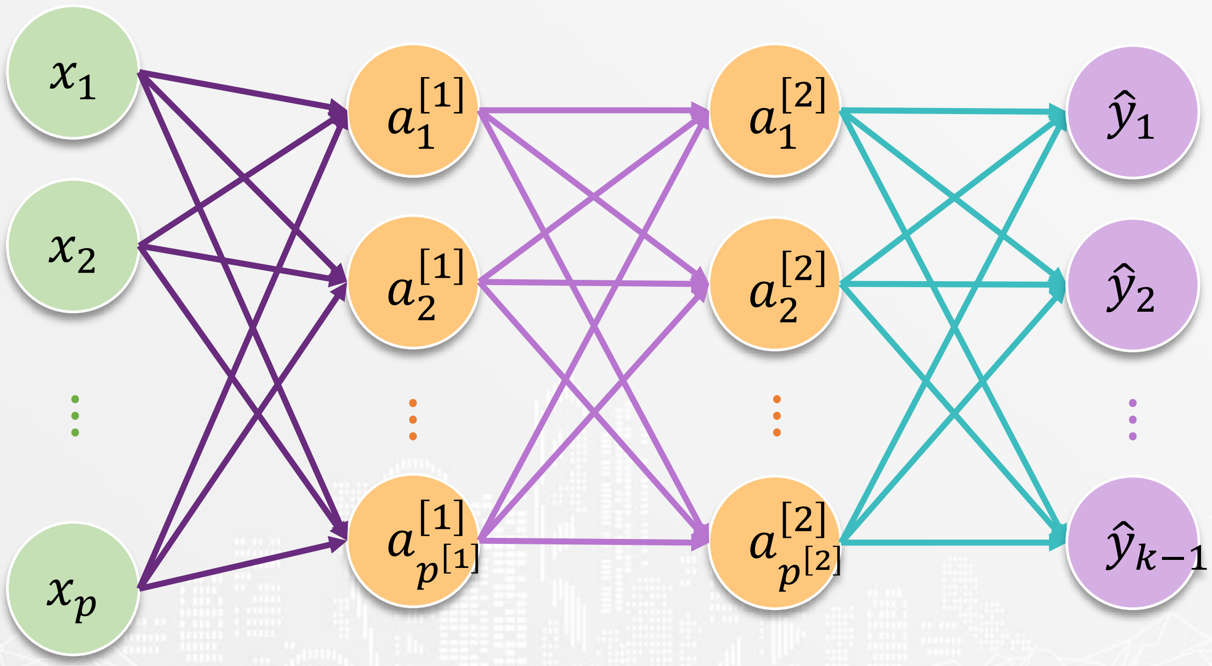
Architecture of Deep Learning

Multi-Class Classification



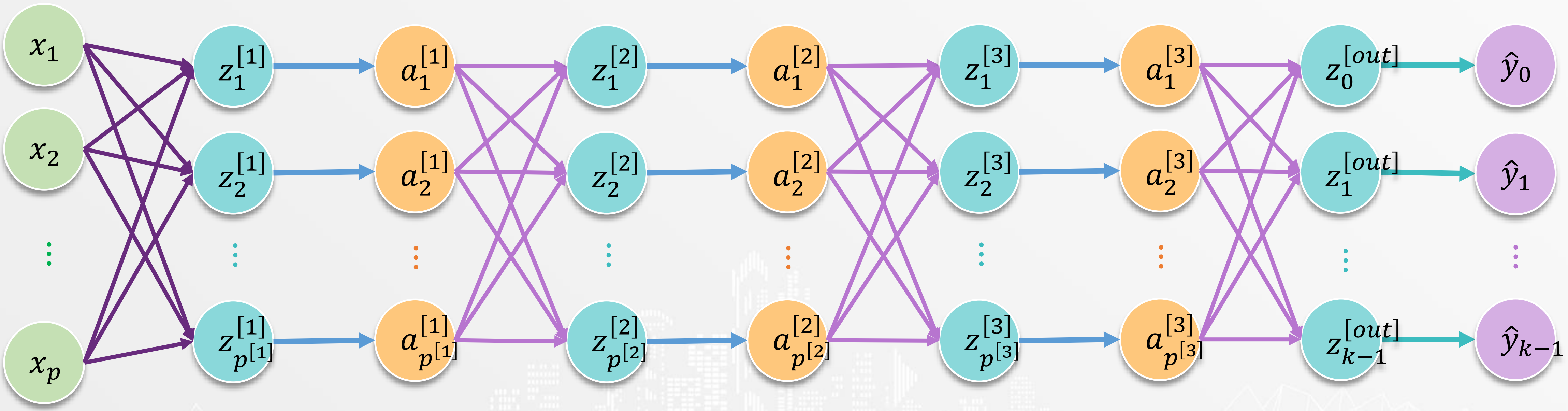
Architecture of Deep Learning

Multi-Class Classification



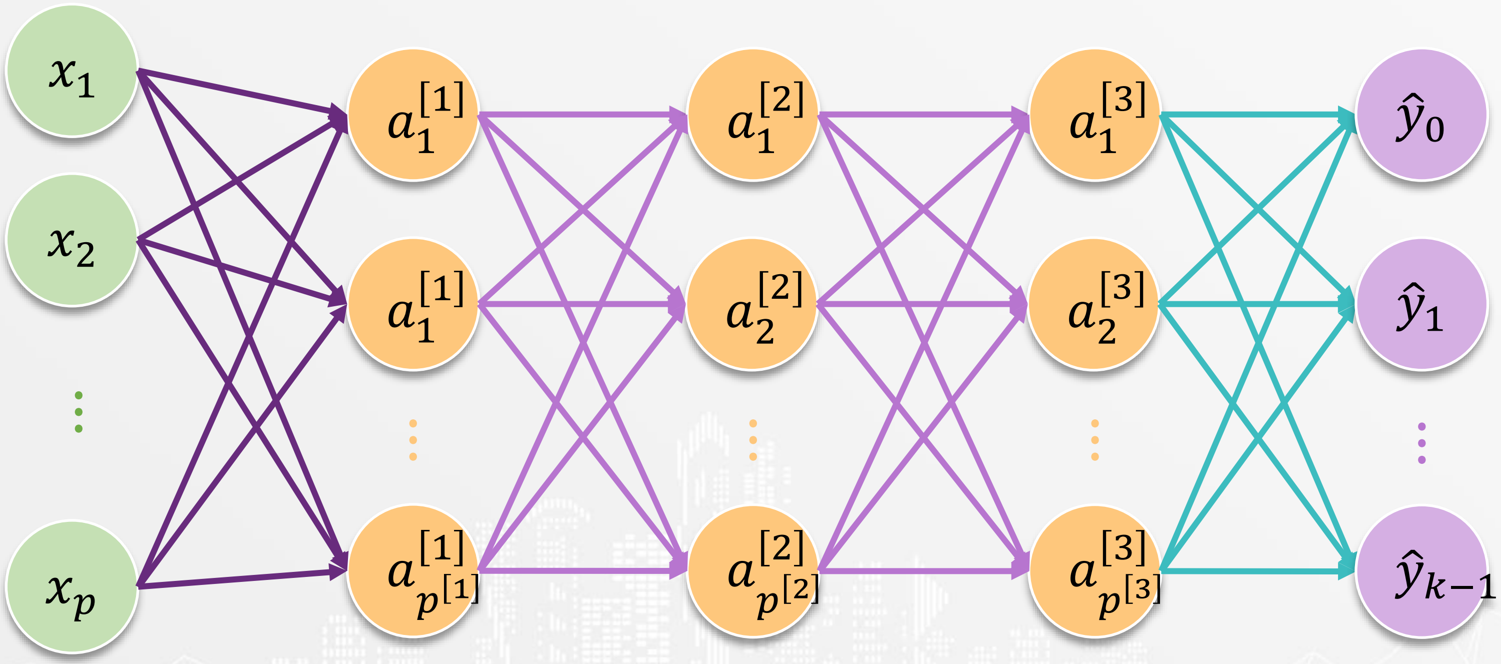
Architecture of Deep Learning

Multi-Class Classification

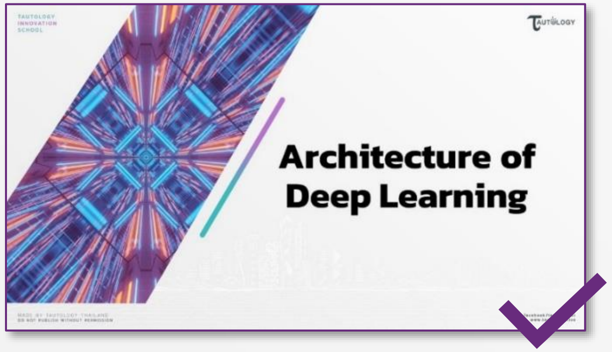


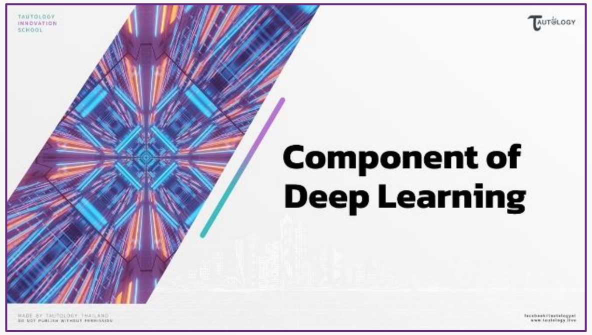
Architecture of Deep Learning

Multi-Class Classification



Deep Learning





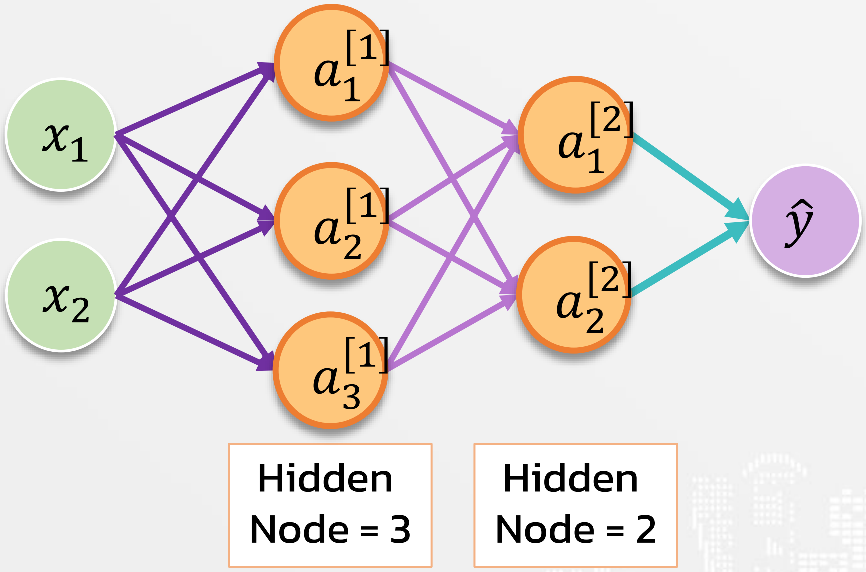
Component of Deep Learning

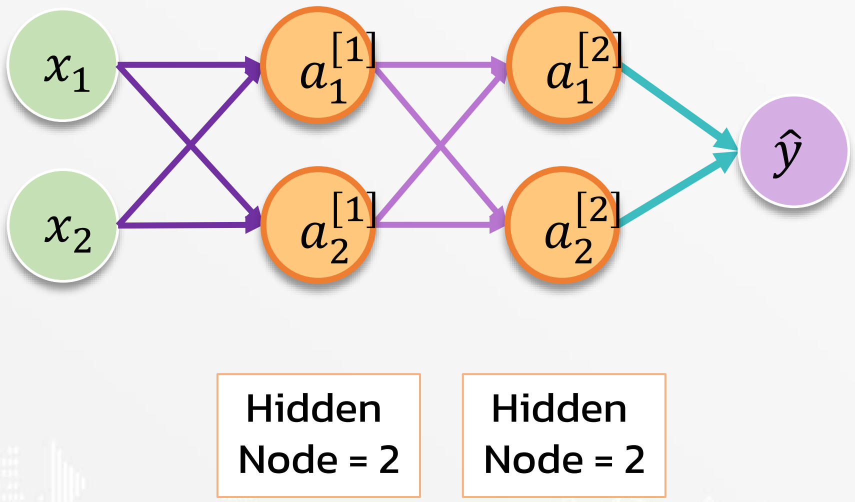
Component of Neural Network

- Hidden Node
- Hidden Layer
- Weight & Bias
- Activation Function

Hidden Node

Hidden Node คือ จำนวนของ nonlinear function ที่ใช้





Component of Neural Network

Hidden Node

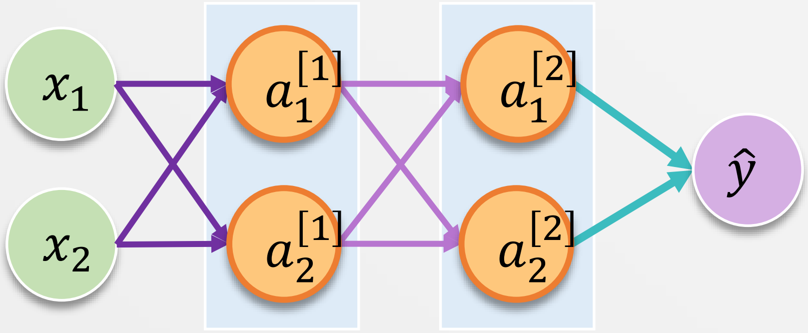
Hidden Layer

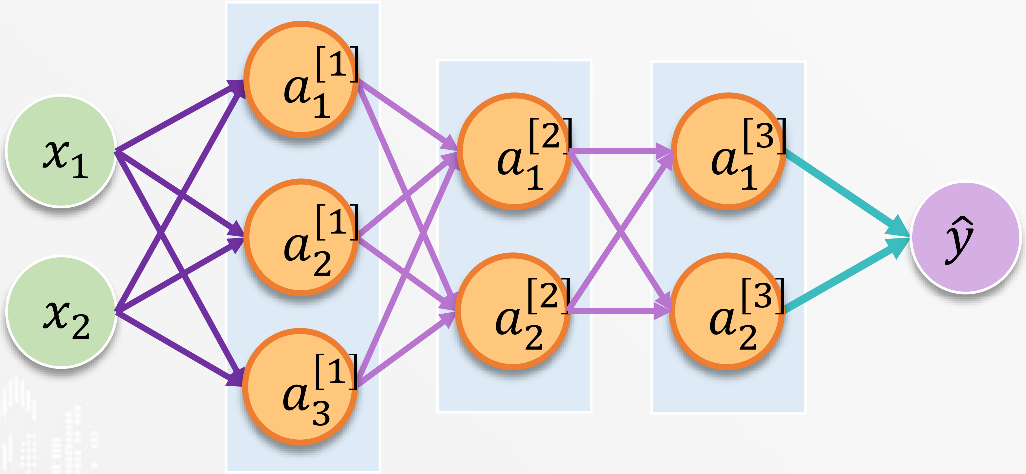
Weight & Bias

Activation Function

Hidden Layer

Hidden Layer คือ ชั้นที่เก็บ hidden node





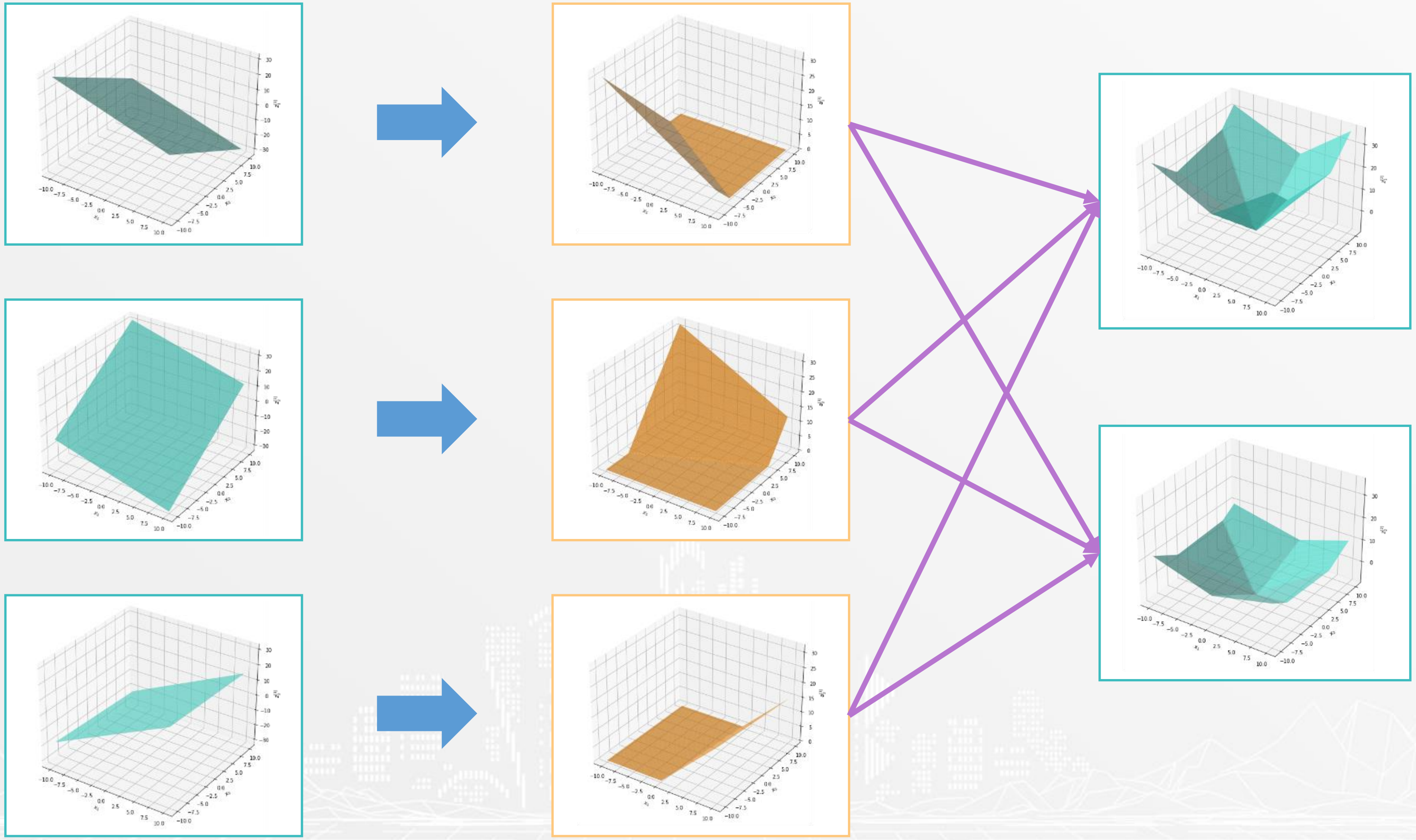
จำนวน Hidden Layer = 2

จำนวน Hidden Layer = 3

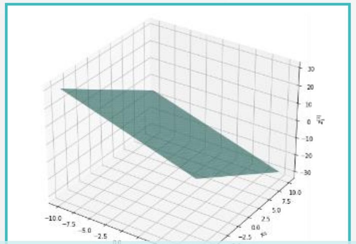
Component of Neural Network

- **Hidden Node** ✓
- **Hidden Layer** ✓
- Weight & Bias
- Activation Function

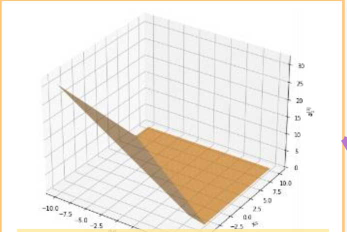
Weight & Bias



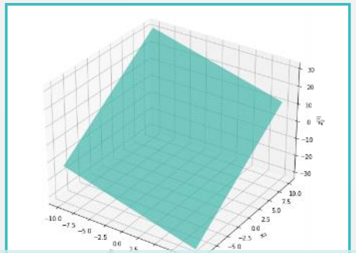
Weight & Bias



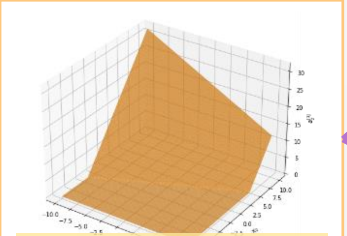
$$z_1^{[1]} = b_1^{[1]} + w_{1,1}^{[1]} x_1 + w_{2,1}^{[1]} x_2$$



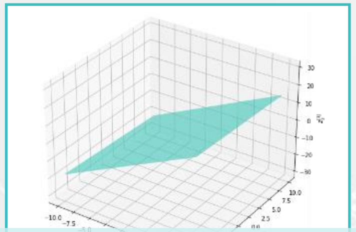
$$a_1^{[1]} = af\left(z_1^{[1]}\right)$$



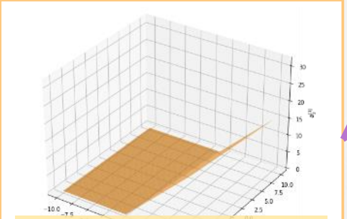
$$z_2^{[1]} = b_2^{[1]} + w_{1,2}^{[1]} x_1 + w_{2,2}^{[1]} x_2$$



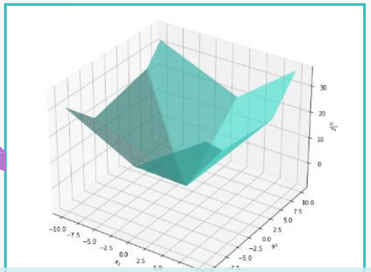
$$a_2^{[1]} = af\left(z_2^{[1]}\right)$$



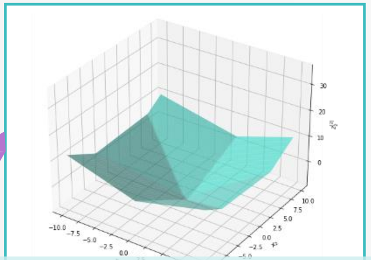
$$z_3^{[1]} = b_3^{[1]} + w_{1,3}^{[1]} x_1 + w_{2,3}^{[1]} x_2$$



$$a_1^{[1]} = af\left(z_1^{[1]}\right)$$

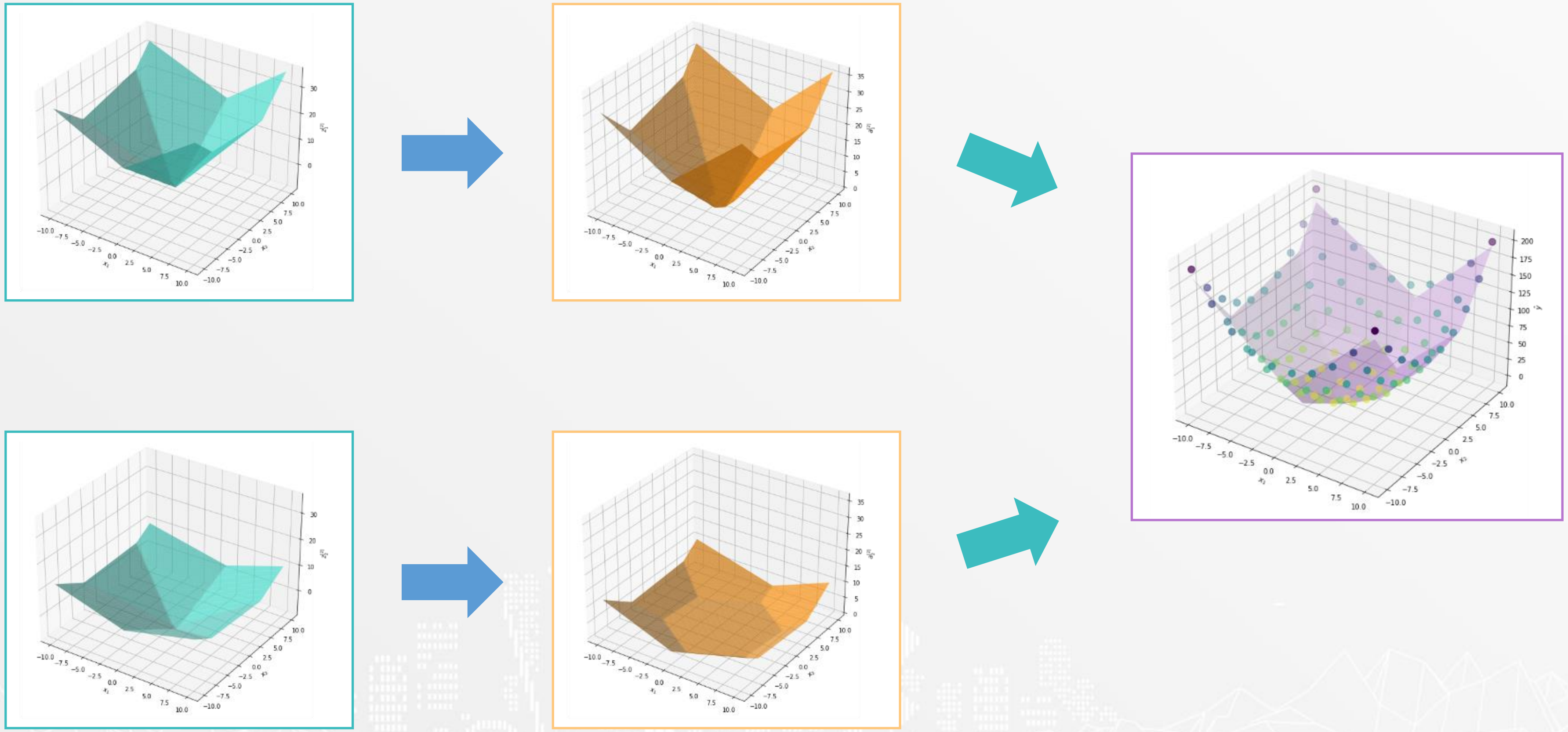


$$z_1^{[2]} = b_1^{[2]} + w_{1,1}^{[2]} a_1^{[1]} + w_{2,1}^{[2]} a_2^{[1]} + w_{3,1}^{[2]} a_3^{[1]}$$

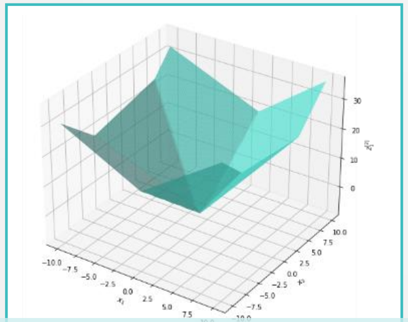


$$z_2^{[2]} = b_2^{[2]} + w_{1,2}^{[2]} a_1^{[1]} + w_{2,2}^{[2]} a_2^{[1]} + w_{3,2}^{[2]} a_3^{[1]}$$

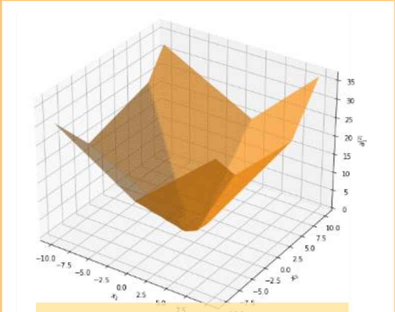
Weight & Bias



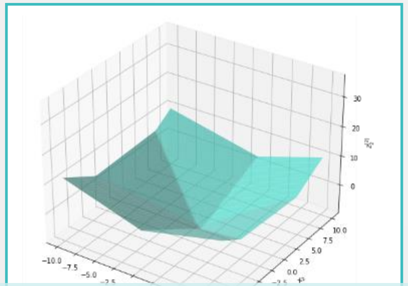
Weight & Bias



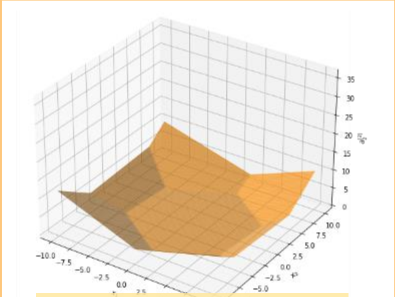
$$z_1^{[2]} = b_1^{[2]} + w_{1,1}^{[1]} a_1^{[1]} + w_{2,1}^{[1]} a_2^{[1]} + w_{3,1}^{[1]} a_3^{[1]}$$



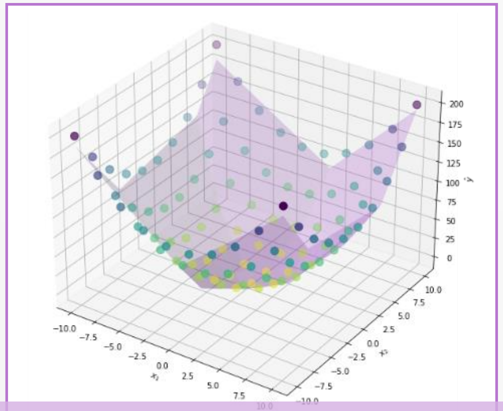
$$a_1^{[2]} = af\left(z_1^{[2]}\right)$$



$$z_2^{[2]} = b_1^{[2]} + w_{1,2}^{[2]} a_1^{[1]} + w_{2,2}^{[2]} a_2^{[1]} + w_{3,2}^{[2]} a_3^{[1]}$$

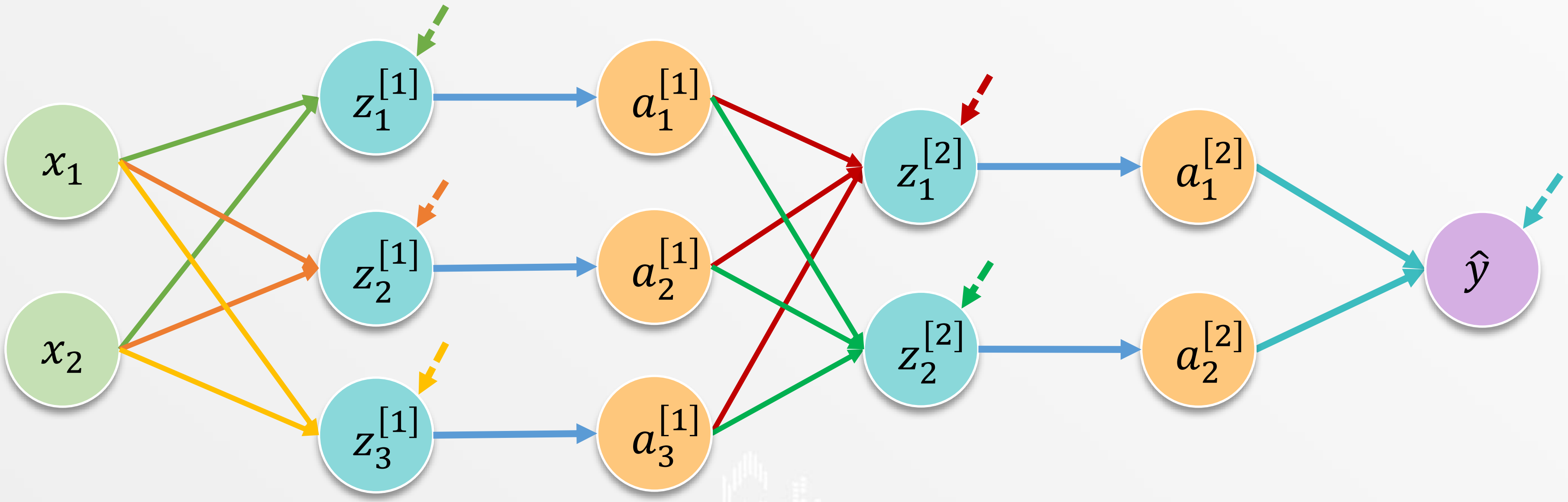


$$a_2^{[2]} = af\left(z_2^{[2]}\right)$$



$$\hat{y} = b^{[out]} + w_1^{[out]} a_1^{[2]} + w_2^{[out]} a_2^{[2]}$$

Weight & Bias



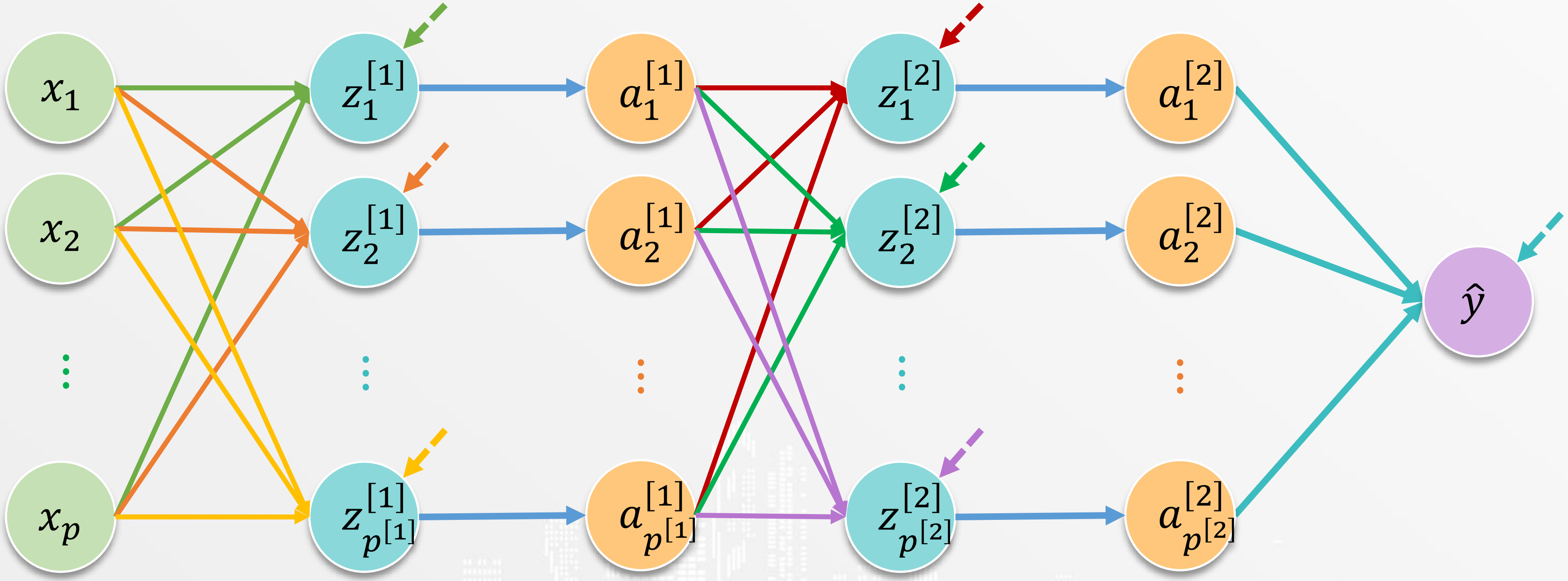
Weight & Bias

$$\mathbf{b}^{[1]} = \begin{bmatrix} b_1^{[1]} & b_2^{[1]} & b_3^{[1]} \end{bmatrix}, \; W^{[1]} = \begin{bmatrix} w_{1,1}^{[1]} & w_{1,2}^{[1]} & w_{1,3}^{[1]} \\ w_{2,1}^{[1]} & w_{2,2}^{[1]} & w_{2,3}^{[1]} \end{bmatrix}$$

$$\mathbf{b}^{[2]} = \begin{bmatrix} b_1^{[2]} & b_2^{[2]} \end{bmatrix}, \; W^{[2]} = \begin{bmatrix} w_{1,1}^{[2]} & w_{1,2}^{[2]} \\ w_{2,1}^{[2]} & w_{2,2}^{[2]} \\ w_{3,1}^{[2]} & w_{3,2}^{[2]} \end{bmatrix}$$

$$\mathbf{b}^{[out]} = \begin{bmatrix} b^{[out]} \end{bmatrix}, \; W^{[out]} = \begin{bmatrix} w_1^{[out]} \\ w_2^{[out]} \end{bmatrix}$$

Weight & Bias


x_1
x_2
x_p
$z_1^{[1]}$
$z_2^{[1]}$
$z_{p^{[1]}}^{[1]}$
$a_1^{[1]}$
$a_2^{[1]}$
$a_{p^{[1]}}^{[1]}$
$z_1^{[2]}$
$z_2^{[2]}$
$z_{p^{[2]}}^{[2]}$
$a_1^{[2]}$
$a_2^{[2]}$
$a_{p^{[2]}}^{[2]}$
$\hat{y}$

Weight & Bias

$$z_1^{[1]} = b_1^{[1]} + w_{1,1}^{[1]} x_1 + w_{2,1}^{[1]} x_2 + \cdots + w_{p,1}^{[1]} x_p$$

$$z_2^{[1]} = b_2^{[1]} + w_{1,2}^{[1]} x_1 + w_{2,2}^{[1]} x_2 + \cdots + w_{p,2}^{[1]} x_p$$

$$\vdots$$

$$z_{p^{[1]}}^{[1]} = b_{p^{[1]}}^{[1]} + w_{1,p^{[1]}}^{[1]} x_1 + w_{2,p^{[1]}}^{[1]} x_2 + \cdots + w_{p,p^{[1]}}^{[1]} x_p$$

Weight & Bias

$$a_1^{[1]} = af(z_1^{[1]})$$

$$a_2^{[1]} = af(z_2^{[1]})$$

$$\vdots$$

$$a_{p^{[1]}}^{[1]} = af\ (z_{p^{[1]}}^{[1]})$$

Weight & Bias

$$\mathbf{b}^{[1]} = \begin{bmatrix} b_1^{[1]} & b_2^{[1]} & \cdots & b_{p^{[1]}}^{[1]} \end{bmatrix}, \; W^{[1]} = \begin{bmatrix} w_{1,1}^{[1]} & w_{1,2}^{[1]} & \cdots & w_{1,p^{[1]}}^{[1]} \\ w_{2,1}^{[1]} & w_{2,2}^{[1]} & \cdots & w_{2,p^{[1]}}^{[1]} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p,1}^{[1]} & w_{p,2}^{[1]} & \cdots & w_{p,p^{[1]}}^{[1]} \end{bmatrix}$$

Weight & Bias

$$z_1^{[2]} = b_1^{[2]} + w_{1,1}^{[2]} a_1^{[1]} + w_{2,1}^{[2]} a_2^{[1]} + \cdots + w_{p^{[1]},1}^{[2]} a_{p^{[1]}}^{[1]}$$

$$z_2^{[2]} = b_2^{[2]} + w_{1,2}^{[2]} a_1^{[1]} + w_{2,2}^{[2]} a_2^{[1]} + \cdots + w_{p^{[1]},2}^{[2]} a_{p^{[1]}}^{[1]}$$

$$\vdots$$

$$z_{p^{[2]}}^{[2]} = b_{p^{[2]}}^{[2]} + w_{1,p^{[2]}}^{[2]} a_1^{[1]} + w_{2,p^{[2]}}^{[2]} a_2^{[1]} + \cdots + w_{p^{[1]},p^{[2]}}^{[2]} a_{p^{[1]}}^{[1]}$$

Weight & Bias

$$a_1^{[2]} = af(z_1^{[2]})$$

$$a_2^{[2]} = af\ (z_2^{[2]})$$

$$\vdots$$

$$a_{p^{[2]}}^{[2]} = af(z_{p^{[2]}}^{[2]})$$

$$\hat{y} = b^{[out]} + w_1^{[out]} a_1^{[2]} + w_2^{[out]} a_2^{[2]} + \cdots + w_{p^{[2]}}^{[out]} a_{p^{[2]}}^{[2]}$$

Weight & Bias

$$\mathbf{b}^{[2]} = \begin{bmatrix} b_1^{[2]} & b_2^{[2]} & \cdots & b_{p^{[2]}}^{[2]} \end{bmatrix},\ W^{[2]} = \begin{bmatrix} w_{1,1}^{[2]} & w_{1,2}^{[2]} & \cdots & w_{1,p^{[2]}}^{[2]} \\ w_{2,1}^{[2]} & w_{2,2}^{[2]} & \cdots & w_{2,p^{[2]}}^{[2]} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p^{[1]},1}^{[2]} & w_{p^{[1]},2}^{[2]} & \cdots & w_{p^{[1]},p^{[2]}}^{[2]} \end{bmatrix}$$

$$\mathbf{b}^{[out]} = \begin{bmatrix} b^{[out]} \end{bmatrix},\ W^{[out]} = \begin{bmatrix} w_1^{[out]} \\ w_2^{[out]} \\ \vdots \\ w_{p^{[2]}}^{[out]} \end{bmatrix}$$

Component of Neural Network

- **Hidden Node**
- **Hidden Layer**
- **Weight & Bias**
- Activation Function

Activation Function

1. ReLU
2. Parametric ReLU
3. Sigmoid
4. Tanh
5. SELU
6. ELU
7. Softplus
8. Exponential
9. Gaussian
10. Swish

Activation Function

1. ReLU
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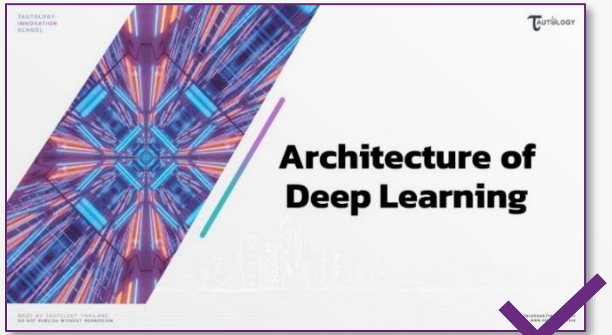
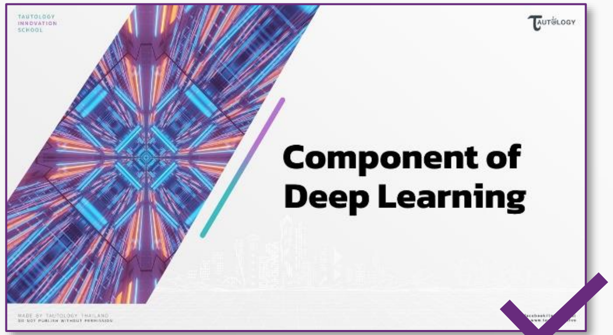
Component of Neural Network

- Hidden Node
- Hidden Layer
- Weight & Bias
- Activation Function

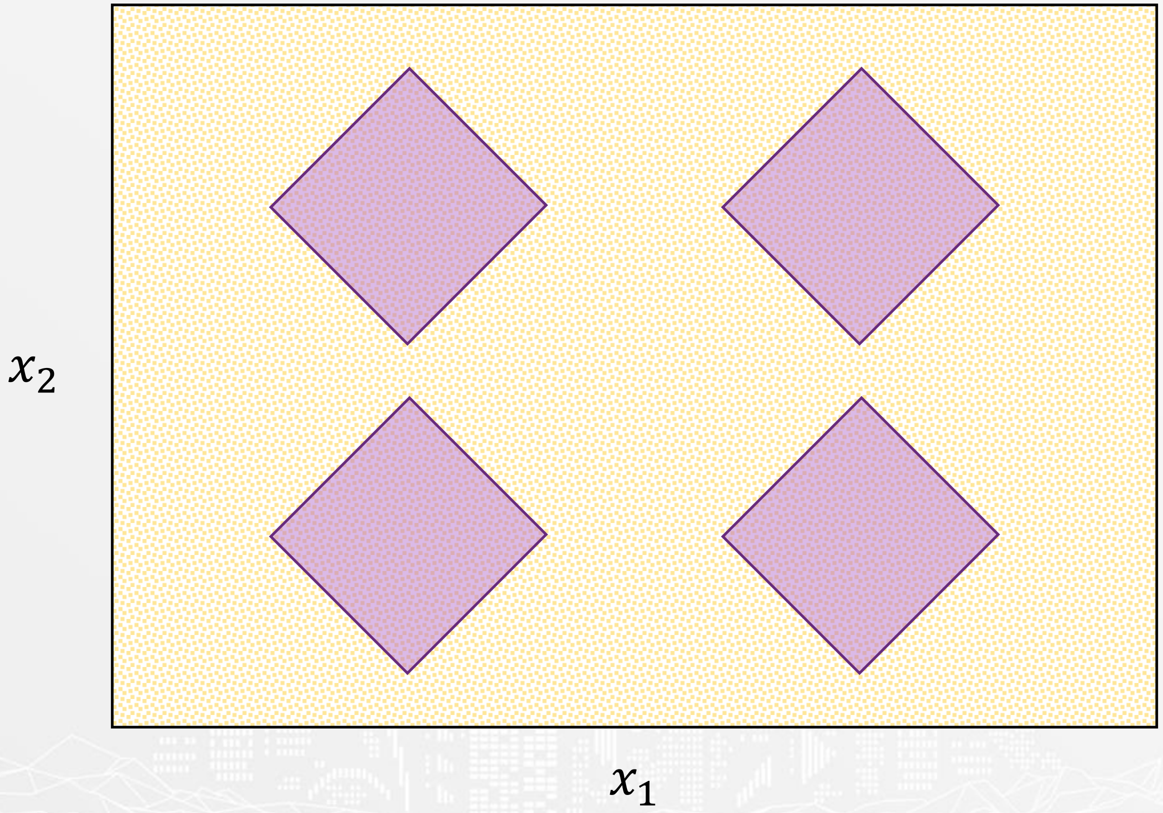
Deep Learning



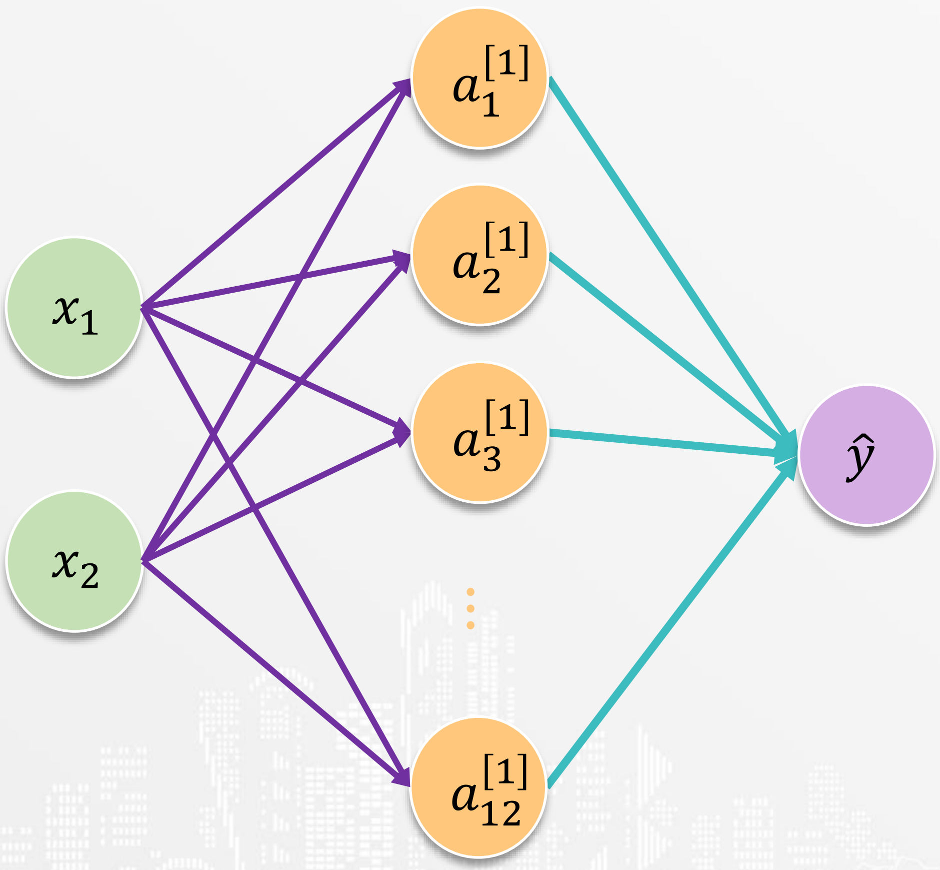


Why we need Deep Learning?

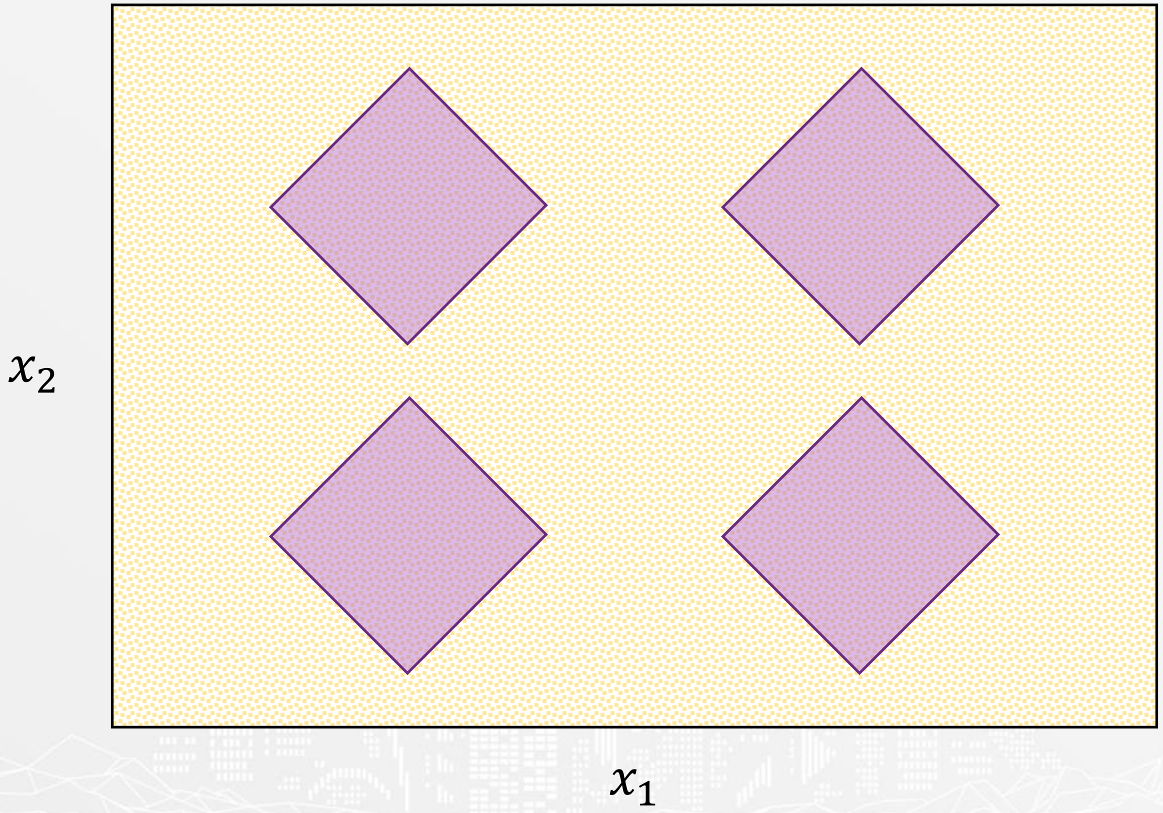
Why we need Deep Learning?



Why we need Deep Learning?

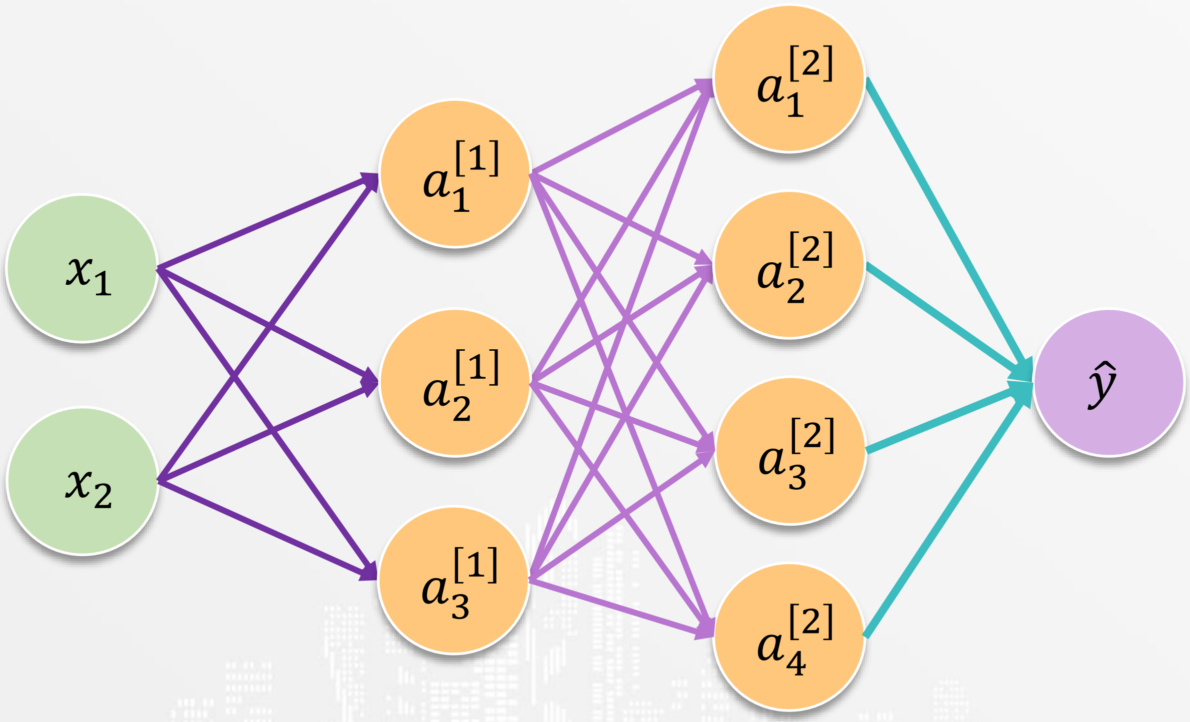


Why we need Deep Learning?



TAUTOLOGY

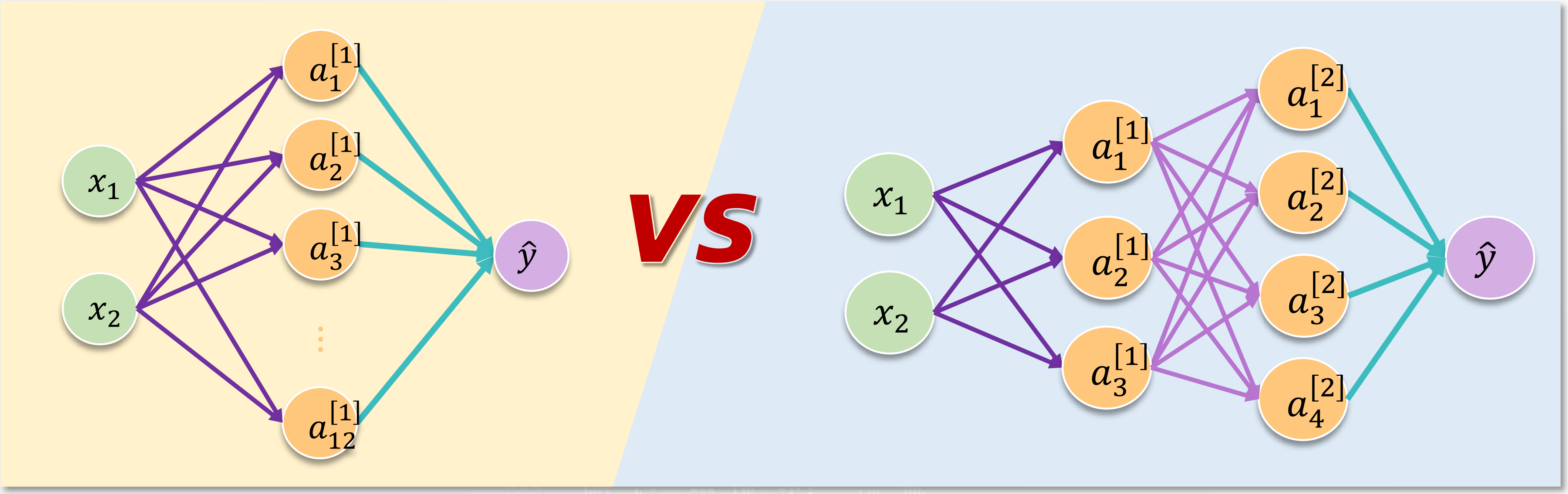
Why we need Deep Learning?



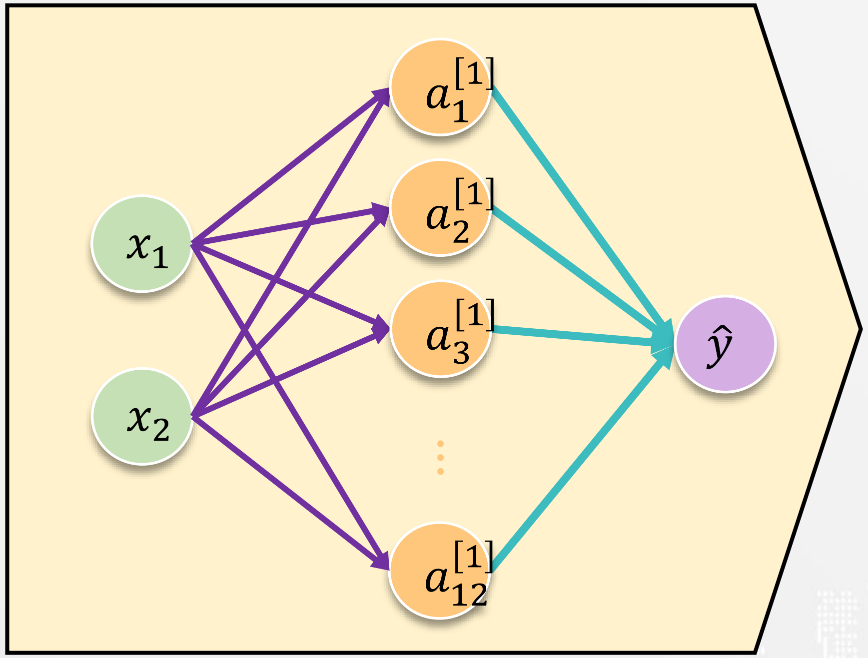
Why we need Deep Learning?

Computation cost ที่ใช้ในการคำนวณ deep learning แปรผันตรงกับจำนวน connection ใน architecture

Why we need Deep Learning?



Why we need Deep Learning?

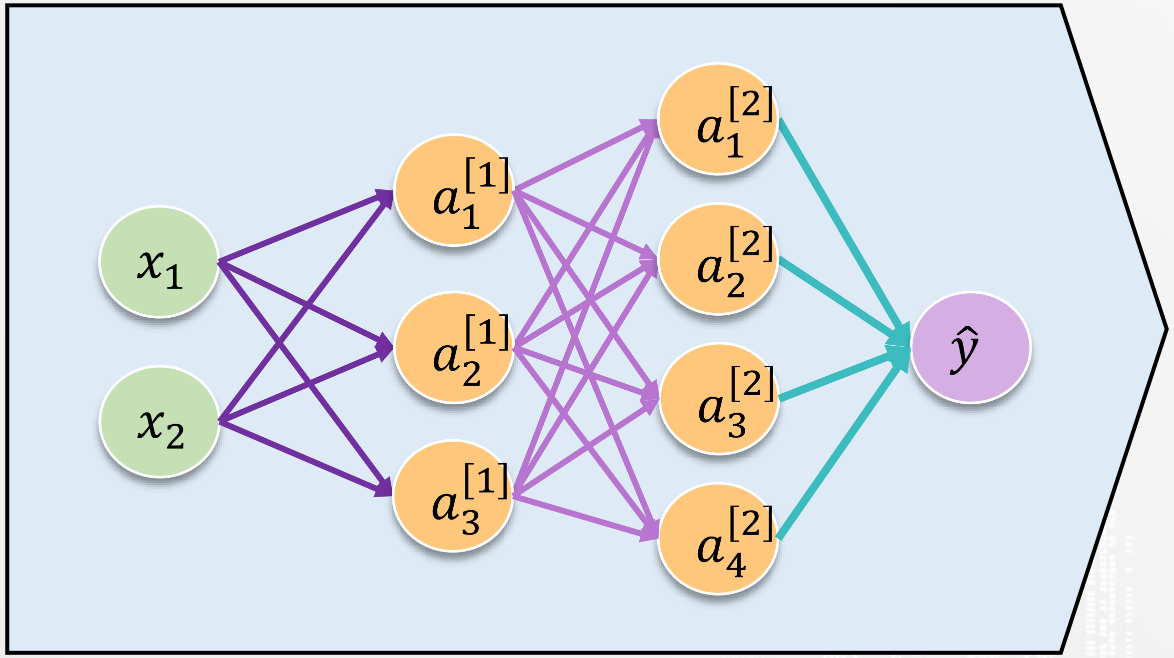


Cost ≈ (2 x 12) + (12 x 1)

= 24 +12

= 36

Why we need Deep Learning?

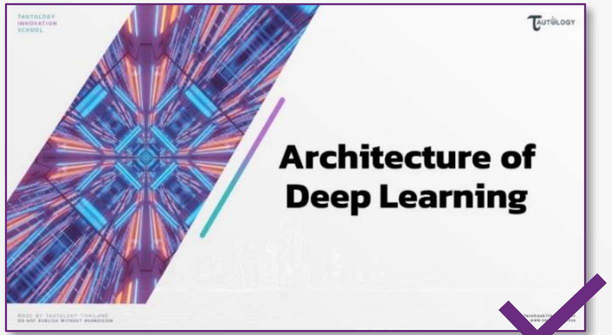


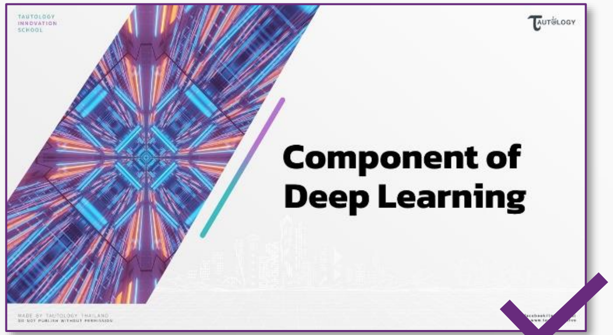
Cost ≈ (2 x 3) + (3 x 4) + (4 x 1)

= 6 + 12 + 4

= 22

Deep Learning





How Deep Learning Work

How Deep Learning Work

Regression

Classification

How Deep Learning Work

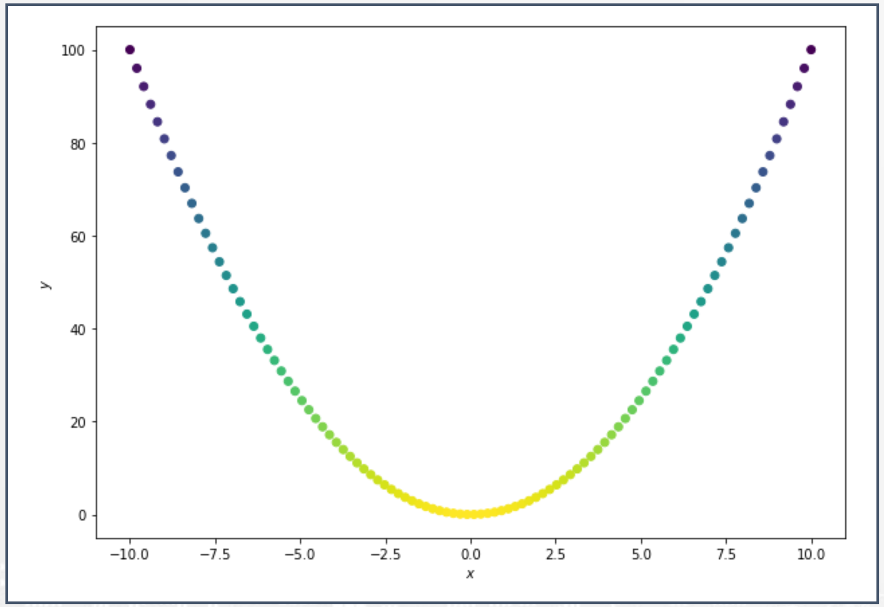
Regression

Classification

How Deep Learning Work

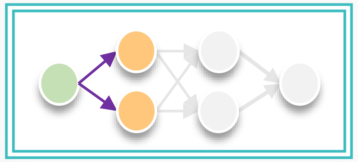
Regression

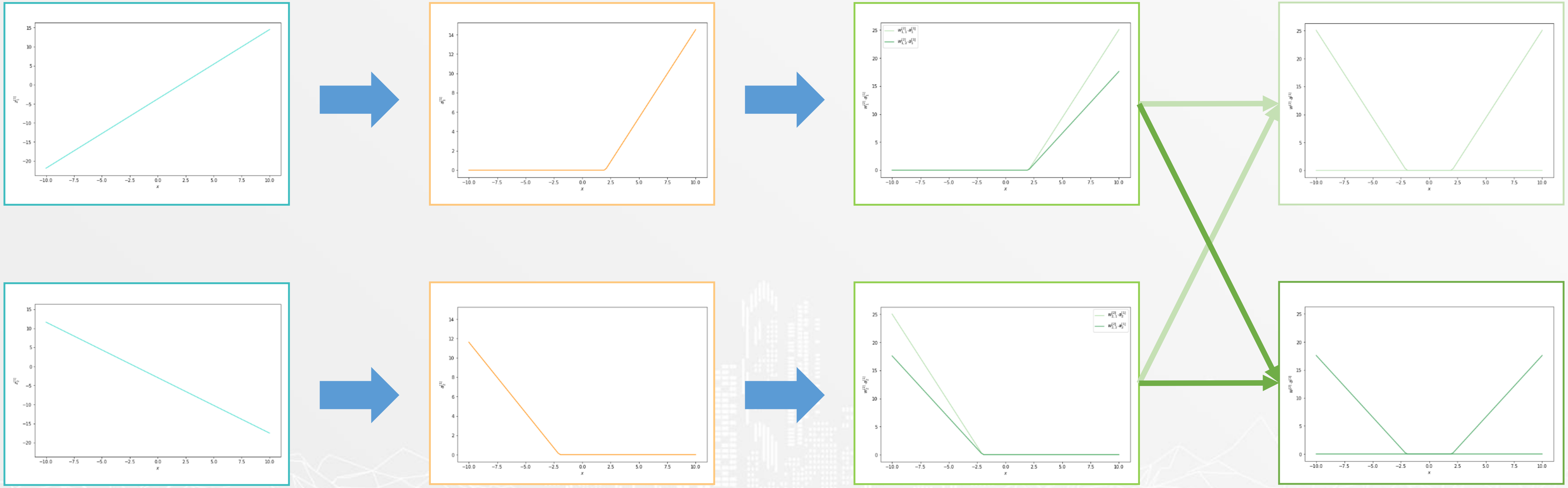
Example 1



How Deep Learning Work

Regression **Example 1**

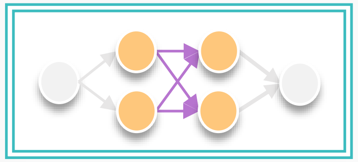


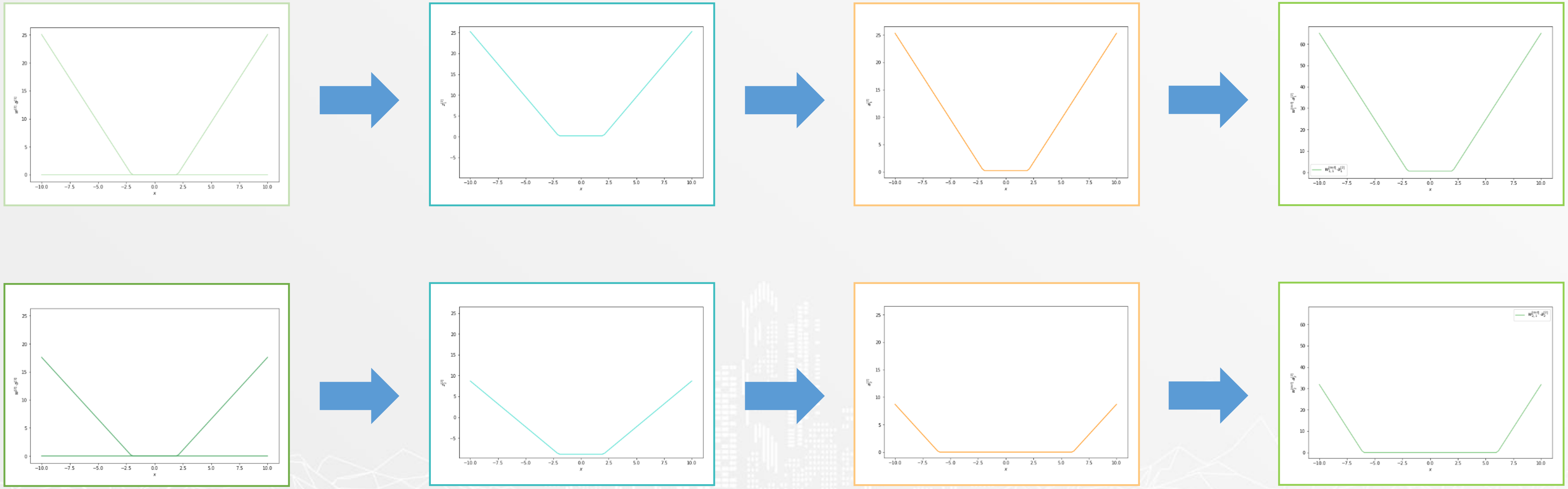


TAUTOLOGY

How Deep Learning Work

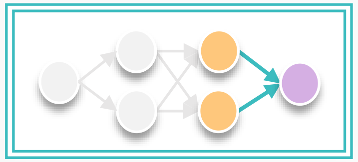
Regression Example 1

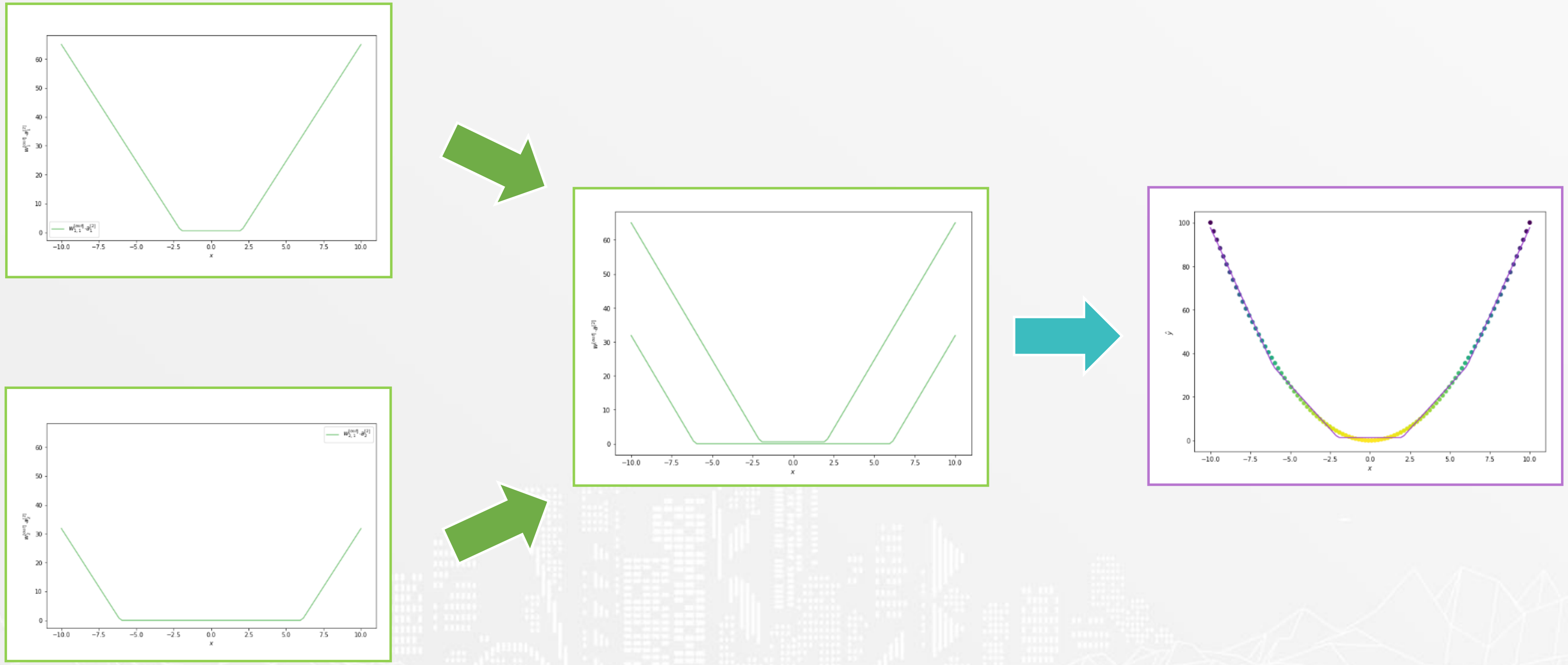




How Deep Learning Work

Regression | **Example 1**

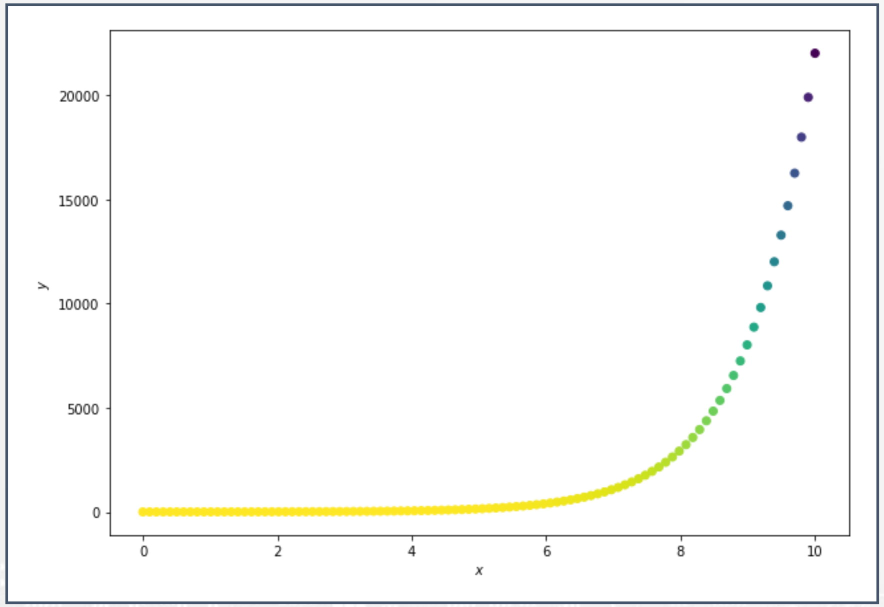




How Deep Learning Work

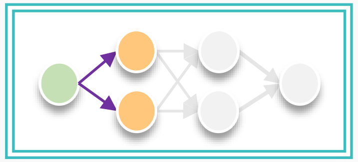
Regression

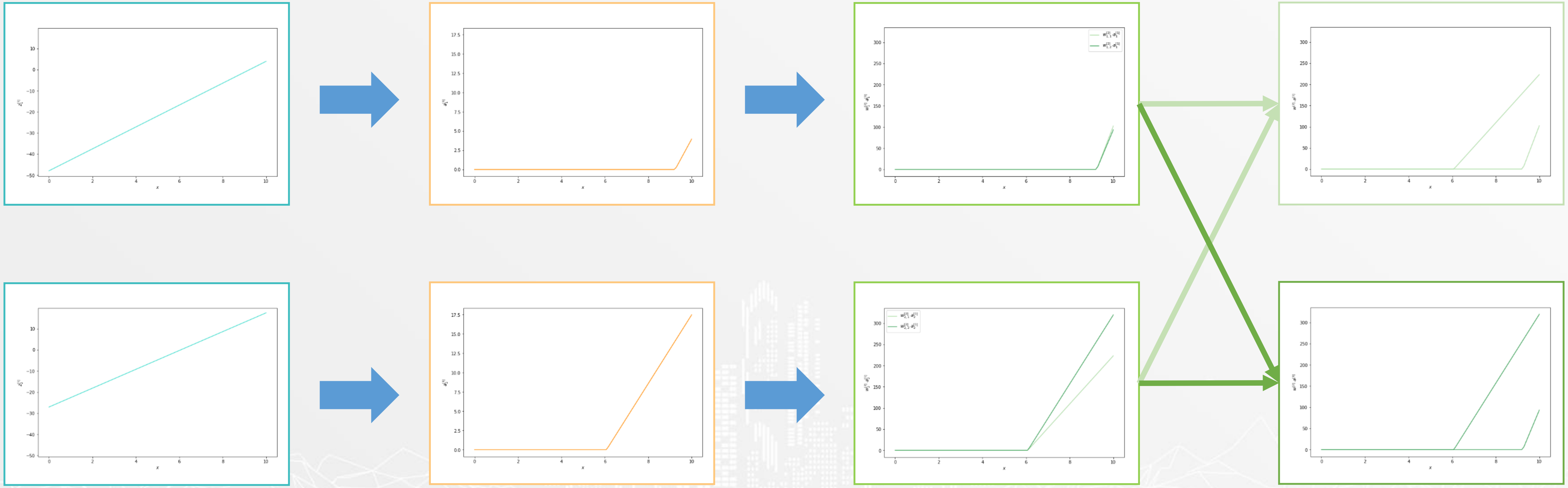
Example 2



How Deep Learning Work

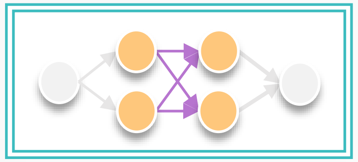
Regression Example 2

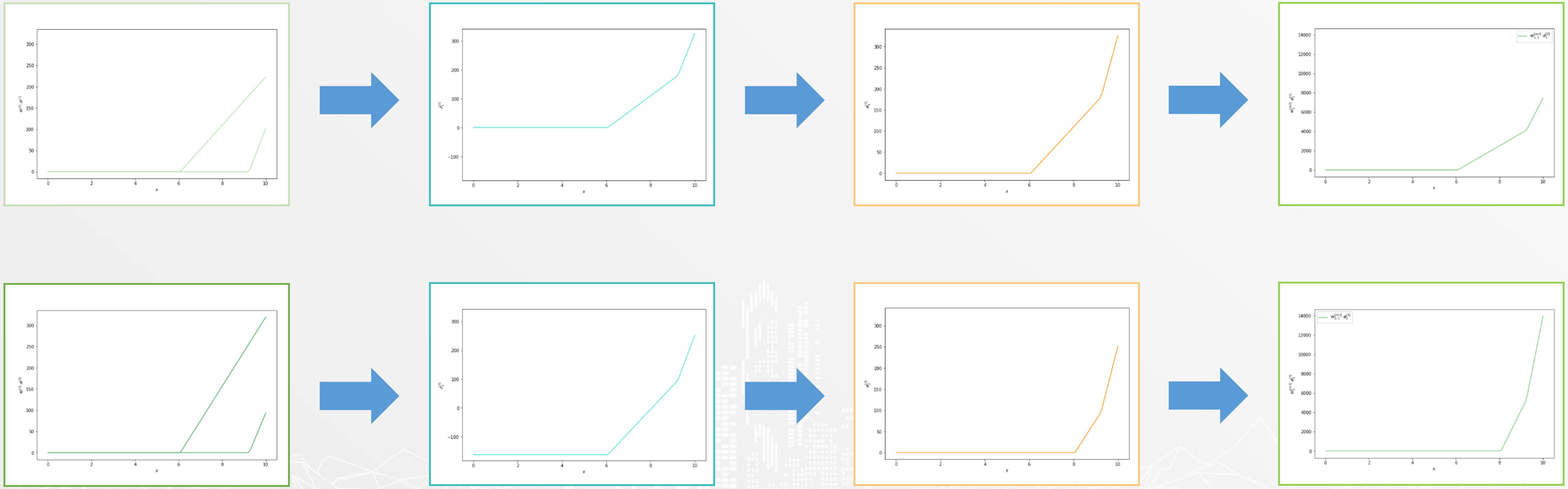




How Deep Learning Work

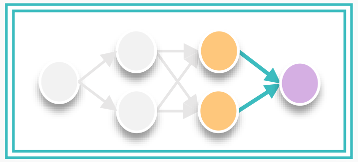
Regression Example 2

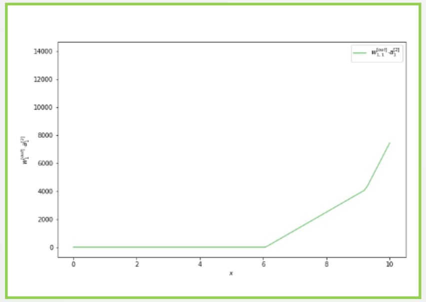


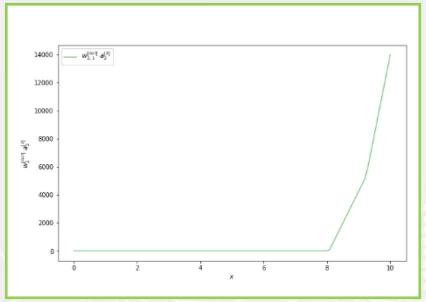


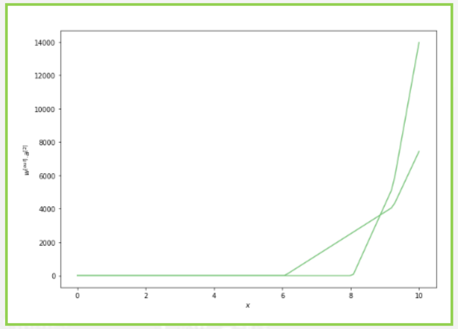
How Deep Learning Work

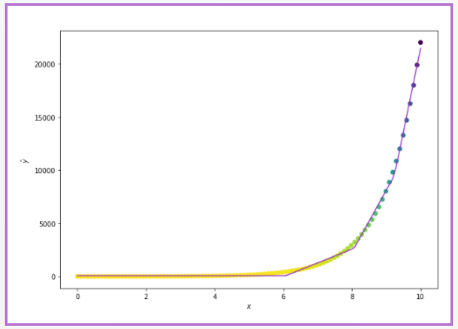
Regression Example 2







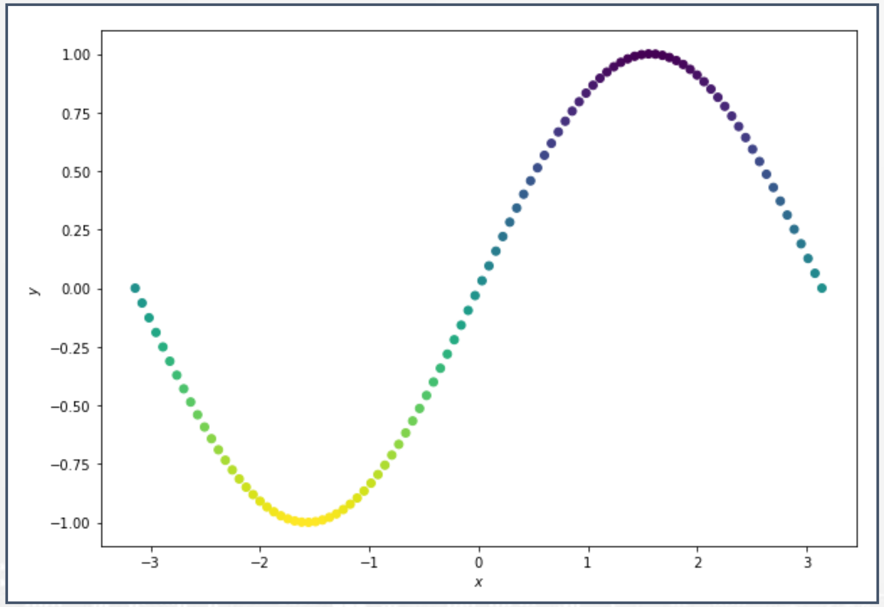




How Deep Learning Work

Regression

Example 3



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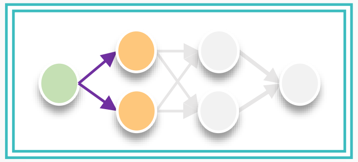
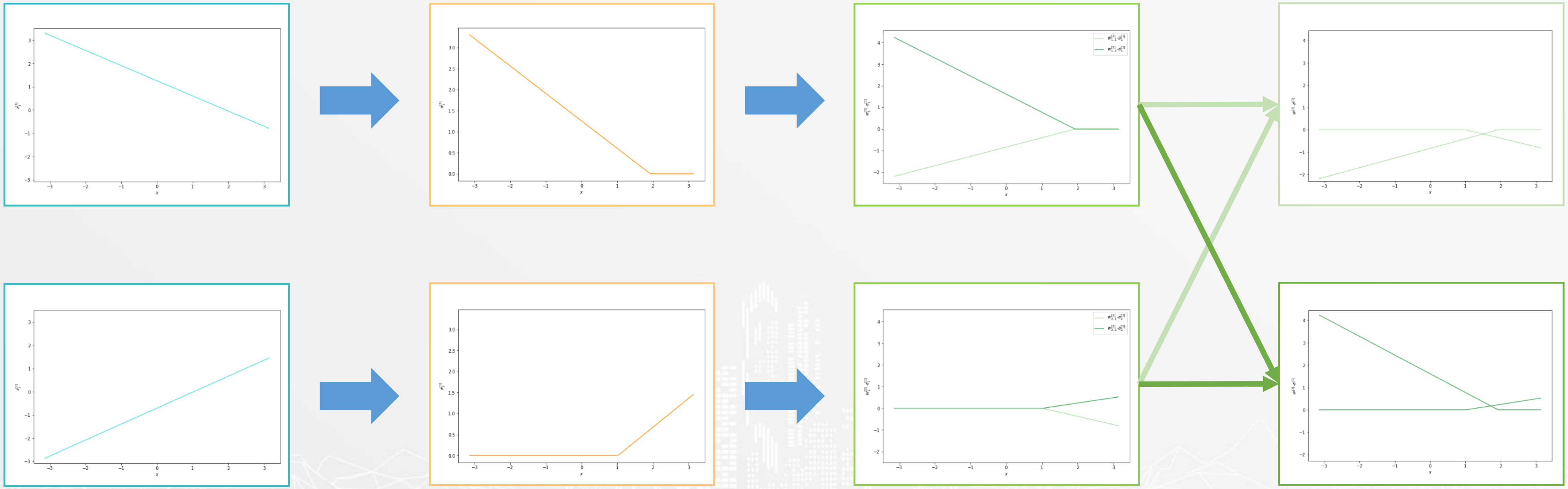
How Deep Learning Work

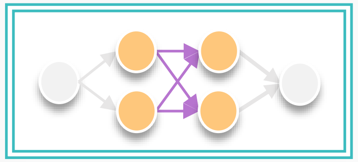
Regression Example 3

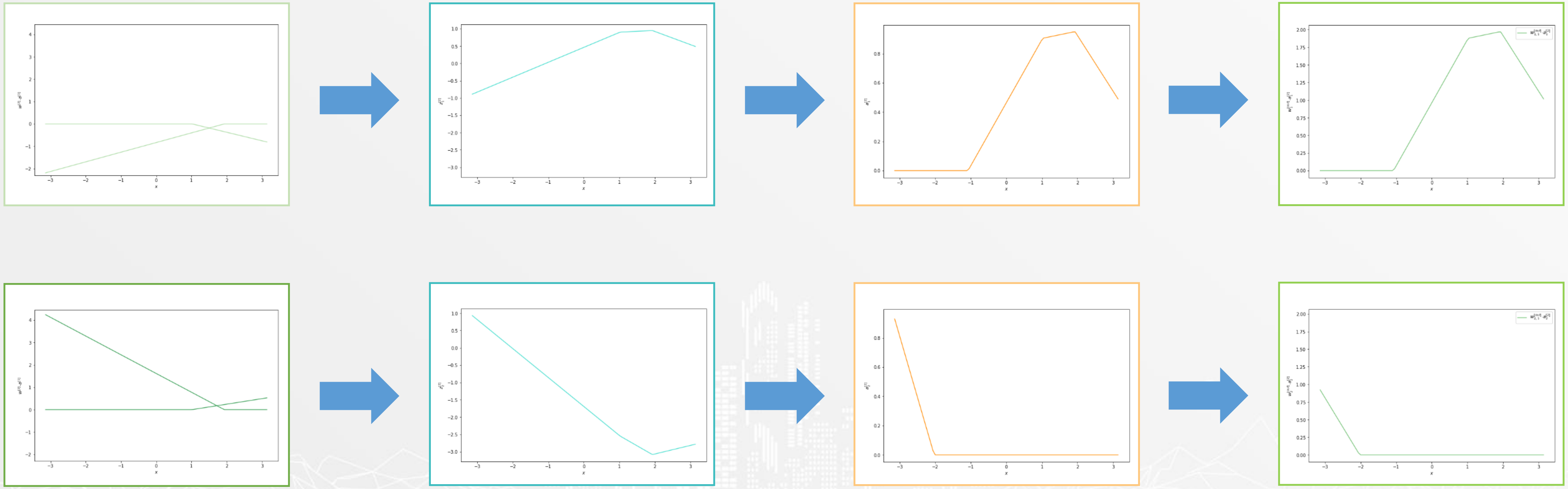




How Deep Learning Work

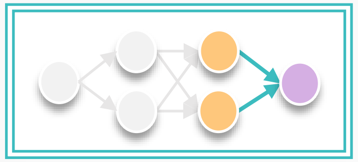
Regression | Example 3

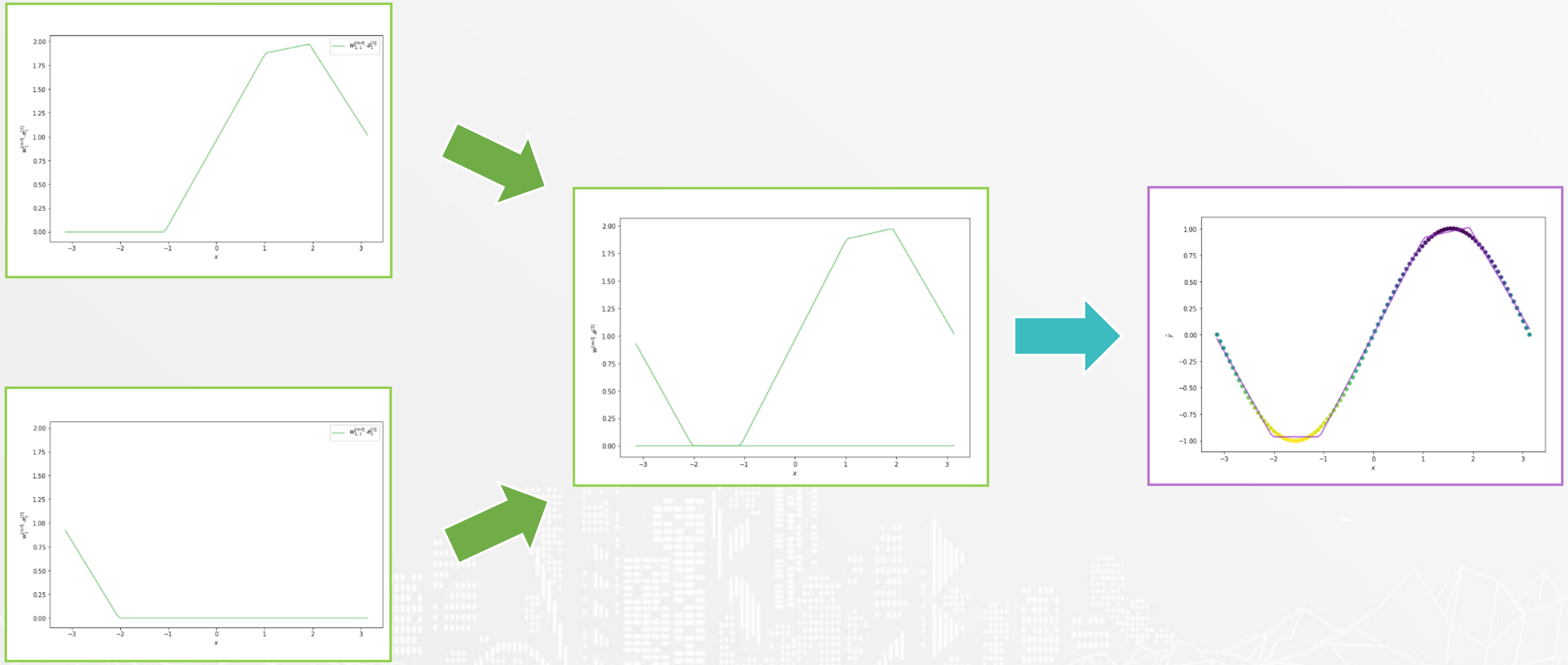




How Deep Learning Work

Regression Example 3

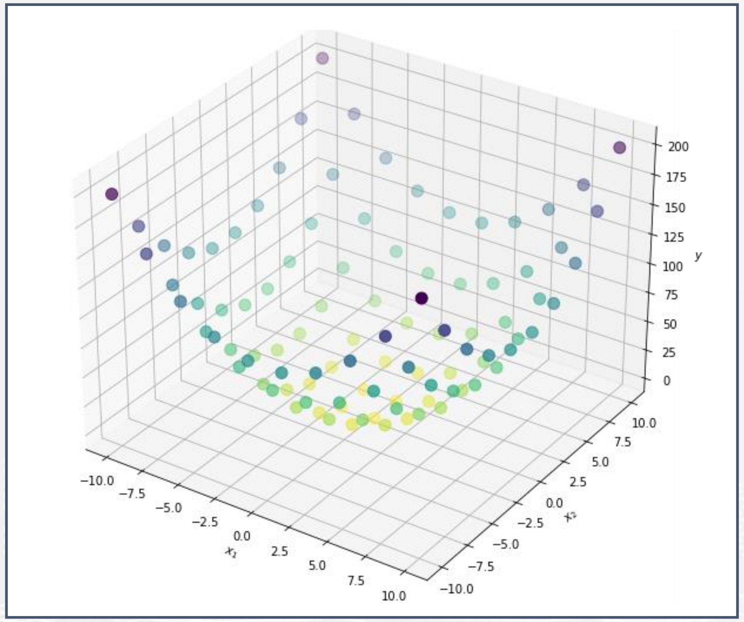




How Deep Learning Work

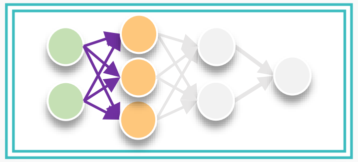
Regression

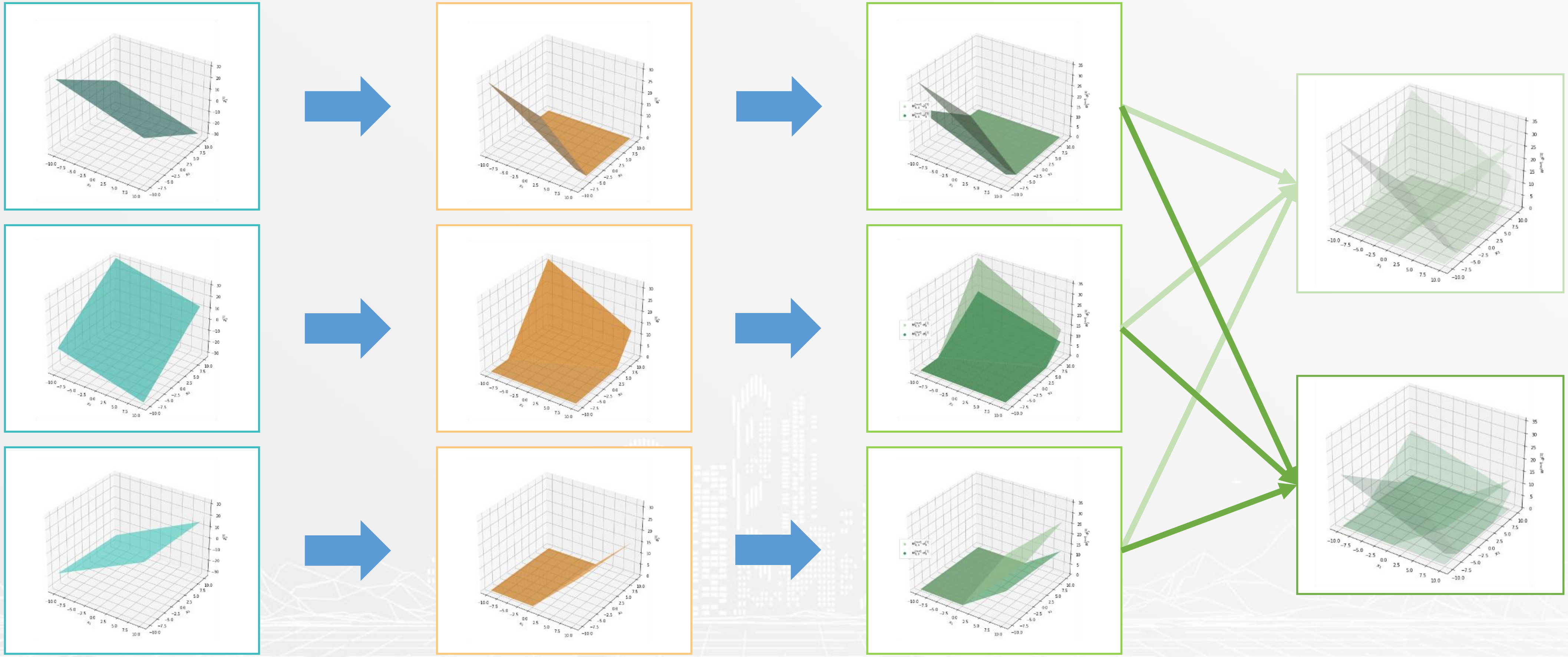
Example 4



How Deep Learning Work

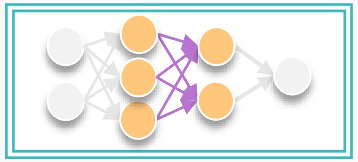
Regression Example 4

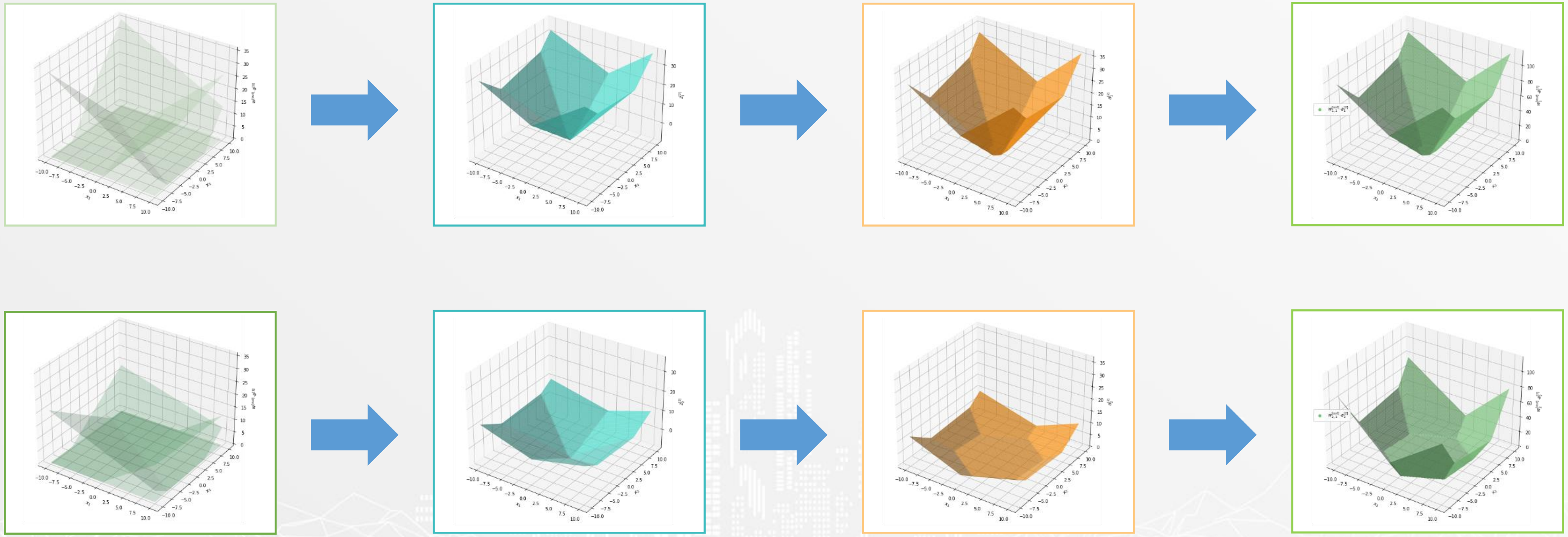




How Deep Learning Work

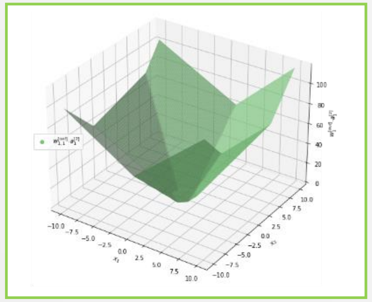
Regression Example 4

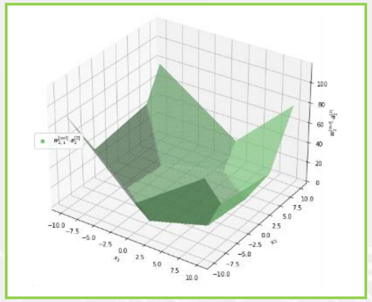


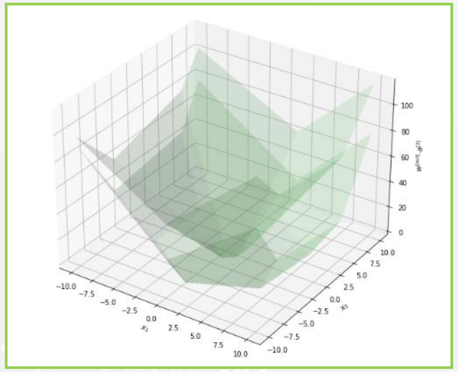


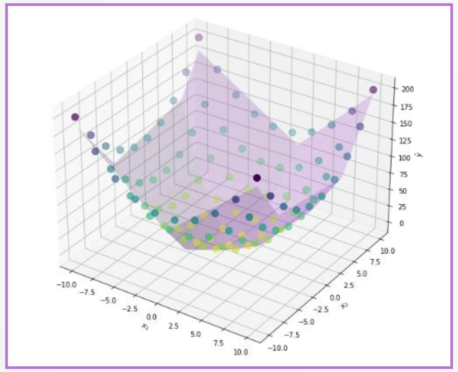
How Deep Learning Work

Regression Example 4





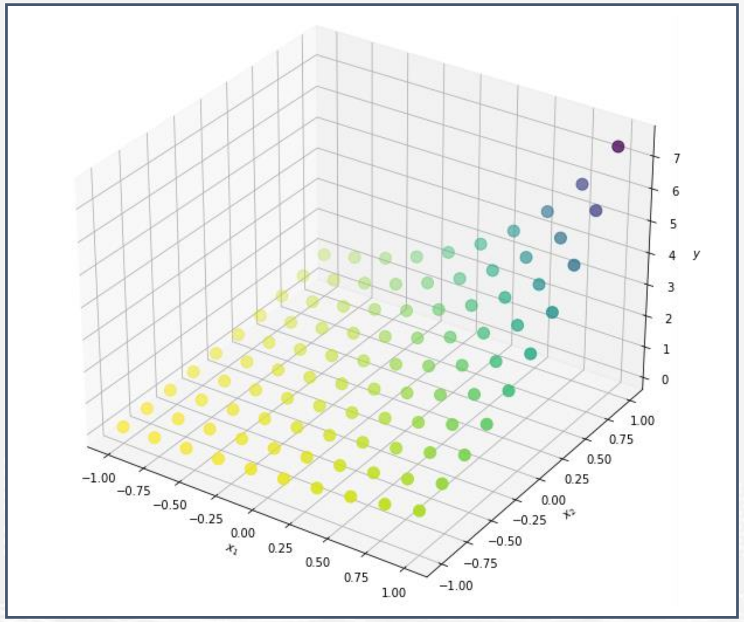




How Deep Learning Work

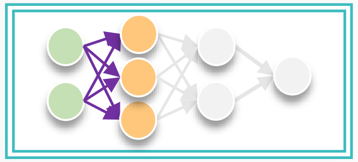
Regression

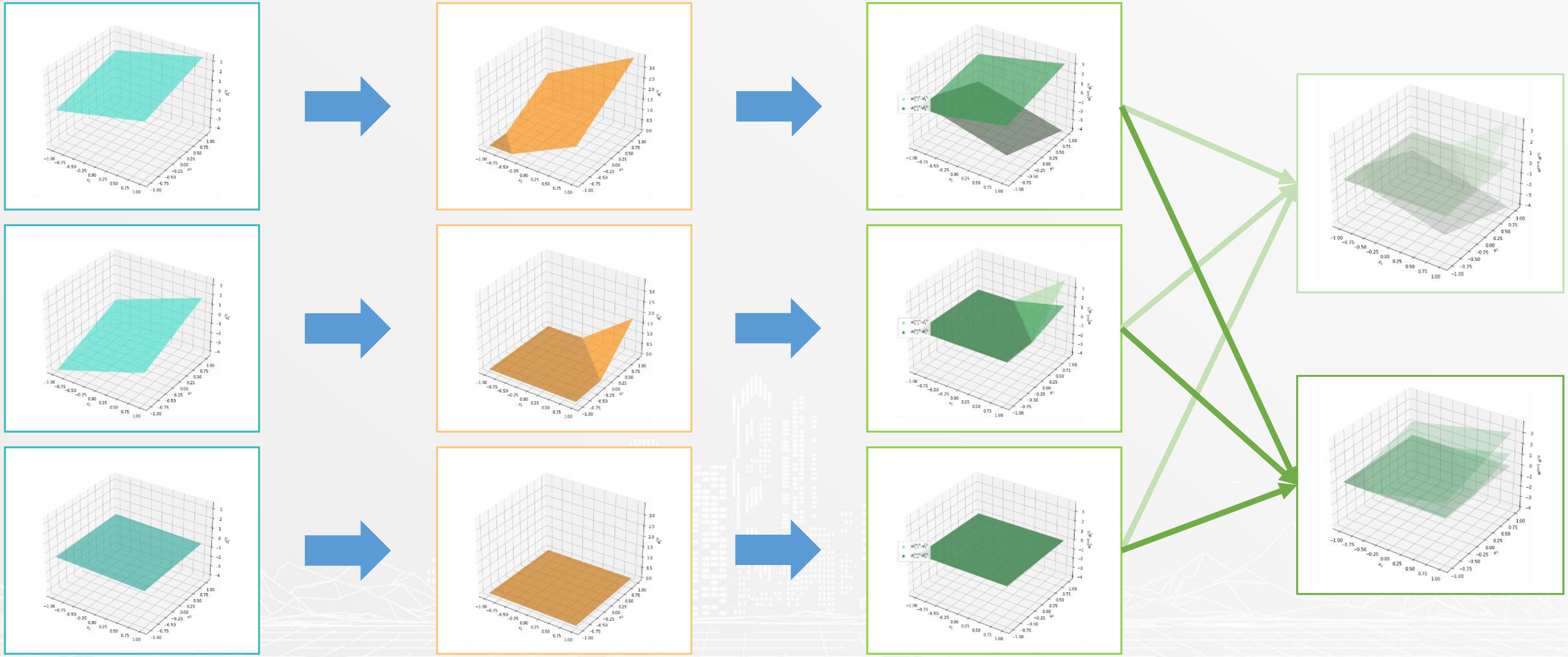
Example 5



How Deep Learning Work

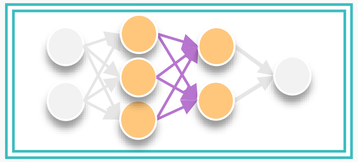
Regression | **Example 5**

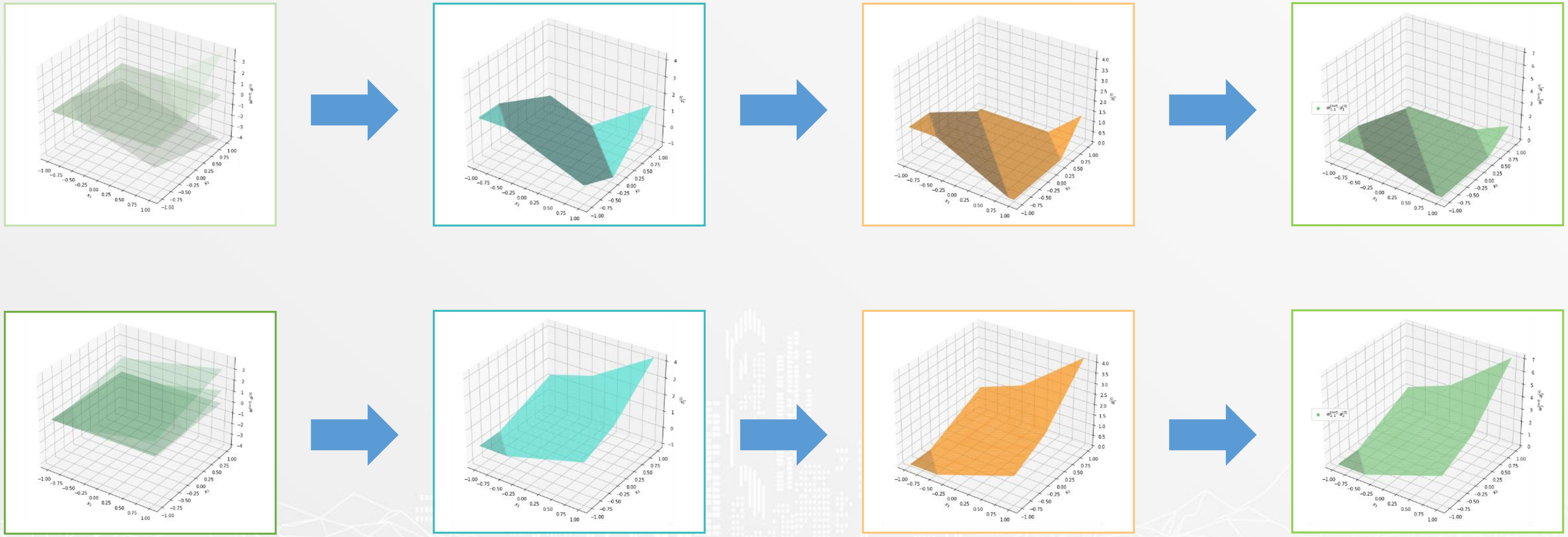




How Deep Learning Work

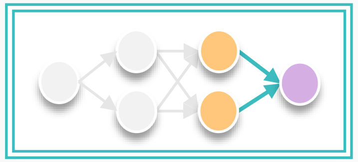
Regression | **Example 5**

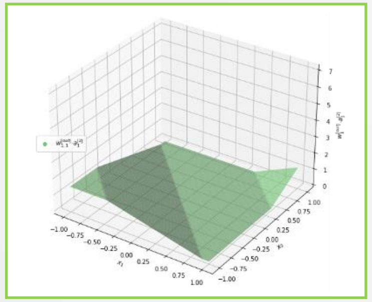


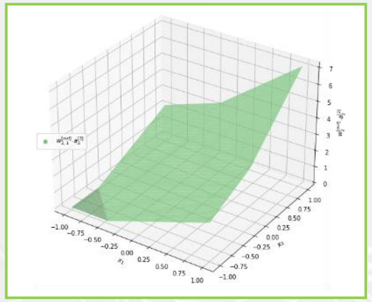


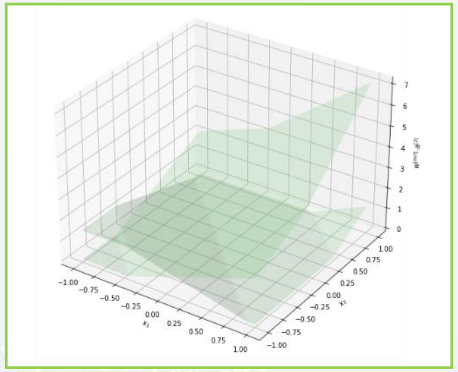
How Deep Learning Work

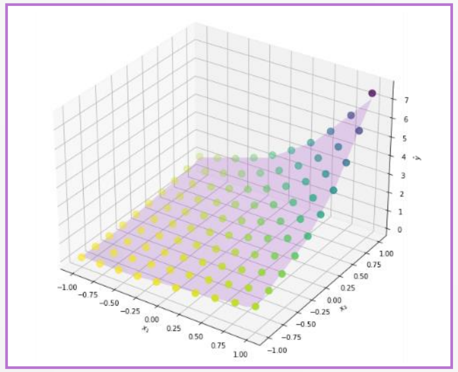
Regression | **Example 5**







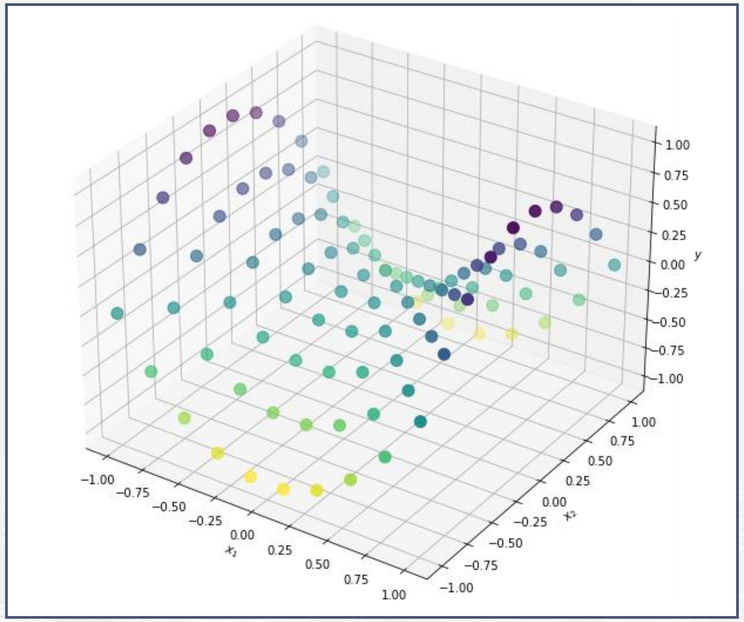




How Deep Learning Work

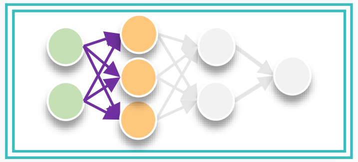
Regression

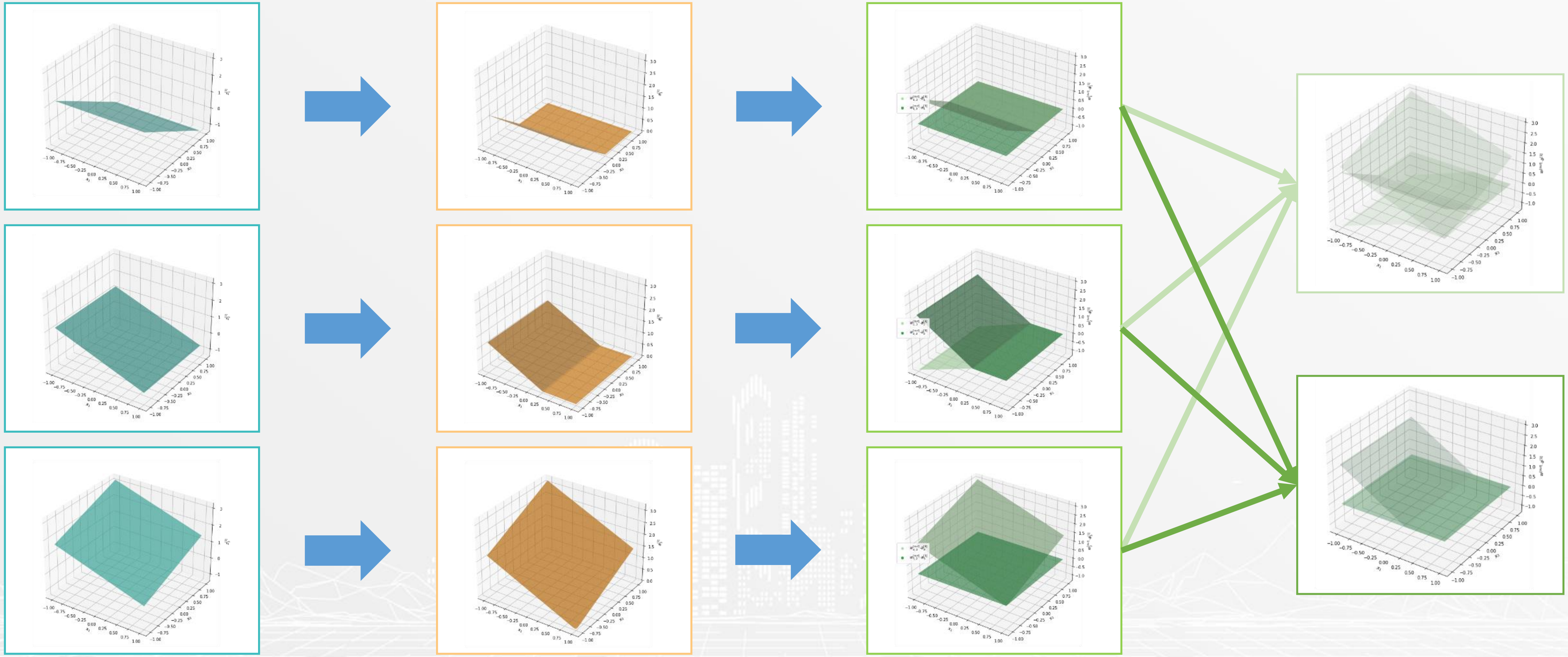
Example 6



How Deep Learning Work

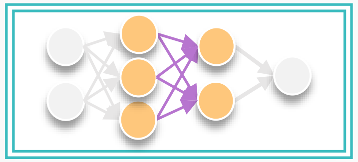
Regression Example 6

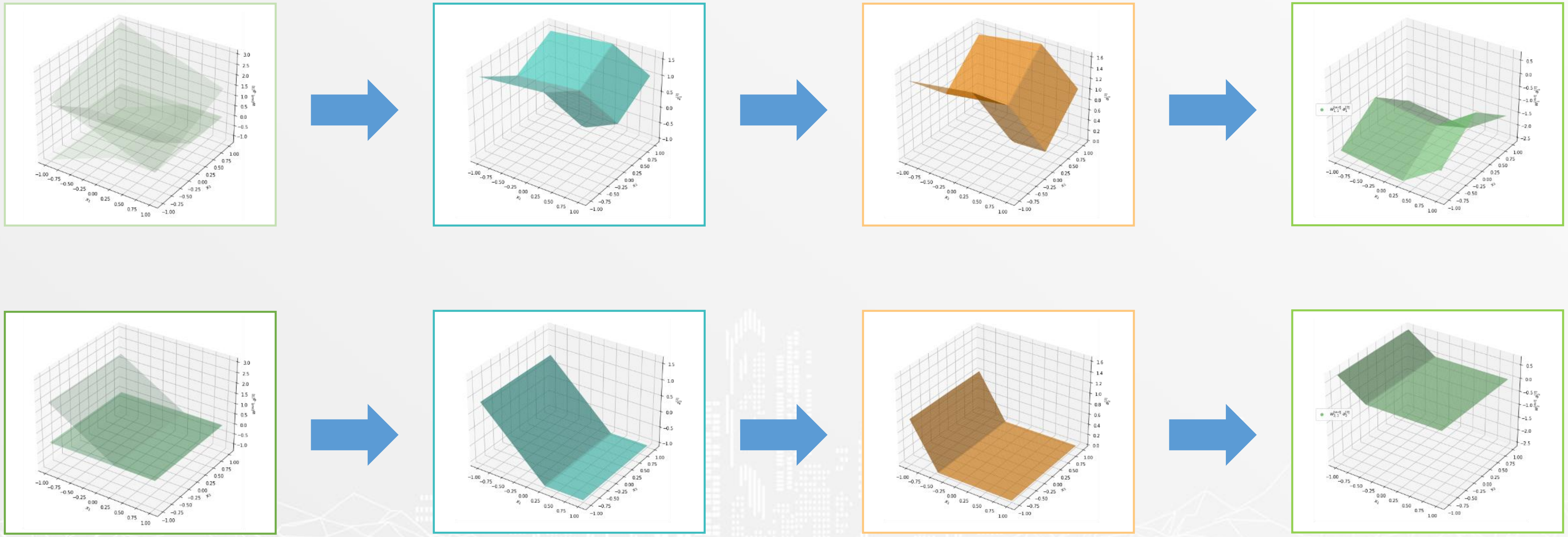




How Deep Learning Work

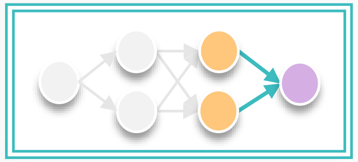
Regression Example 6

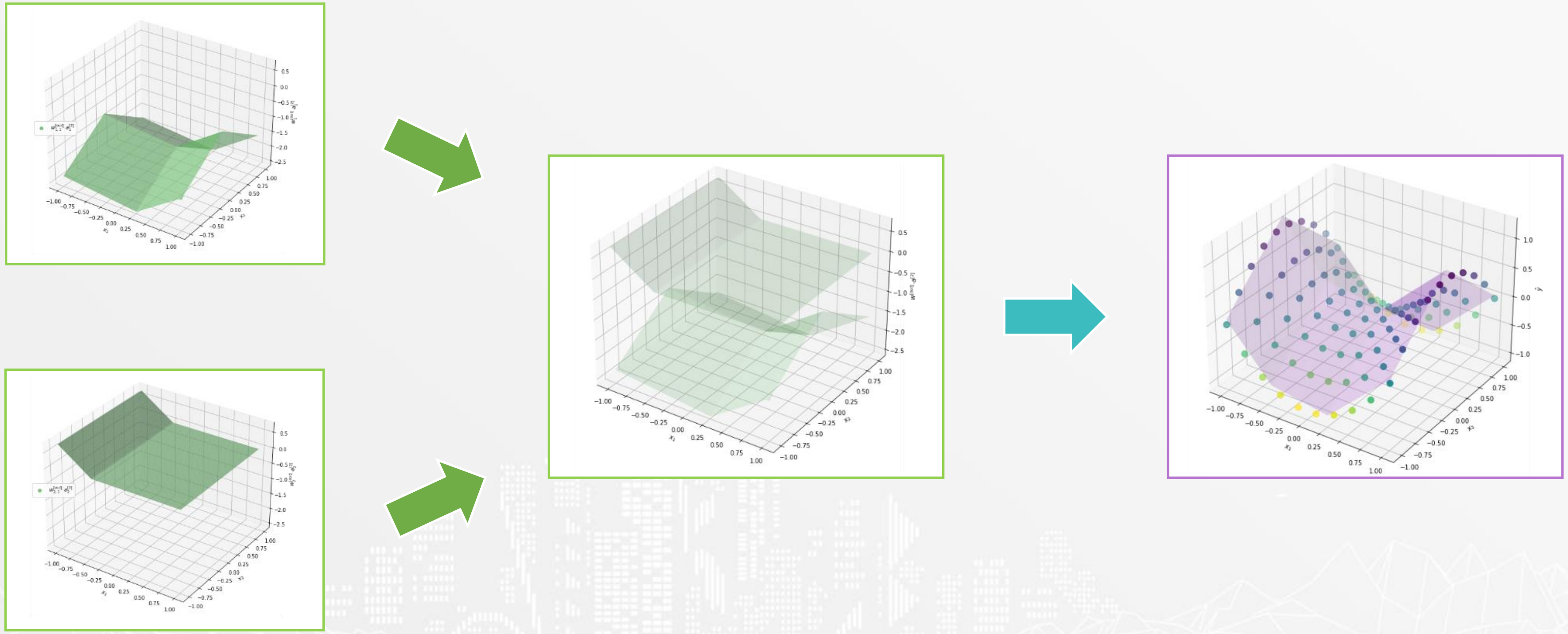




How Deep Learning Work

Regression | Example 6





How Deep Learning Work

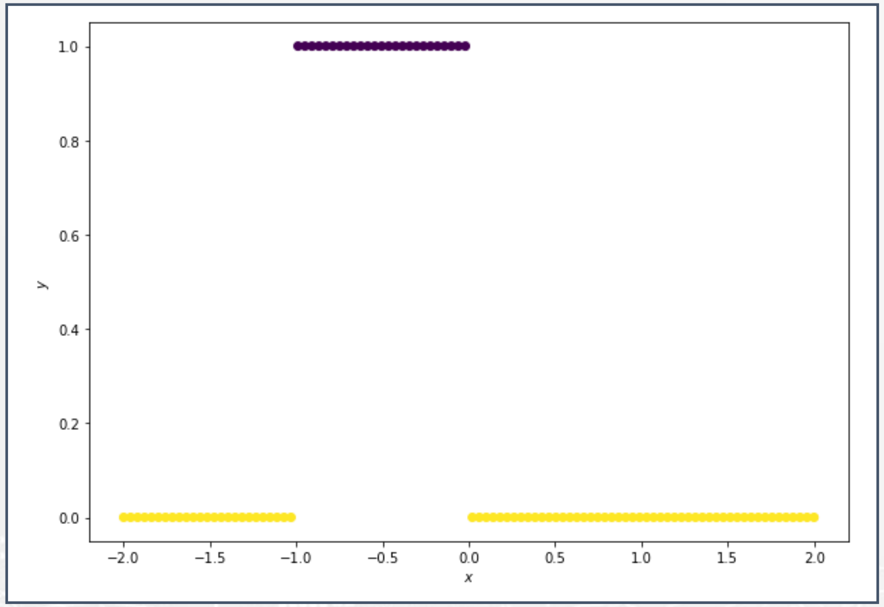
Regression

Classification

How Deep Learning Work

Classification

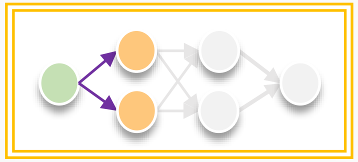
Example 1 : Binary Classification

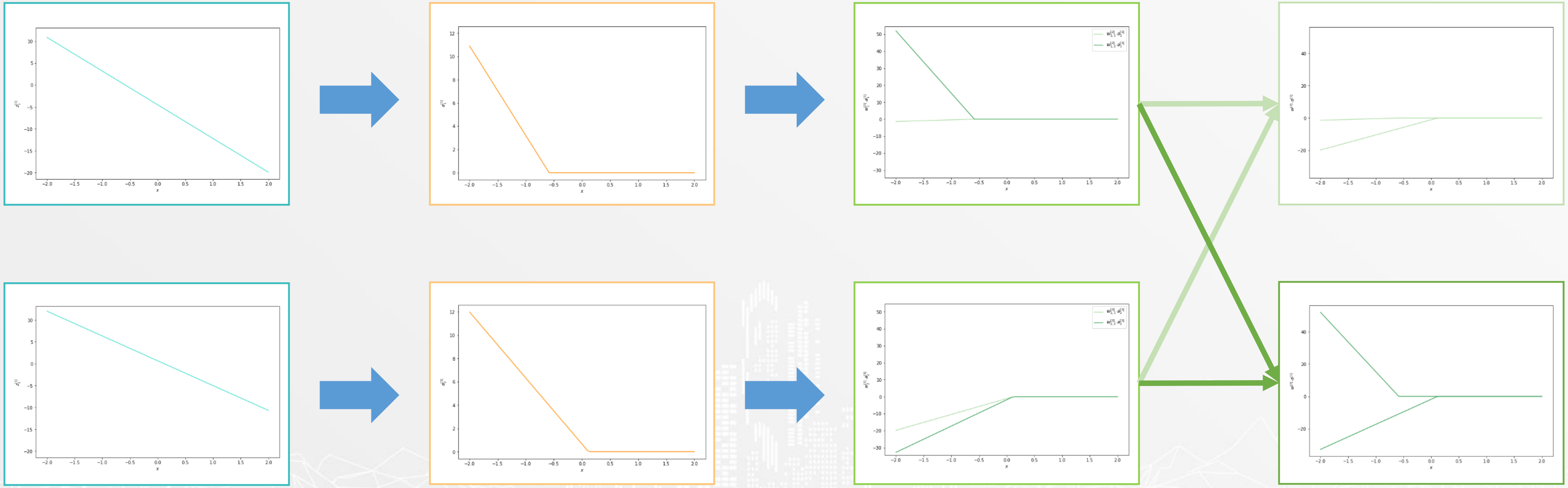


TAUTOLOGY

How Deep Learning Work

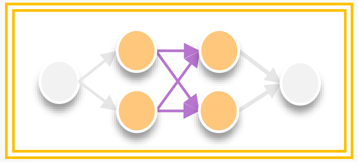
Classification Example 1

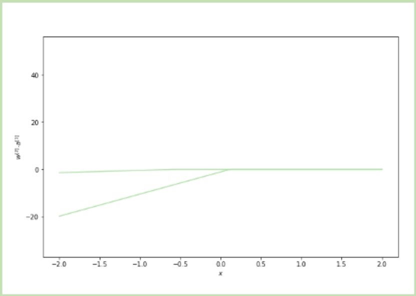


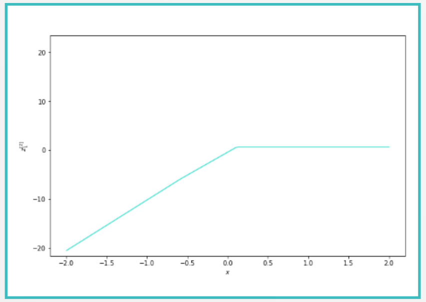


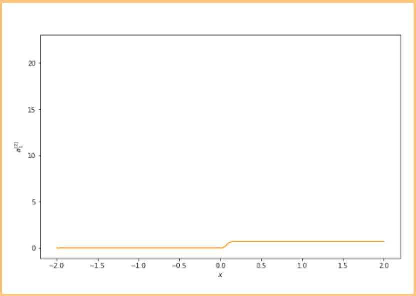
How Deep Learning Work

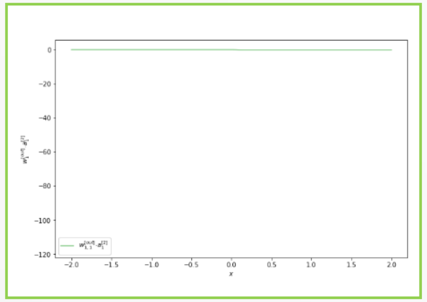
Classification Example 1

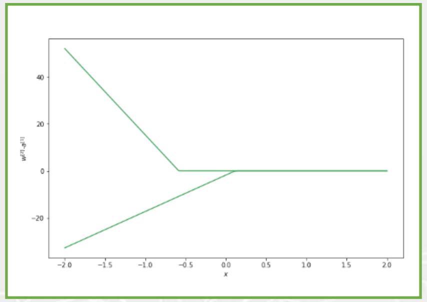


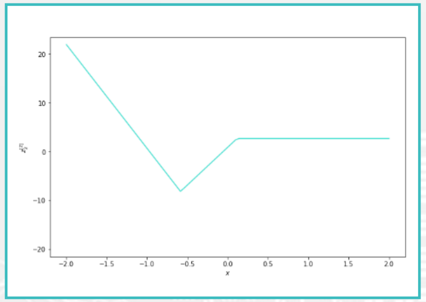


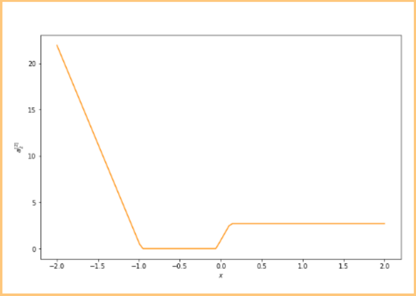


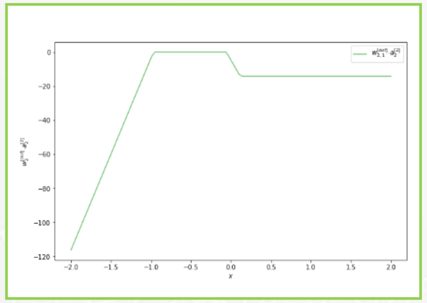






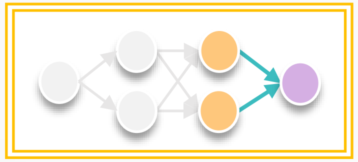


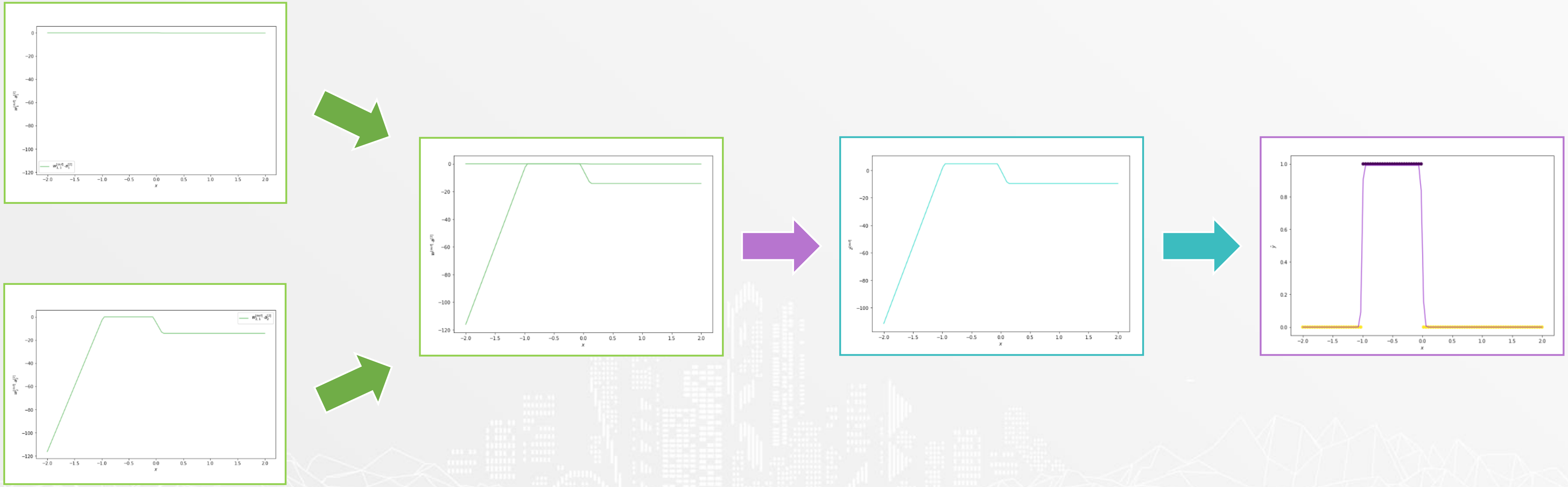




How Deep Learning Work

Classification Example 1

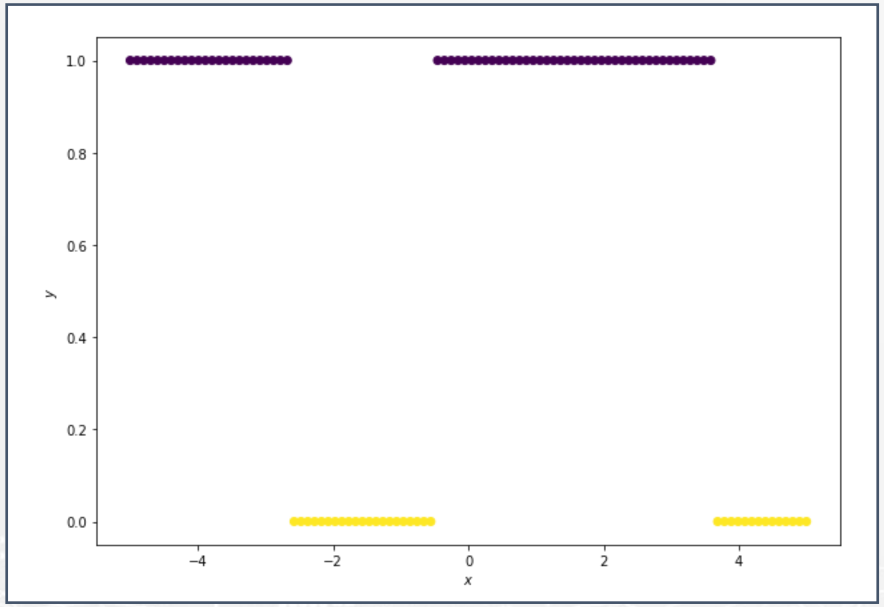




How Deep Learning Work

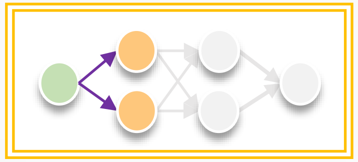
Classification

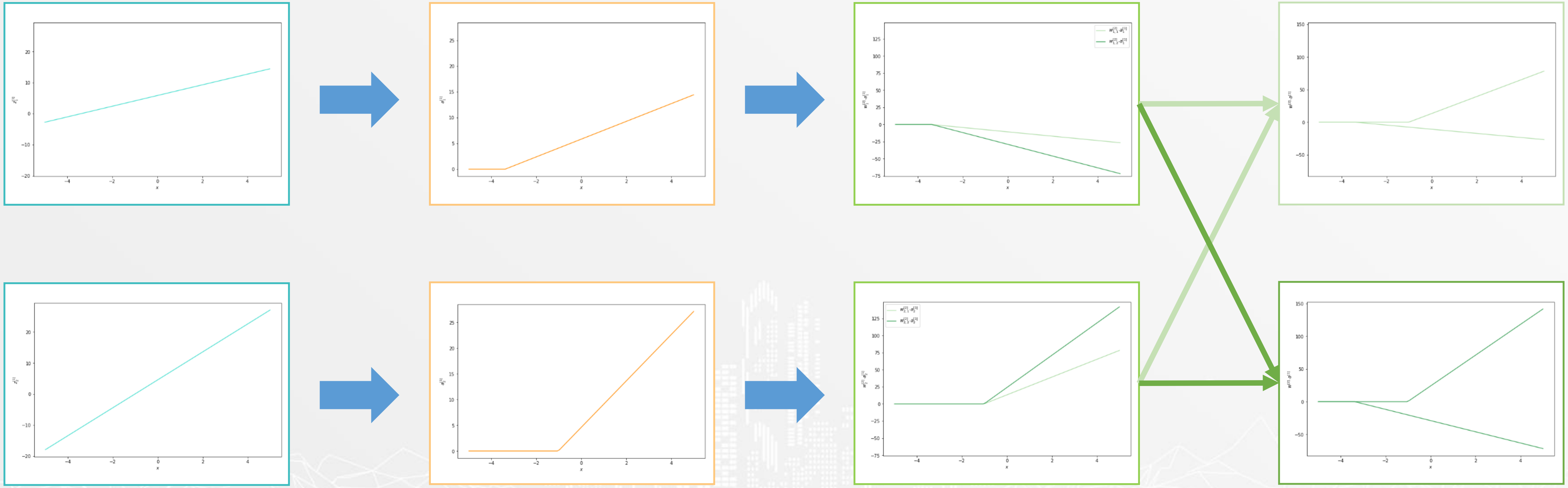
Example 2 : Binary Classification



How Deep Learning Work

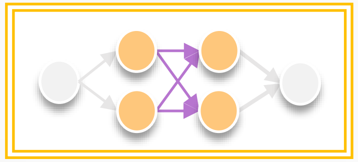
Classification Example 2

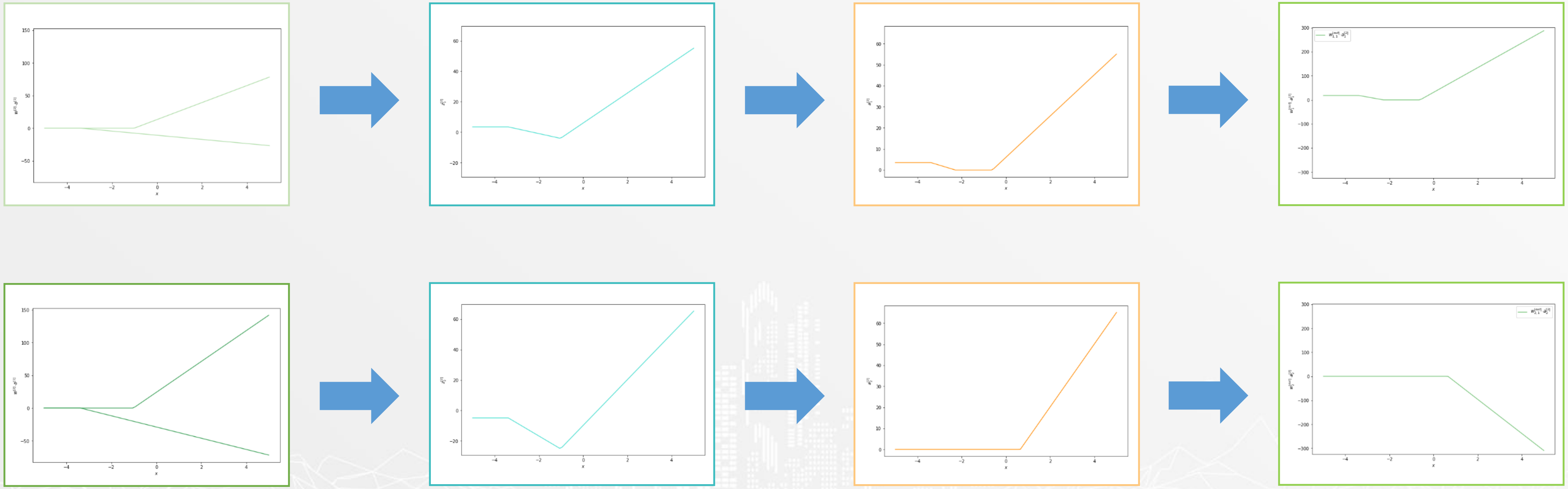




How Deep Learning Work

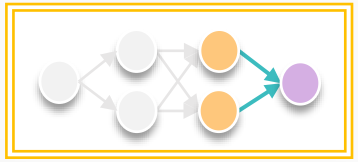
Classification Example 2

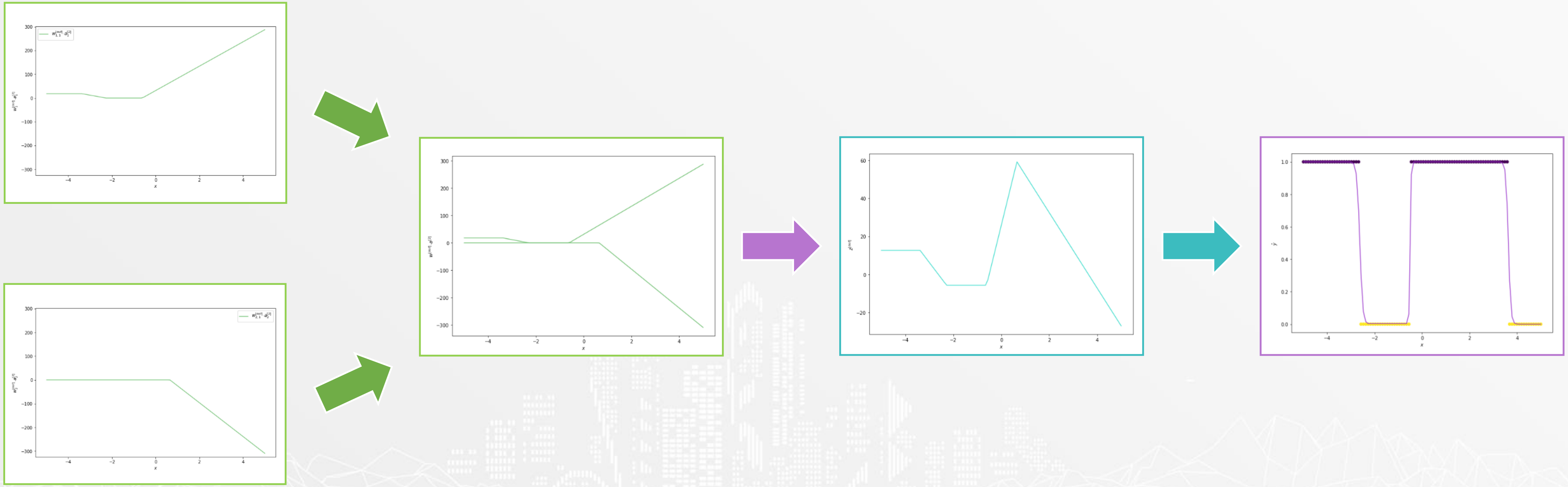




How Deep Learning Work

Classification Example 2

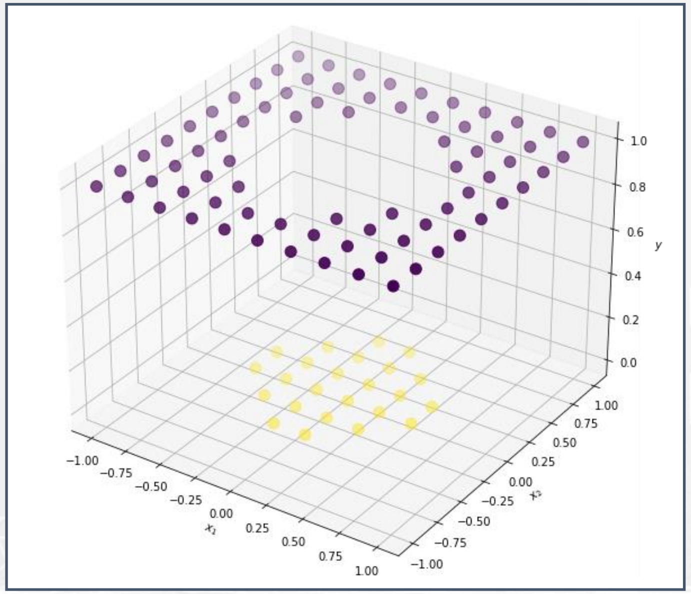


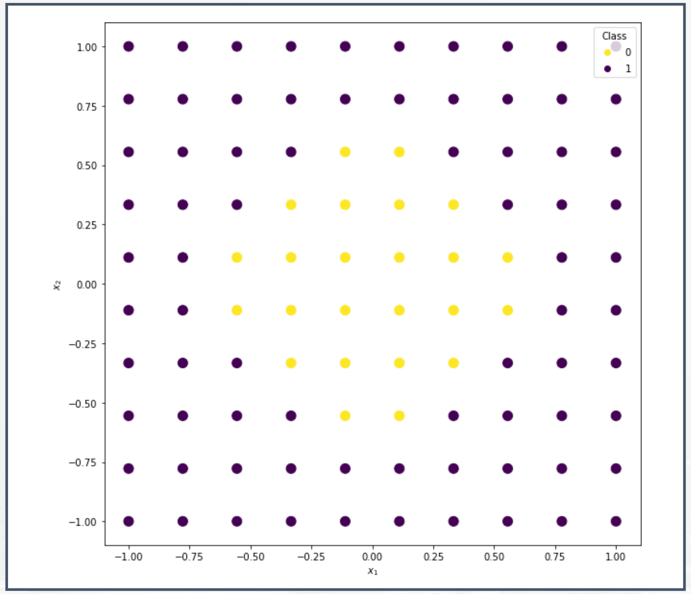


How Deep Learning Work

Classification

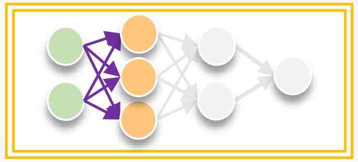
Example 3 : Binary Classification

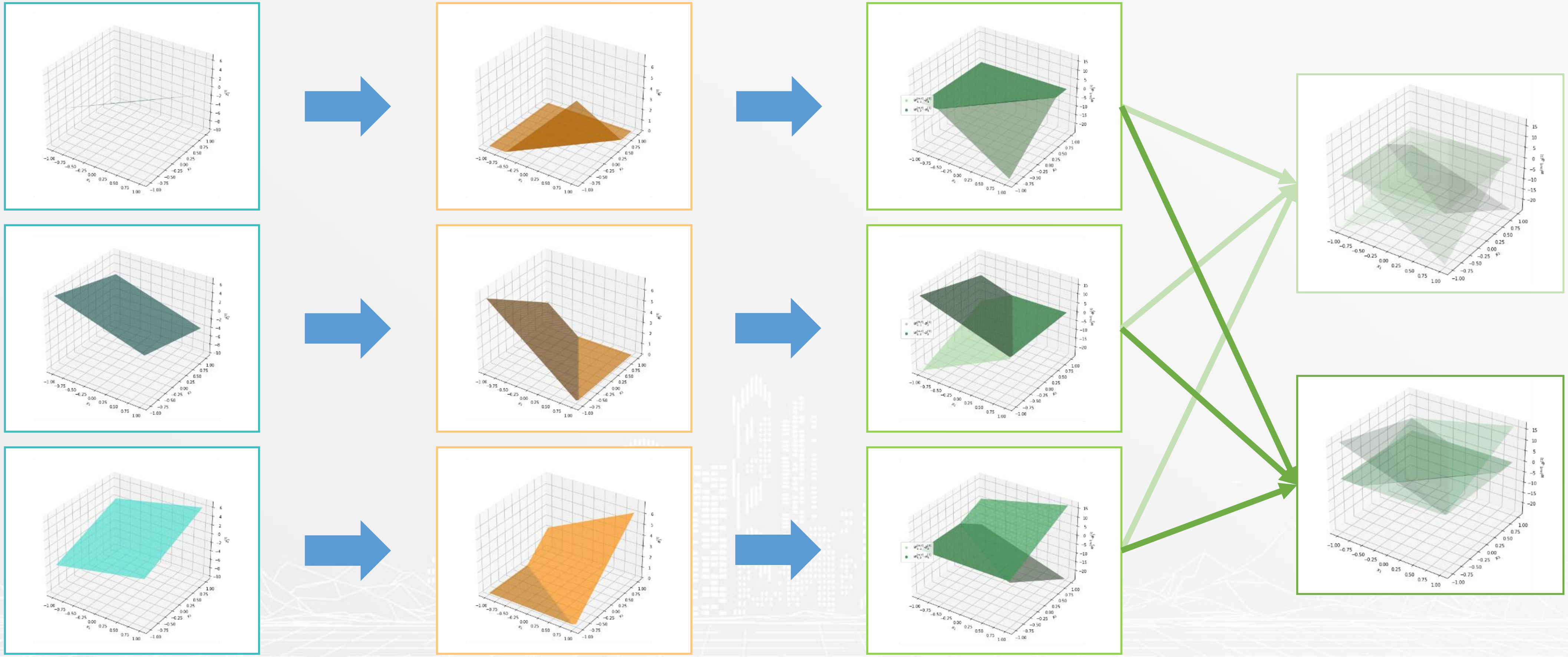




How Deep Learning Work

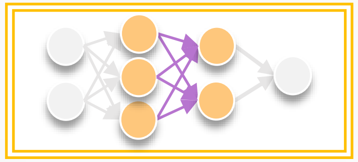
Classification Example 3

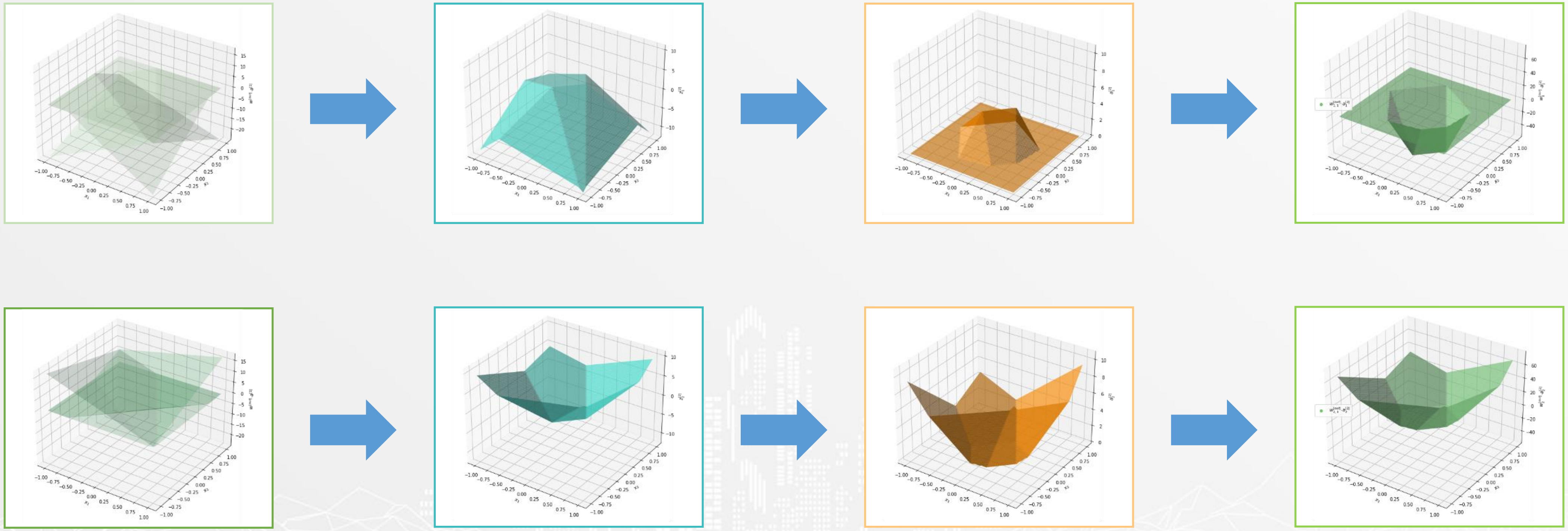




How Deep Learning Work

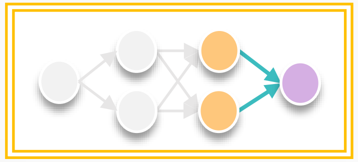
Classification **Example 3**

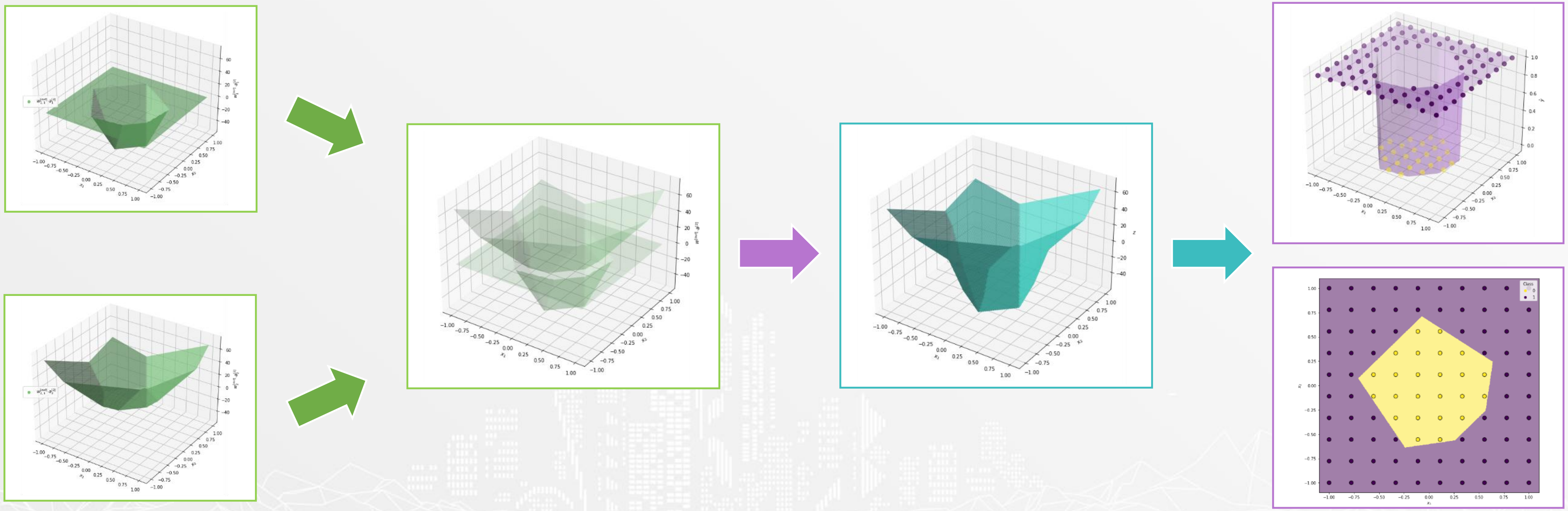




How Deep Learning Work

Classification Example 3

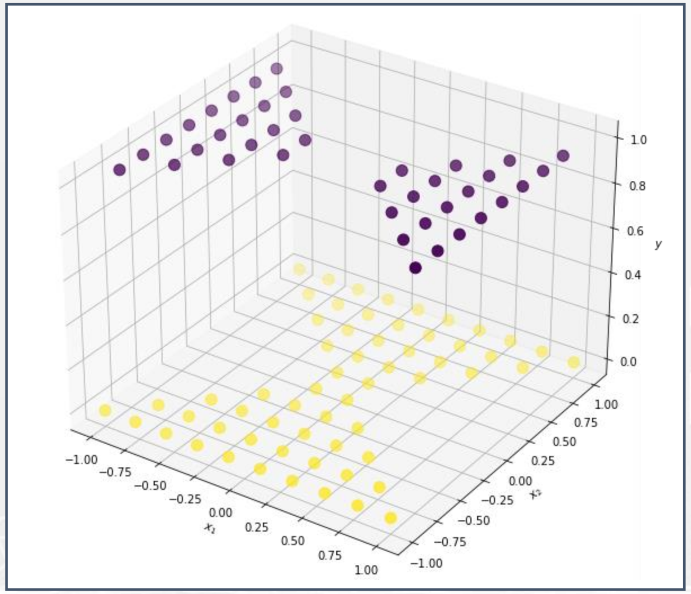


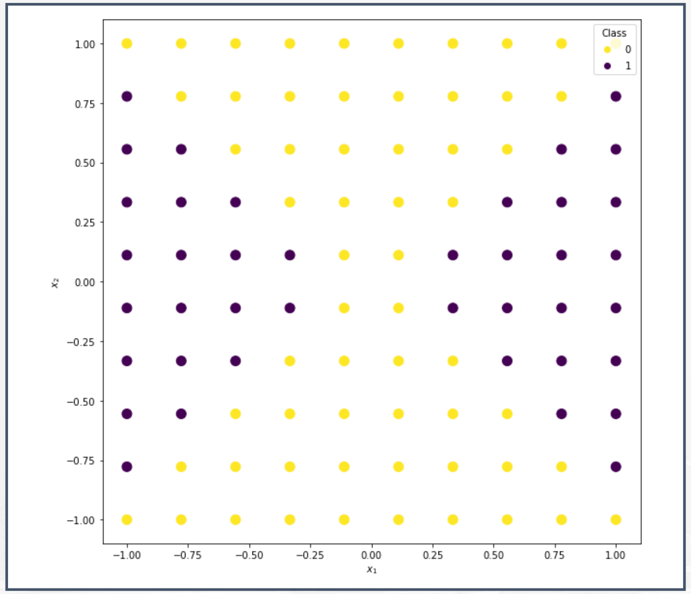


How Deep Learning Work

Classification

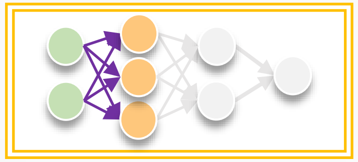
Example 4 : Binary Classification

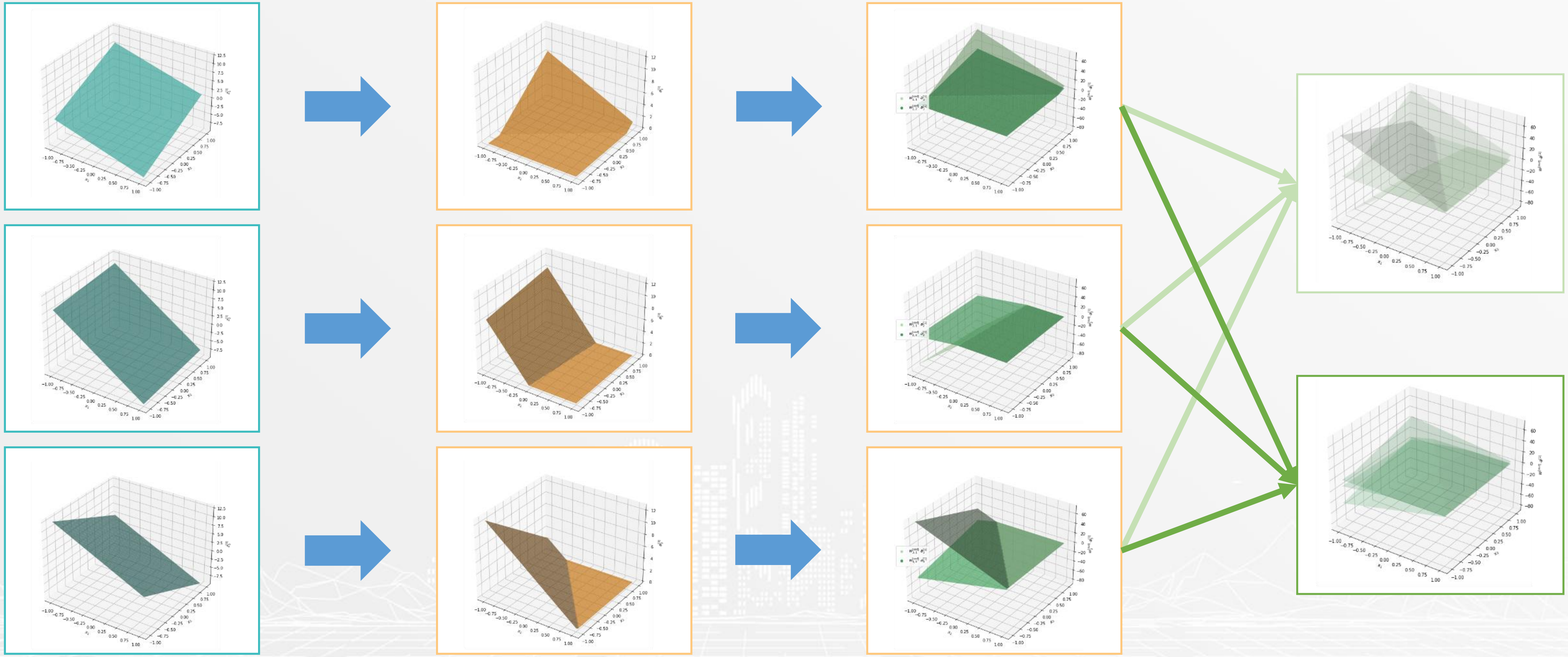




How Deep Learning Work

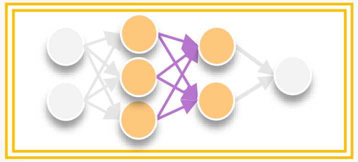
Classification Example 4

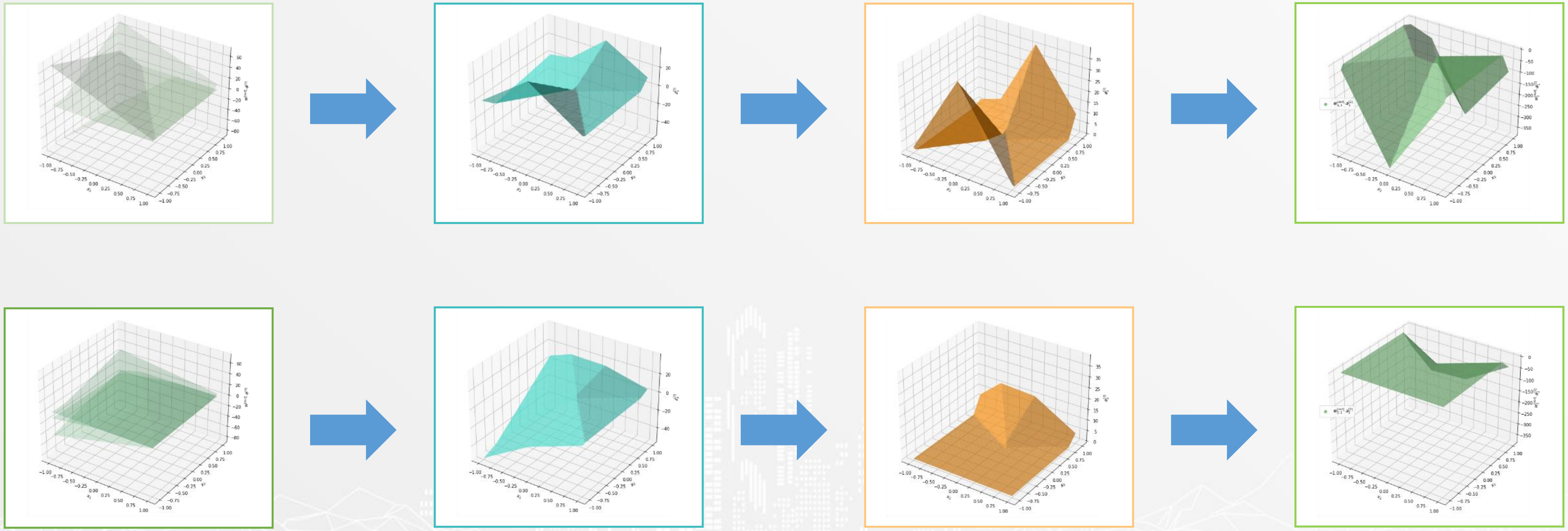




How Deep Learning Work

Classification Example 4





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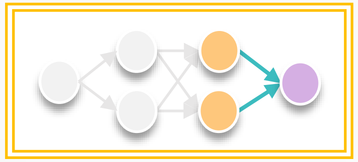
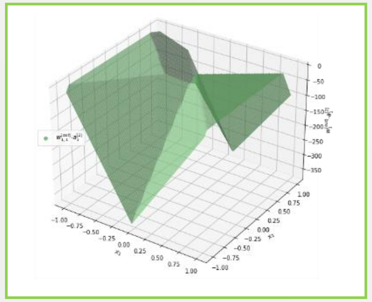
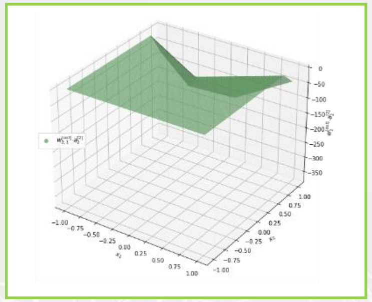
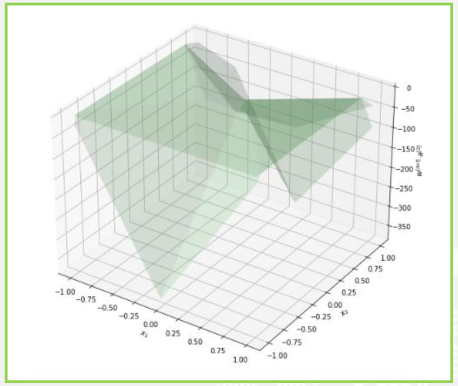
How Deep Learning Work

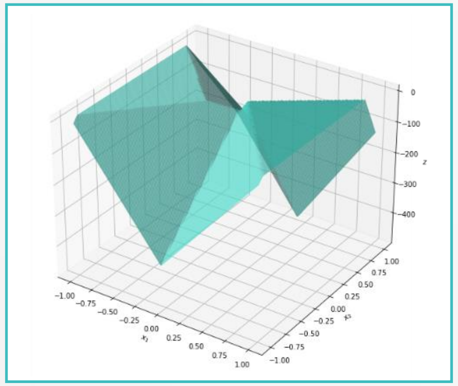
Classification Example 4

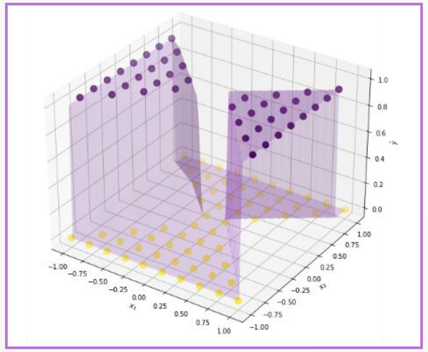


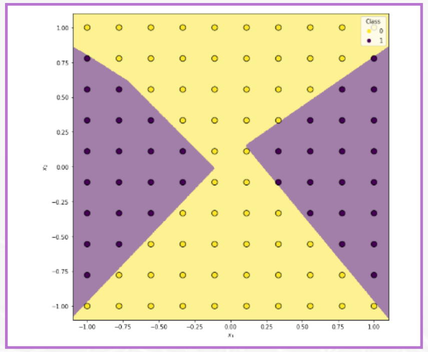








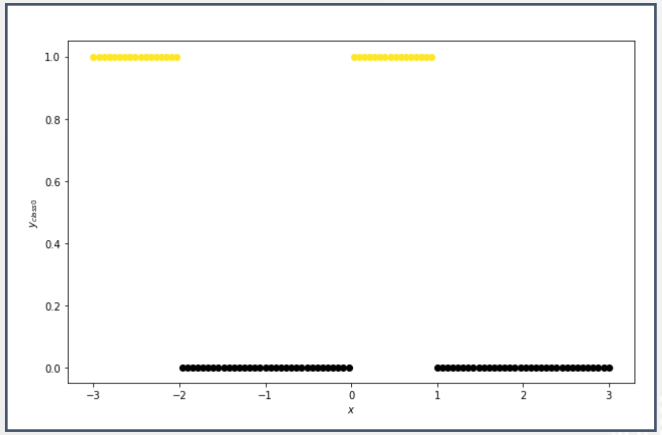


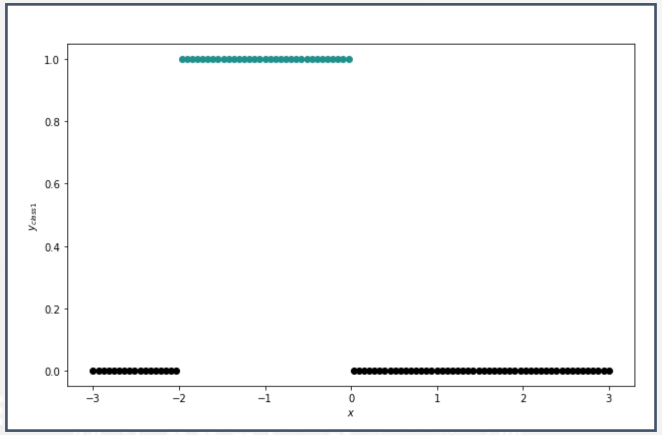


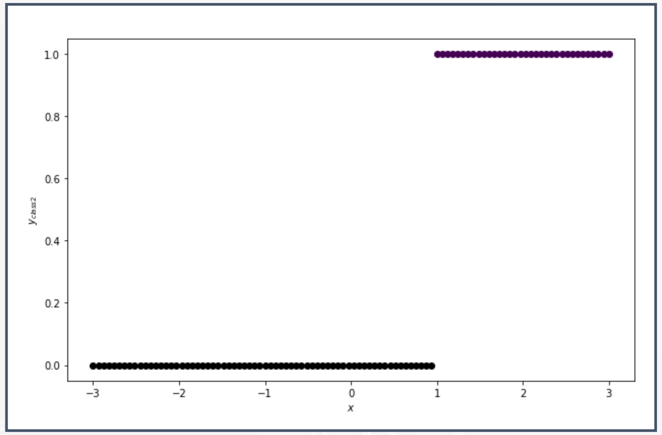
How Deep Learning Work

Classification

Example 5 : Multi-Class Classification

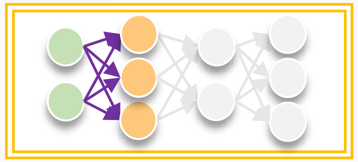


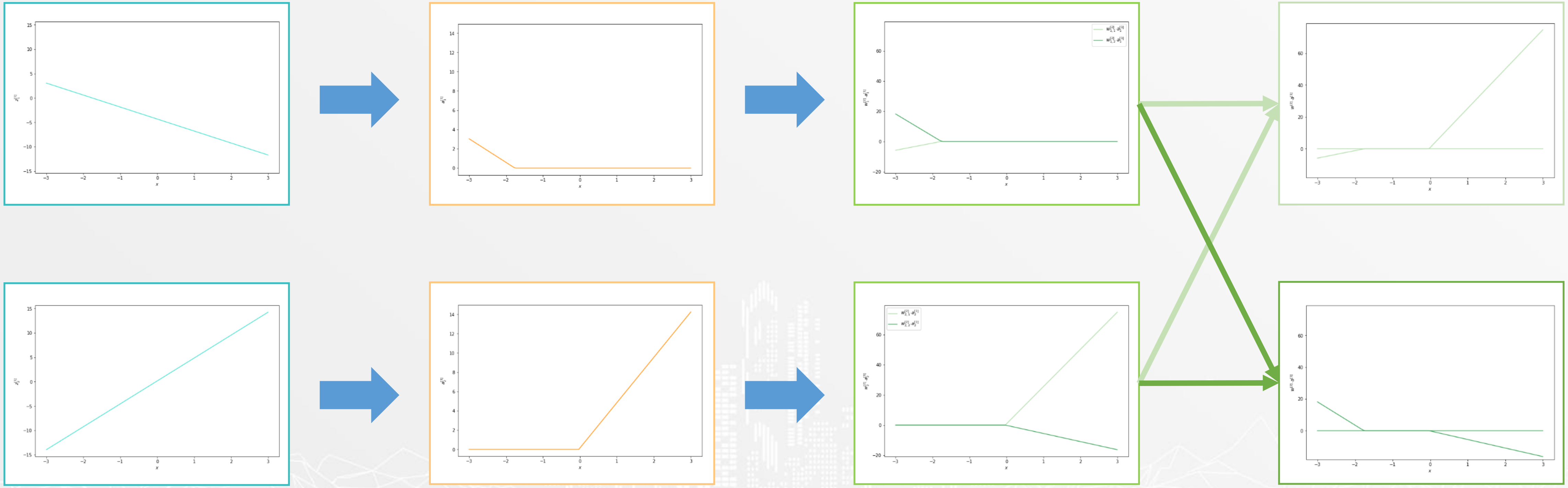




How Deep Learning Work

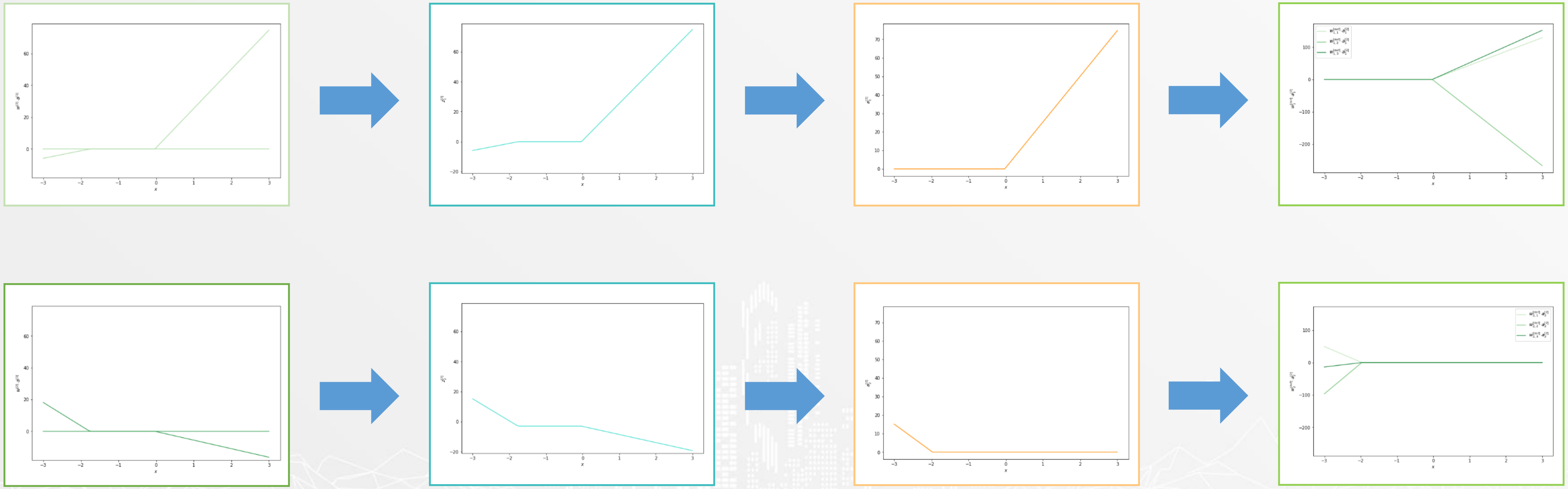
Classification Example 5





How Deep Learning Work

Classification Example 5



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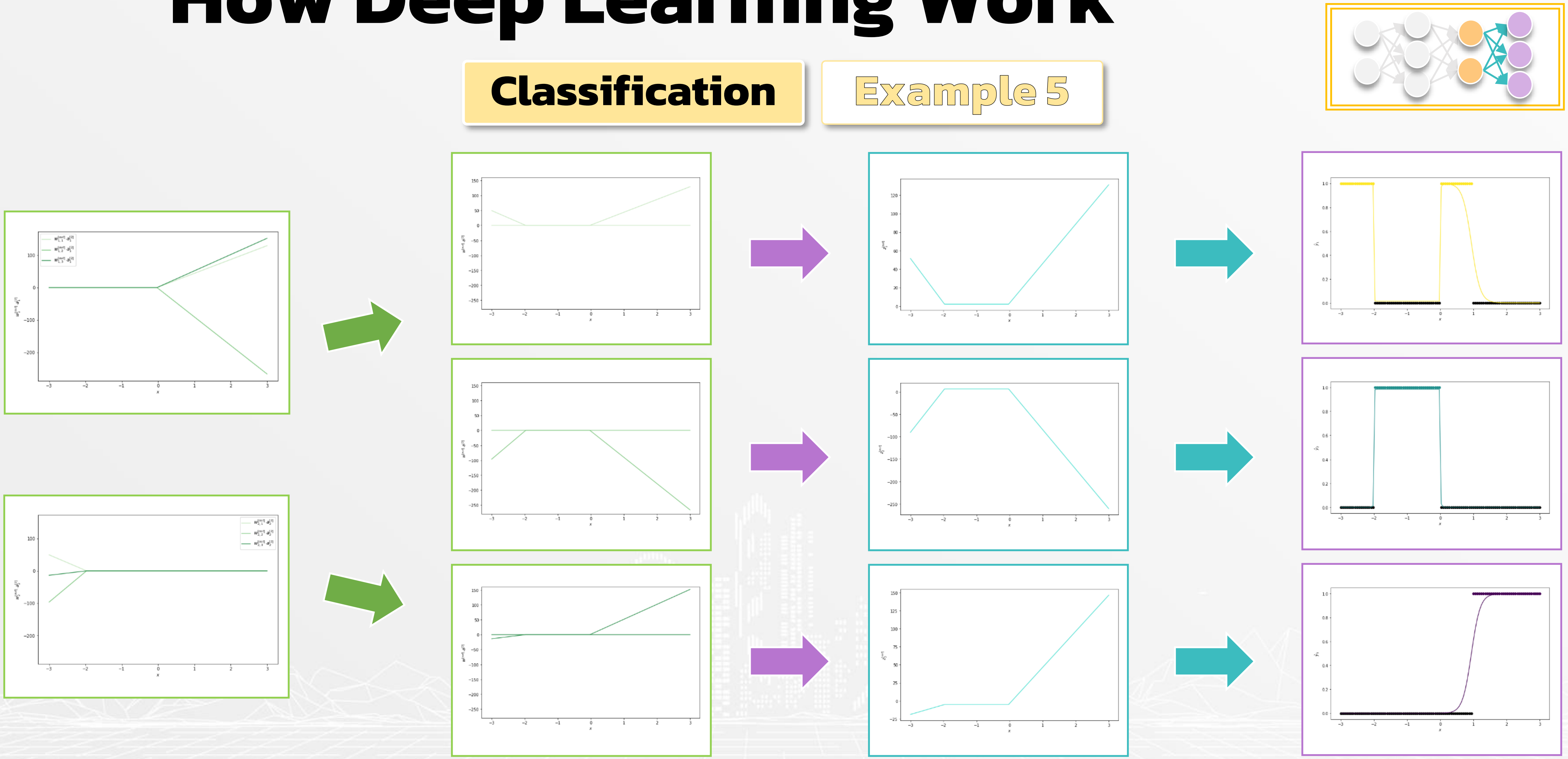
How Deep Learning Work

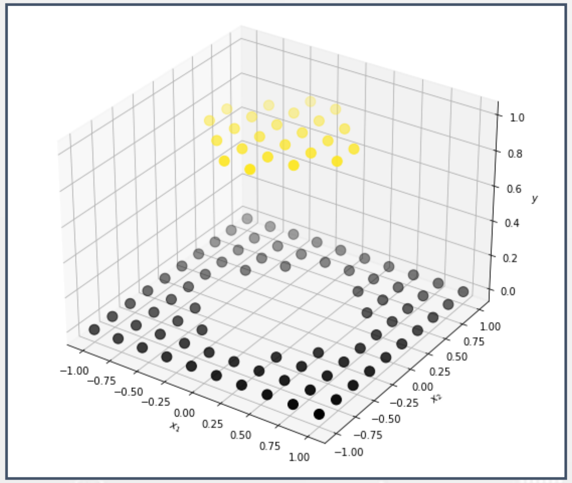
Classification | **Example 5**

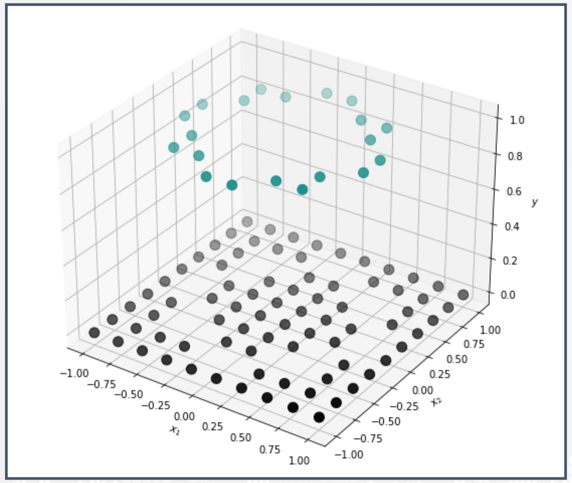


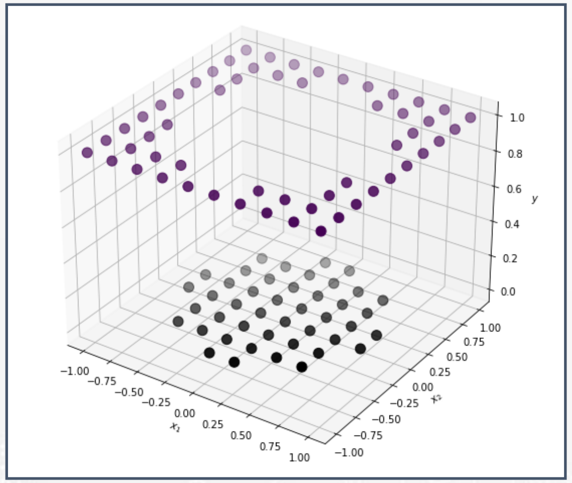
How Deep Learning Work

Classification

Example 6 : Multi-Class Classification

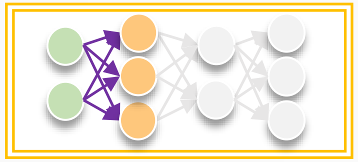


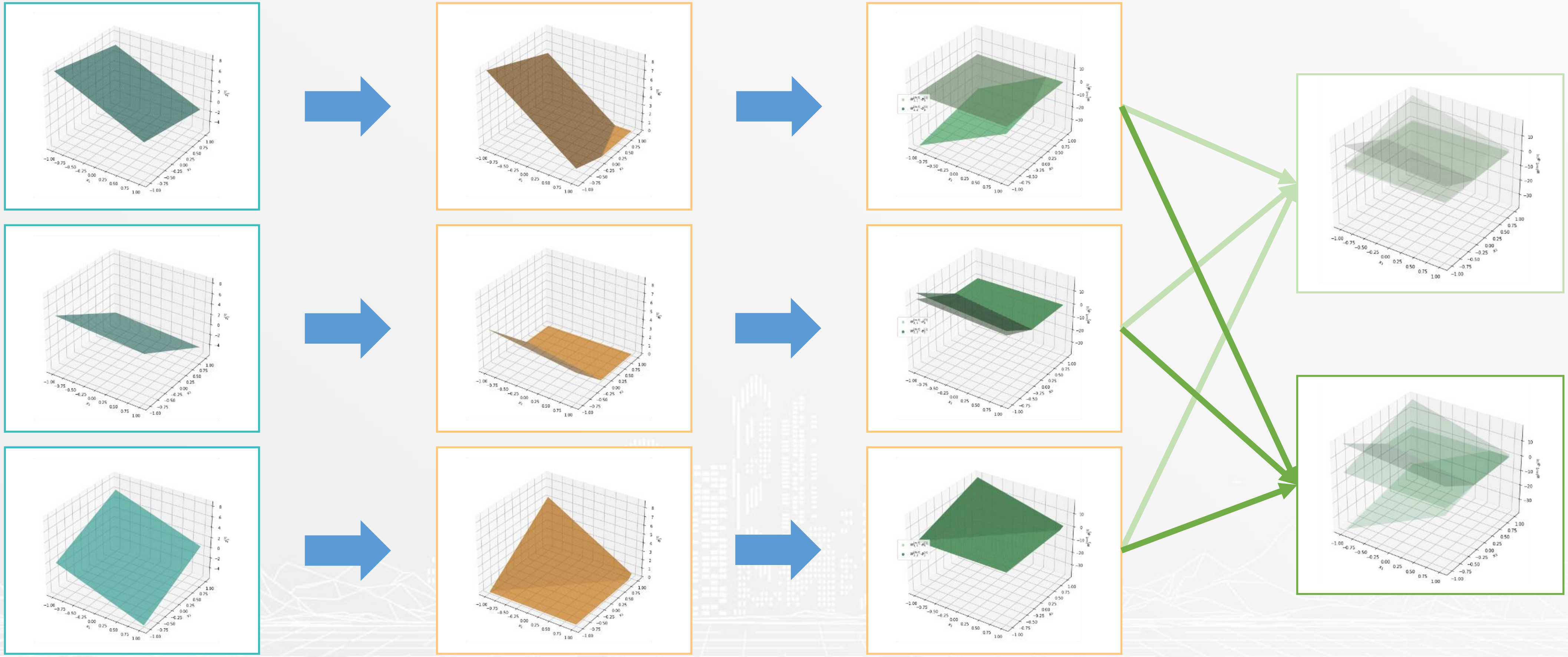




How Deep Learning Work

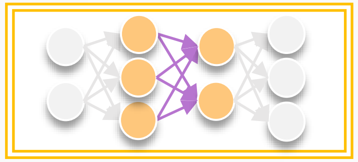
Classification Example 6

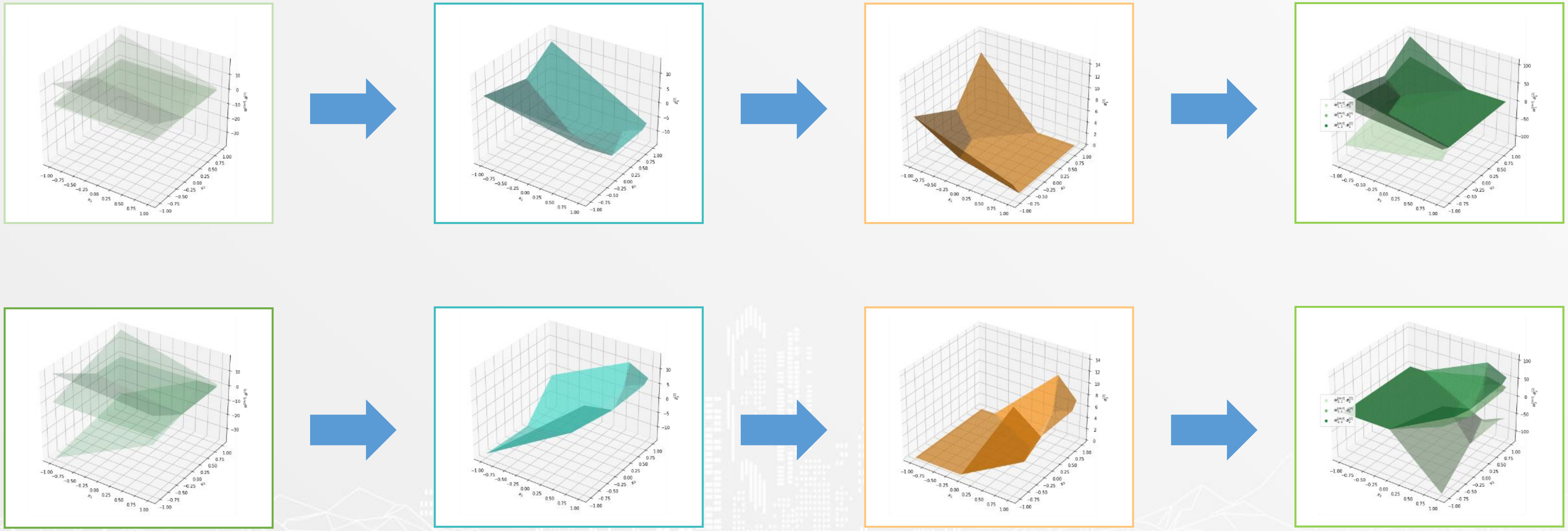




How Deep Learning Work

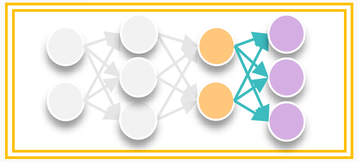
Classification | **Example 6**

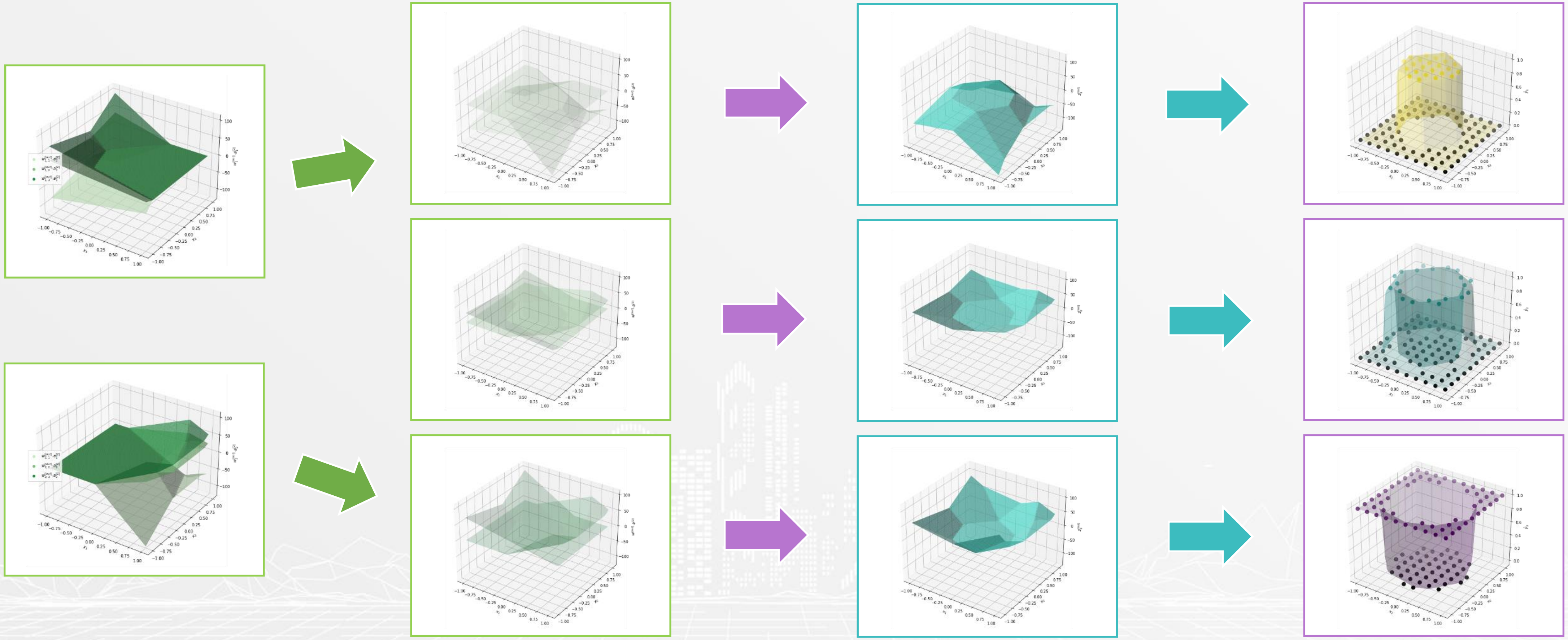




How Deep Learning Work

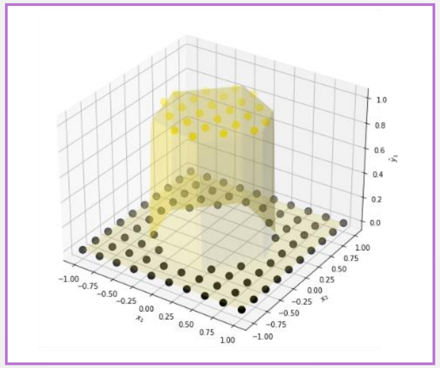
Classification Example 6

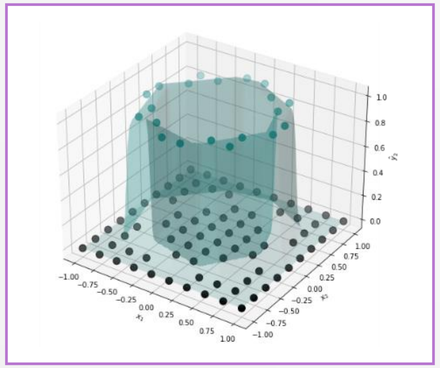


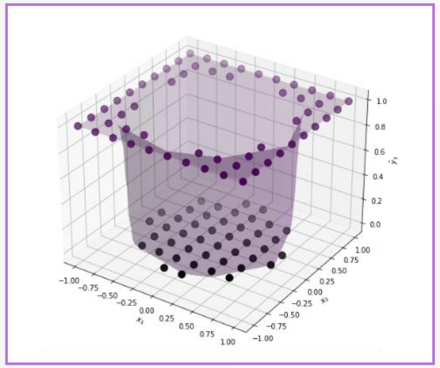


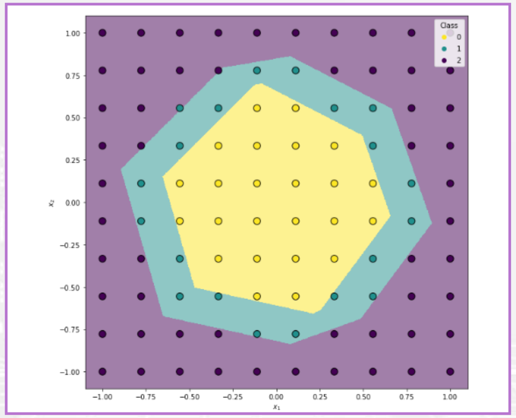
How Deep Learning Work

Classification

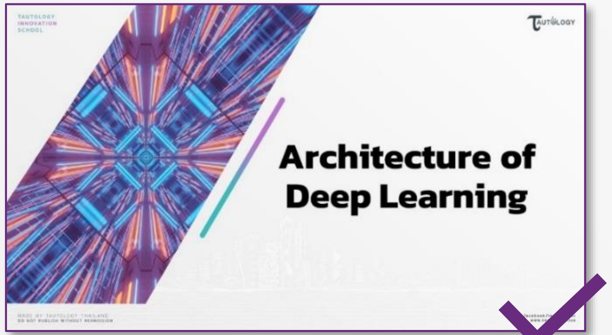


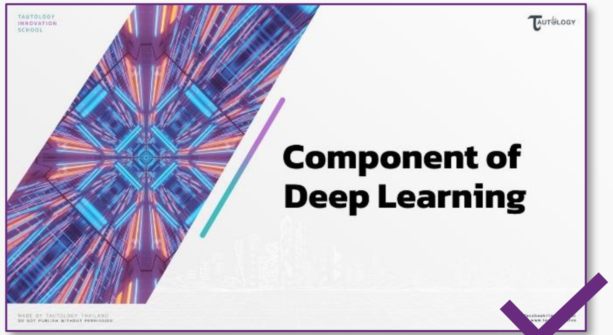






Deep Learning





Neural Network & Deep Learning

- **Neural Network** ✓
- **Deep Learning** ✓
- Deep Learning for Regression
- Deep Learning for Classification
- Workshop

Deep Learning for Regression

Deep Learning เป็นหนึ่งใน algorithm ประเภท supervised learning

Machine Leaning

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

Concept of Supervised Learning

Data ➪ Model ➪ Prediction

Deep Learning for Regression

Model Creation

Model Creation

Assumption

Real Face of the Model

Cost Function and Cost Landscape

How to Create Model (Math)

How to Create Model (Code)

Assumption

1. Non Linear Relationship
2. Normality of Residuals
3. Homoscedasticity
4. No Missing Features
5. No Multicollinearity

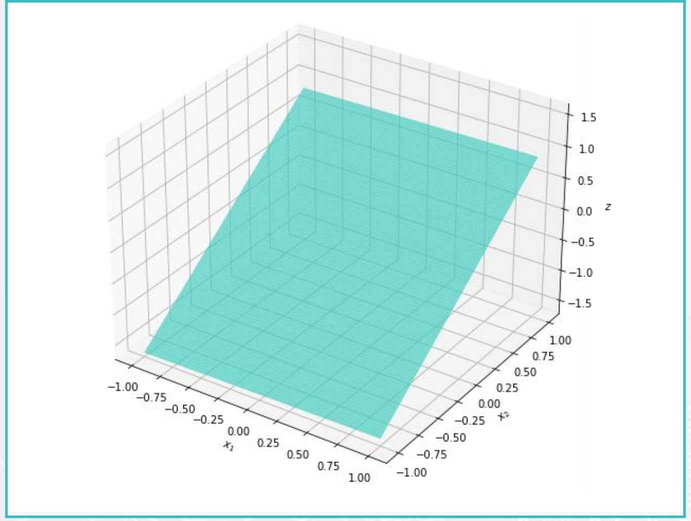
Model Creation

- **Assumption**
- Real Face of the Model
- Cost Function and Cost Landscape
- How to Create Model (Math)
- How to Create Model (Code)

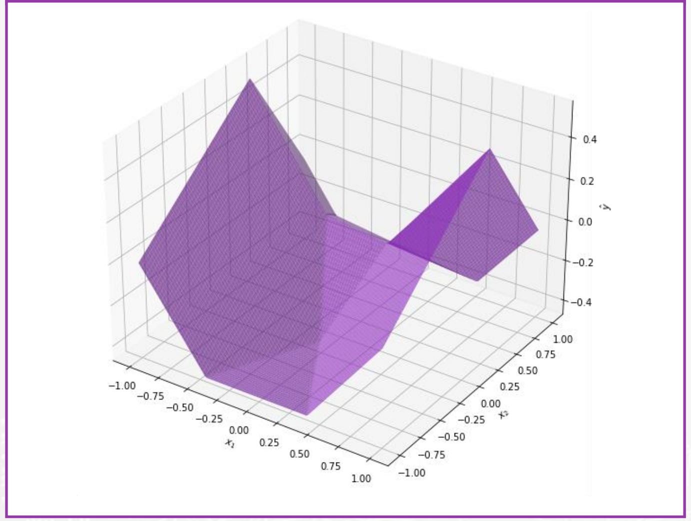
Real Face of the Model

แนวคิดของ deep learning คือ การนำเอา hyperplane หัก ๆ มาประกอบกัน เพื่อให้สามารถประมาณ nonlinear function ที่ซับซ้อนได้

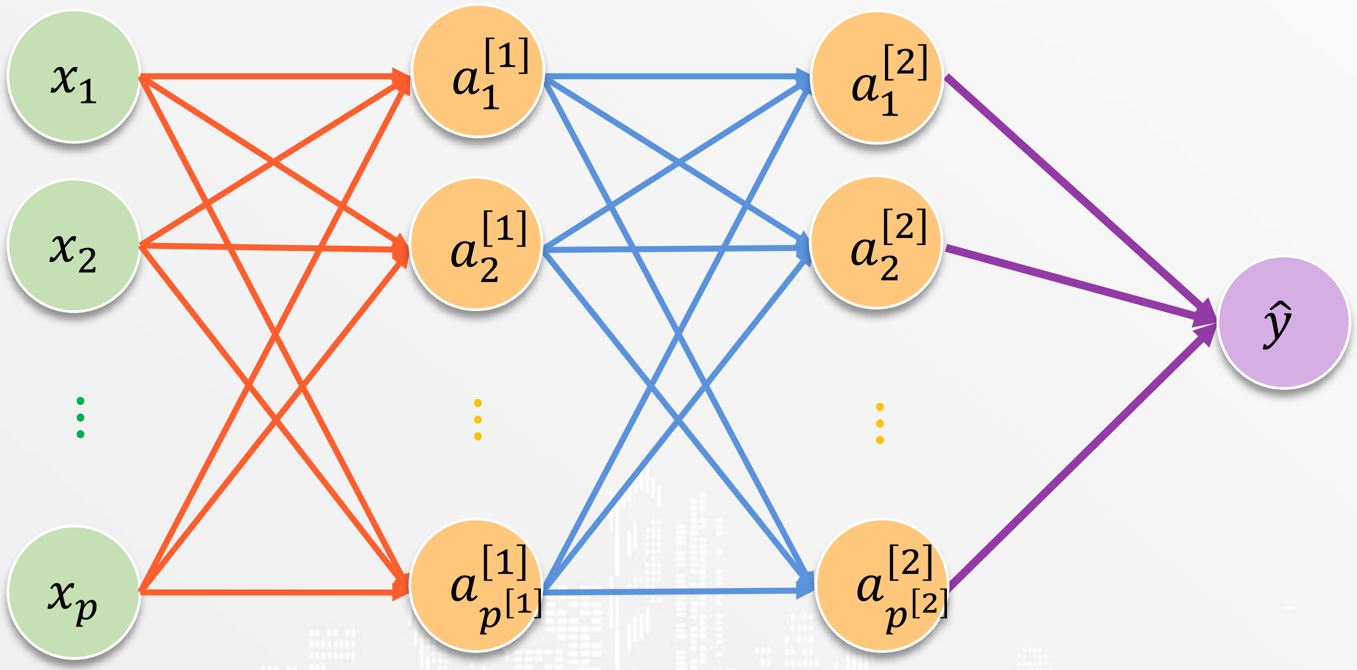
Linear Regression



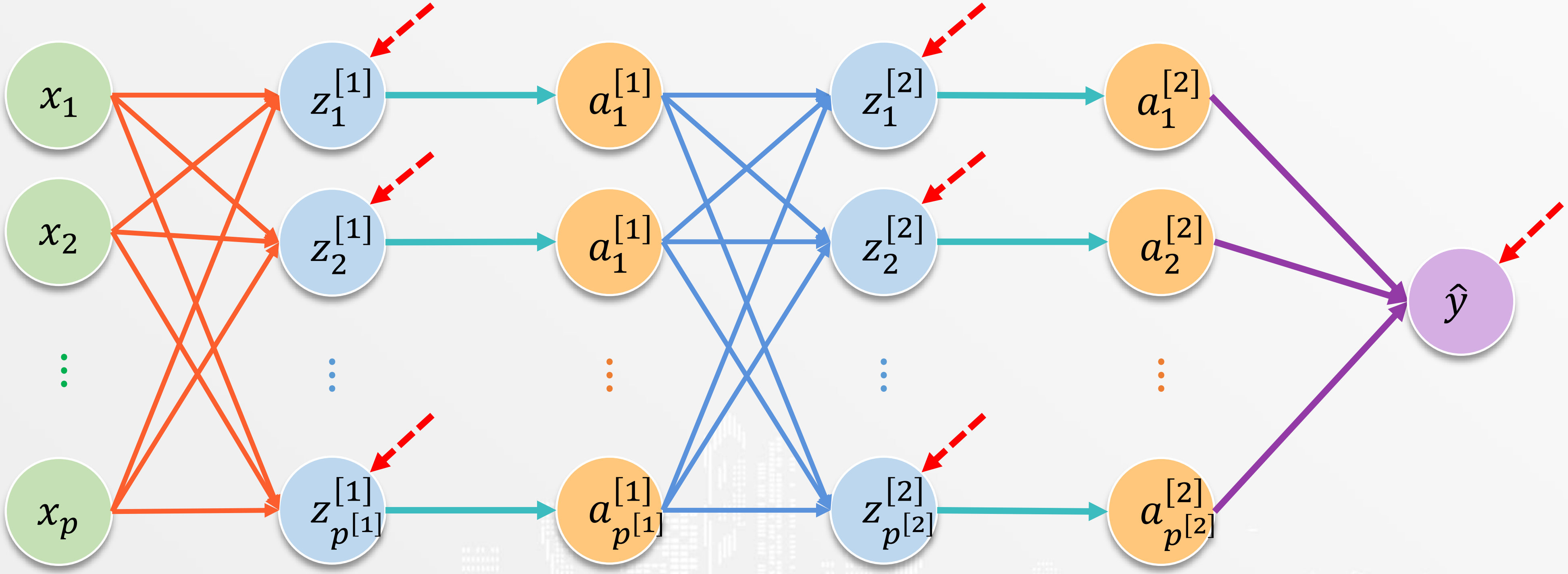
Deep Learning



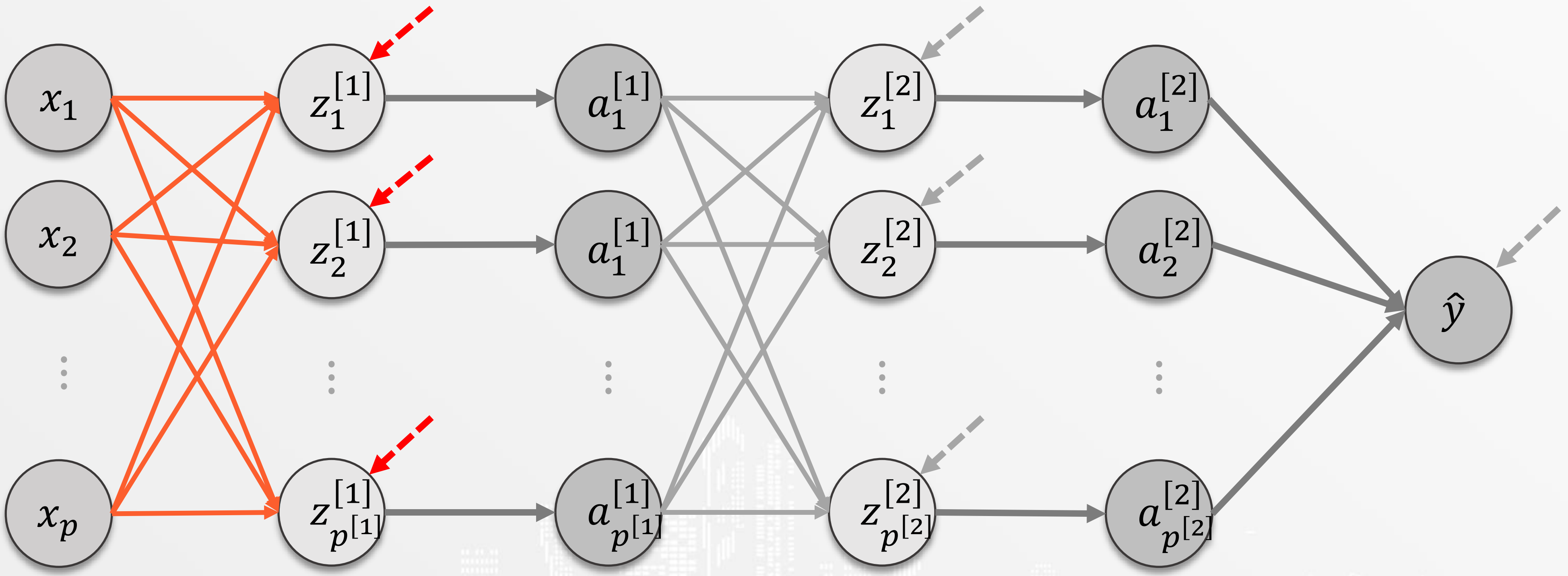
Real Face of the Model



Real Face of the Model



Real Face of the Model

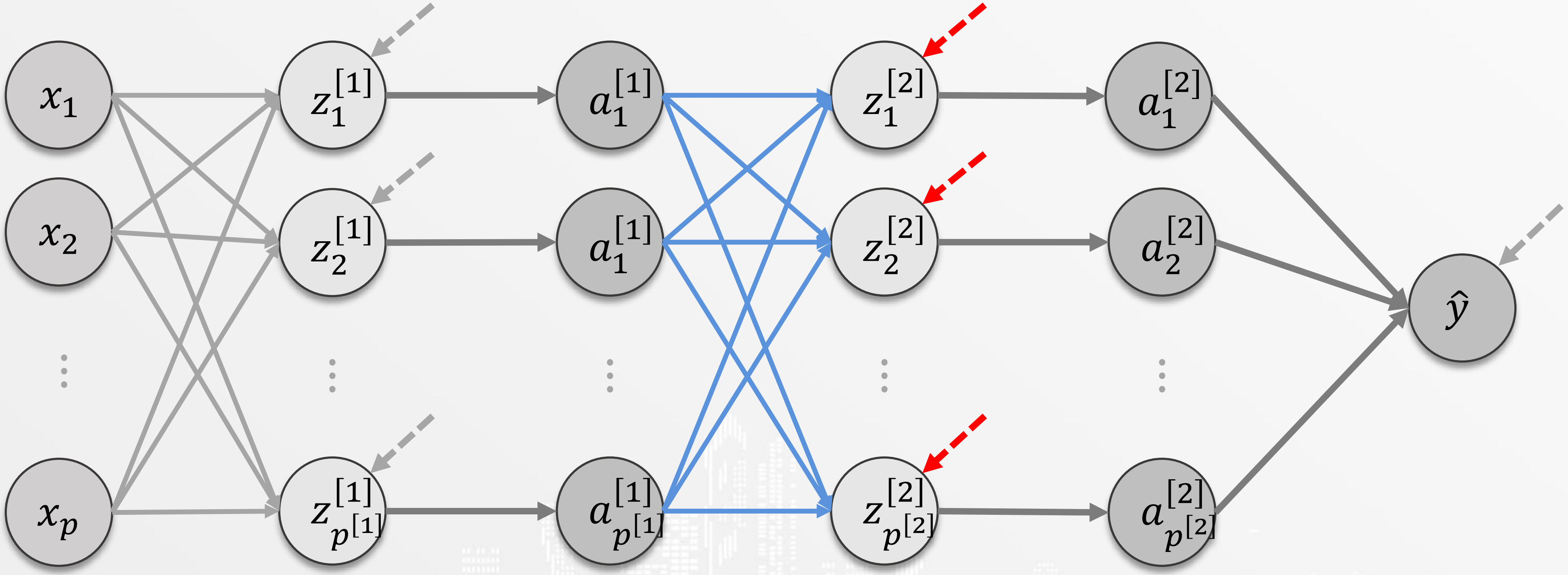


Real Face of the Model

$$b^{[1]} = \begin{bmatrix} b_1^{[1]} & b_2^{[1]} & \cdots & b_{p^{[1]}}^{[1]} \end{bmatrix}$$

$$W^{[1]} = \begin{bmatrix} w_{1,1}^{[1]} & w_{1,2}^{[1]} & \cdots & w_{1,p^{[1]}}^{[1]} \\ w_{2,1}^{[1]} & w_{2,2}^{[1]} & \cdots & w_{2,p^{[1]}}^{[1]} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p,1}^{[1]} & w_{p,2}^{[1]} & \cdots & w_{p,p^{[1]}}^{[1]} \end{bmatrix}$$

Real Face of the Model

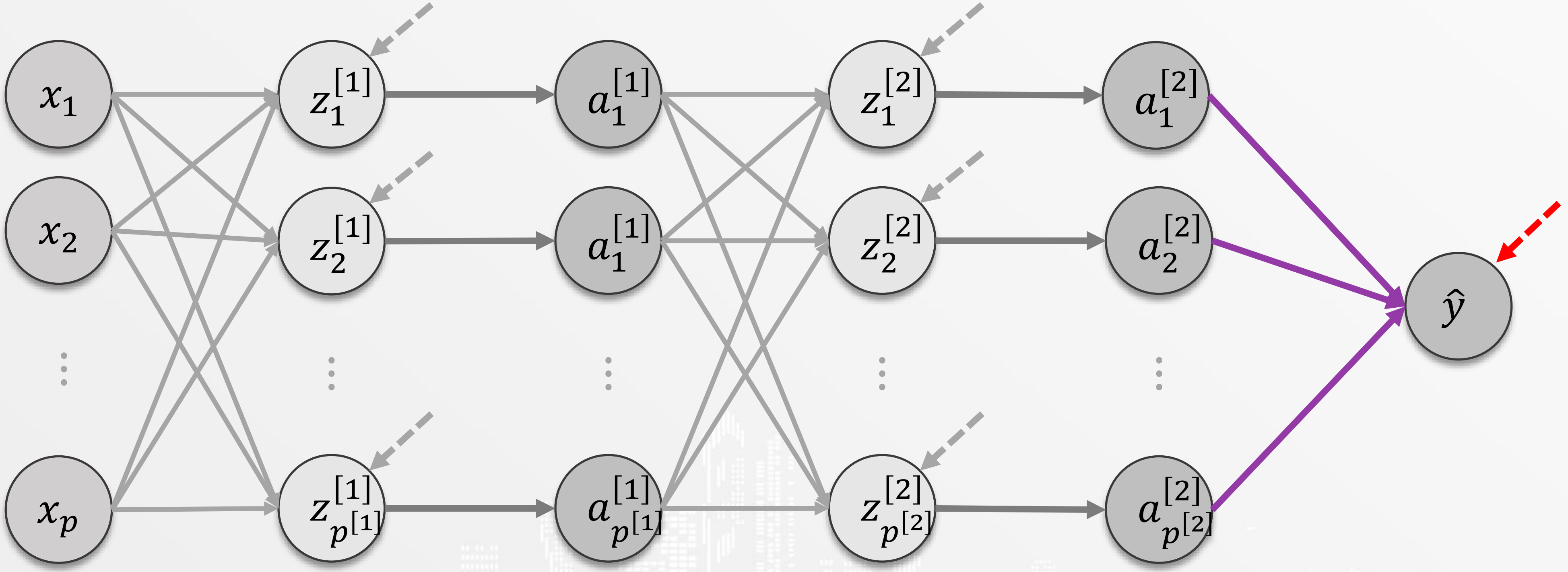


Real Face of the Model

$$b^{[2]} = \begin{bmatrix} b_1^{[2]} & b_2^{[2]} & \cdots & b_{p^{[2]}}^{[2]} \end{bmatrix}$$

$$W^{[2]} = \begin{bmatrix} w_{1,1}^{[2]} & w_{1,2}^{[2]} & \cdots & w_{1,p^{[2]}}^{[2]} \\ w_{2,1}^{[2]} & w_{2,2}^{[2]} & \cdots & w_{2,p^{[2]}}^{[2]} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p,1}^{[2]} & w_{p,2}^{[2]} & \cdots & w_{p,p^{[2]}}^{[2]} \end{bmatrix}$$

Real Face of the Model



Real Face of the Model

$$b^{[out]} = \left[b^{[out]} \right]$$

$$W^{[out]} = \begin{bmatrix} w_1^{[out]} \\ w_2^{[out]} \\ \vdots \\ w_{p^{[2]}}^{[out]} \end{bmatrix}$$

Real Face of the Model

$$b^{[1]}, b^{[2]}, b^{[out]}$$

$$W^{[1]}, W^{[2]}, W^{[out]}$$

Real Face of the Model

$$b^{[1]}, b^{[2]}, \dots, b^{[L]}, b^{[out]}$$

$$W^{[1]}, W^{[2]}, \dots, W^{[L]}, W^{[out]}$$

Real Face of the Model

เราต้องการหา $b^{[1]}, b^{[2]}, \ldots, b^{[L]}, b^{[out]}$ และ $W^{[1]}, W^{[2]}, \ldots, W^{[L]}, W^{[out]}$ ที่ทำให้ cost function ต่ำที่สุด

Model Creation

Assumption

Real Face of the Model

Cost Function and Cost Landscape

How to Create Model (Math)

How to Create Model (Code)

Cost Function & Cost Landscape

Cost function ที่เราจะใช้ในการสร้าง model คือ

$$-\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

โดยสูตรข้างต้นมีชื่อว่า mean square error หรือ MSE

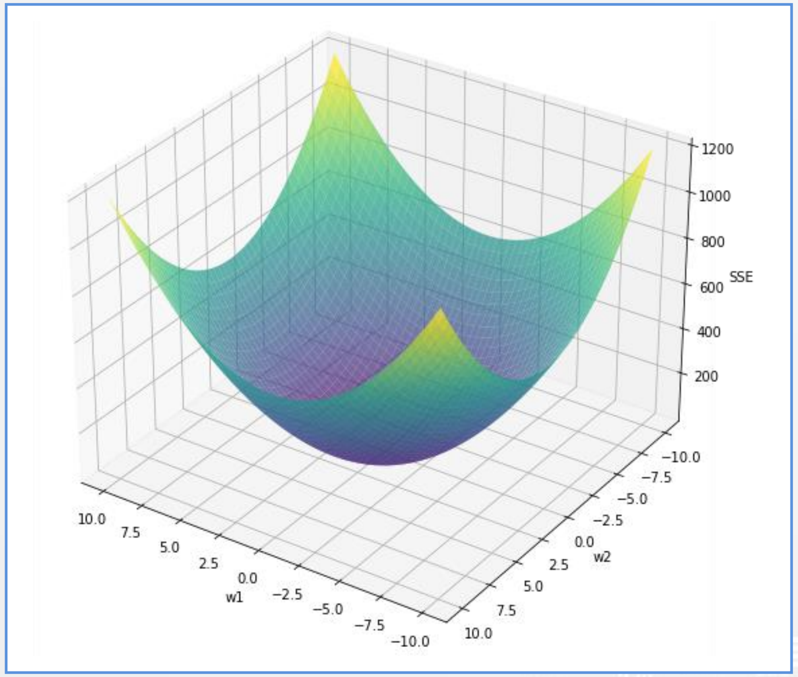
Cost Function & Cost Landscape

Q : ทำไมไม่ใช้ sum of squared error หรือ SSE เป็น cost function เหมือนตอนสร้าง linear regression

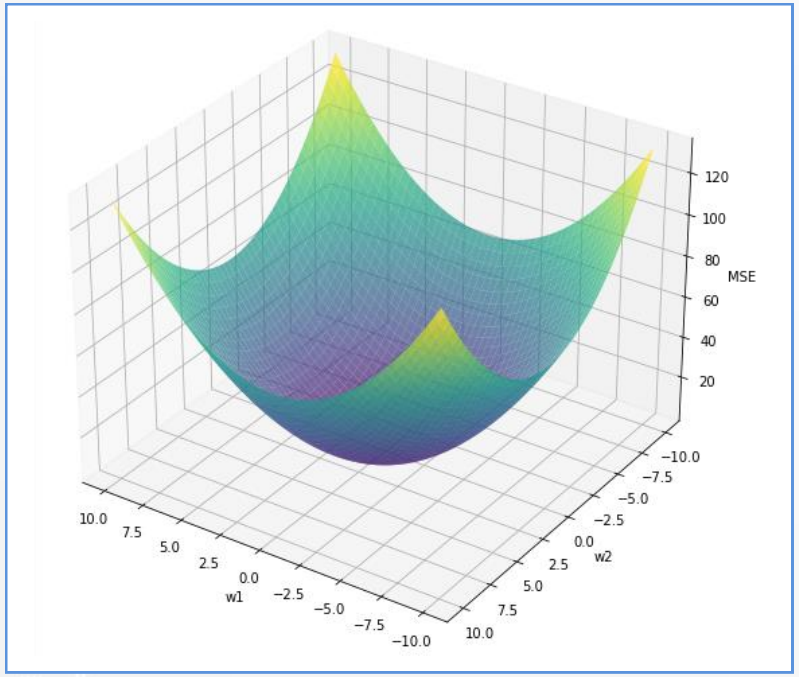
Cost Function & Cost Landscape

A : เนื่องจาก deep learning ใช้ gradient descent ในการสร้าง model ทำให้การใช้ค่าเฉลี่ยมีความเหมาะสมมากกว่า

Cost Function & Cost Landscape

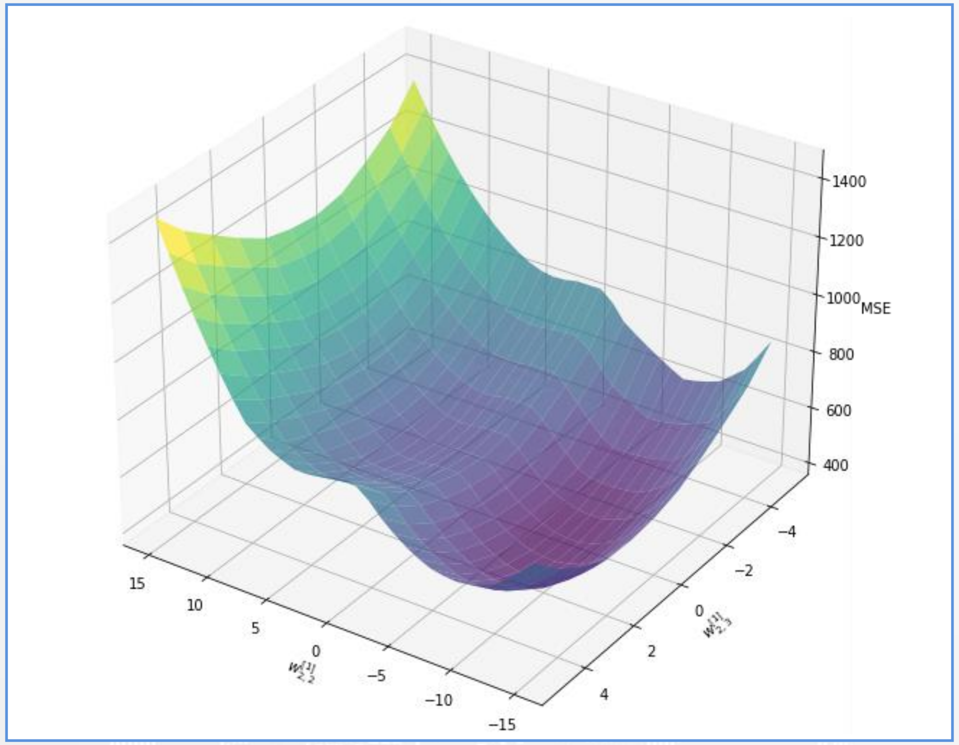


กราฟแสดง cost landscape ของ linear regression โดยที่ cost function เป็น SSE



กราฟแสดง cost landscape ของ linear regression โดยที่ cost function เป็น MSE

Cost Function & Cost Landscape



กราฟแสดง cost landscape ของ deep learning
โดยที่ cost function เป็น MSE

Cost Function & Cost Landscape

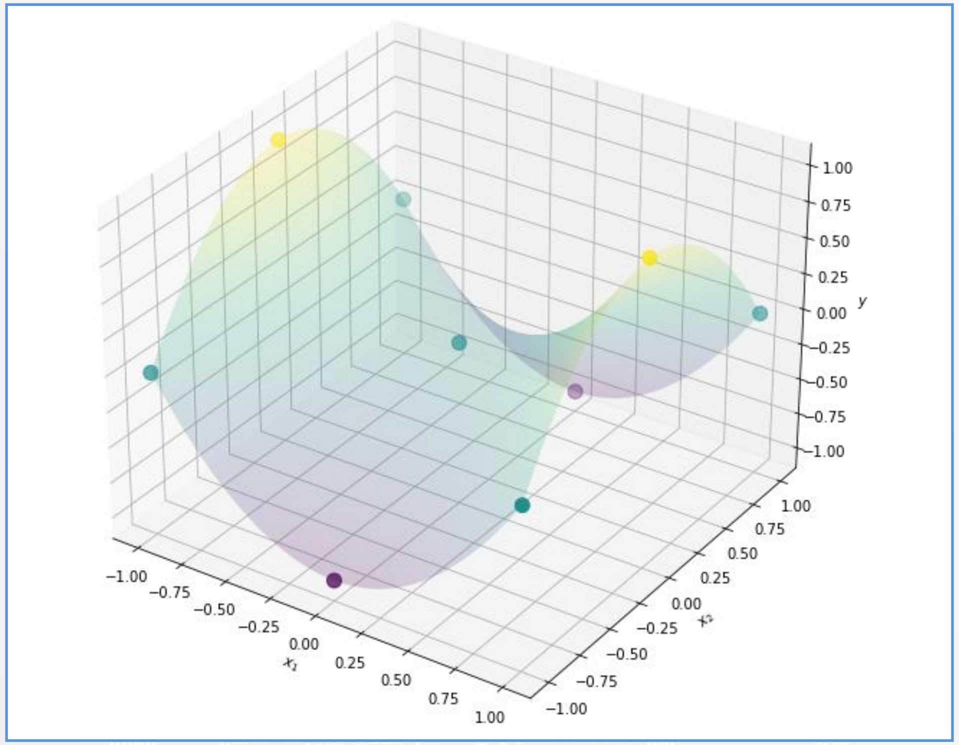
ตัวอย่างการ plot cost landscape ของ deep learning

x_1	x_2	y
-1	-1	2
0	-1	1
1	-1	2
-1	0	1
0	0	0

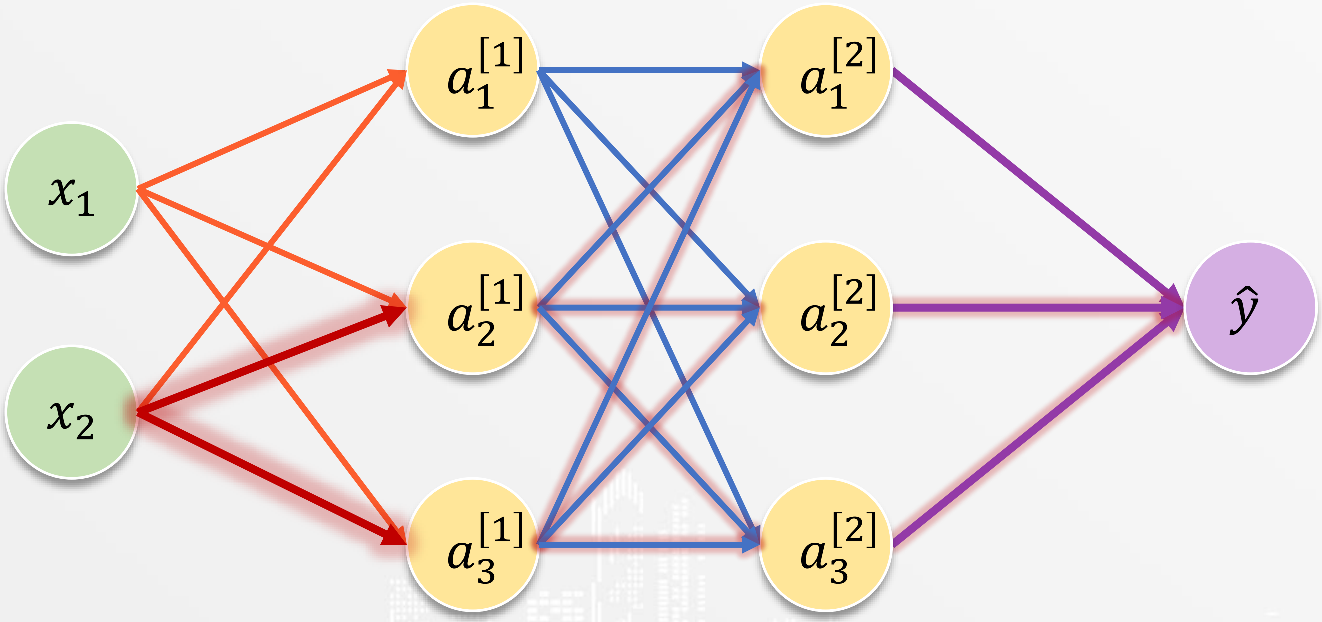
x_1	x_2	y
1	0	1
-1	1	2
0	1	1
1	1	0

ตารางแสดง toy dataset

Cost Function & Cost Landscape



Cost Function & Cost Landscape



Cost Function & Cost Landscape

$$\hat{y} = b^{[out]} + w_1^{[out]} a_1^{[1]} + w_2^{[out]} a_2^{[1]} + w_3^{[out]} a_3^{[1]}$$

$$a_1^{[1]} = ReLU\left(b_1^{[1]} + w_{1,1}^{[1]} x_1 + w_{2,1}^{[1]} x_2\right)$$

$$a_2^{[1]} = ReLU\left(b_2^{[1]} + w_{1,2}^{[1]} x_1 + w_{2,2}^{[1]} x_2\right)$$

$$a_3^{[1]} = ReLU\left(b_3^{[1]} + w_{1,3}^{[1]} x_1 + w_{2,3}^{[1]} x_2\right)$$

Cost Function & Cost Landscape

กำหนดให้

$$b^{[1]} = [-2 \quad -1 \quad 1]$$

$$W^{[1]} = \begin{bmatrix} -1 & 3 & -3 \\ 0 & ? & ? \end{bmatrix}$$

พิจารณา $w_{2,2}^{[1]}, w_{2,3}^{[1]}$

Cost Function & Cost Landscape

กำหนดให้

$$b^{[2]} = \begin{bmatrix} -2 & -1 & -2 \end{bmatrix}$$

$$W^{[2]} = \begin{bmatrix} -1 & 1 & 0 \\ 1 & 1 & 0 \\ 3 & -2 & 0 \end{bmatrix}$$

Cost Function & Cost Landscape

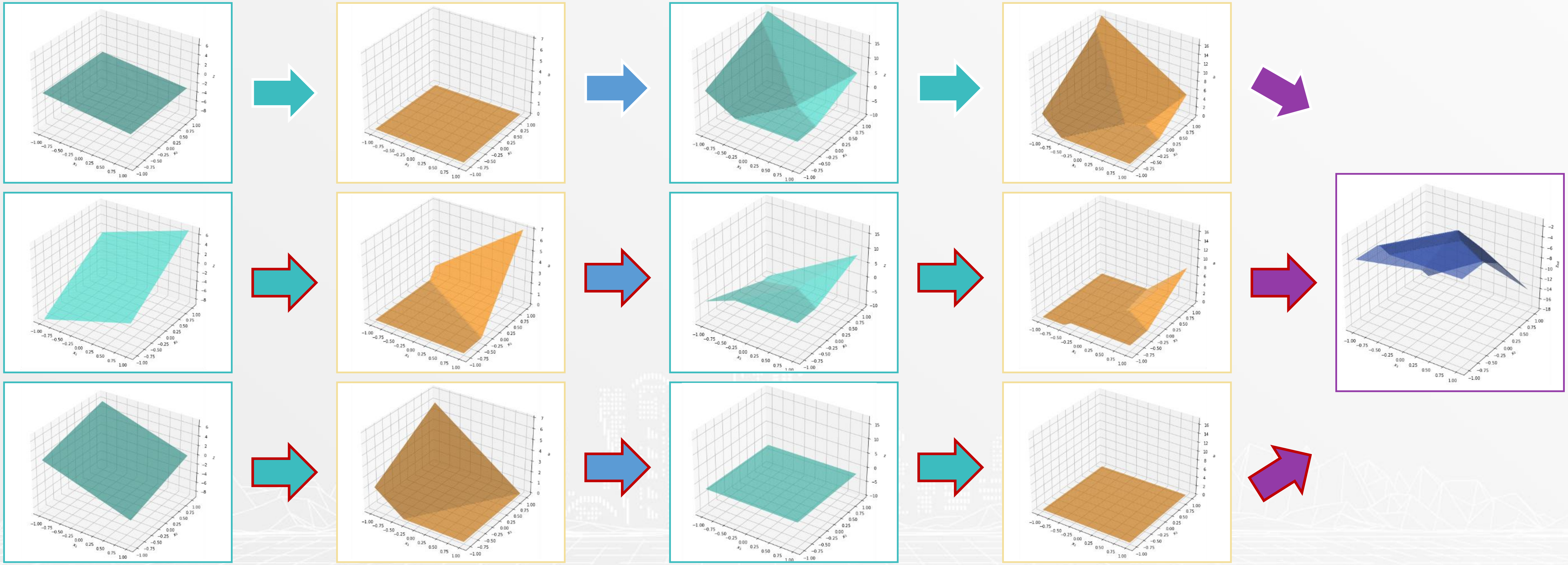
กำหนดให้

$$b^{[out]} = [-1]$$

$$W^{[out]} = \begin{bmatrix} -1 \\ -1 \\ -2 \end{bmatrix}$$

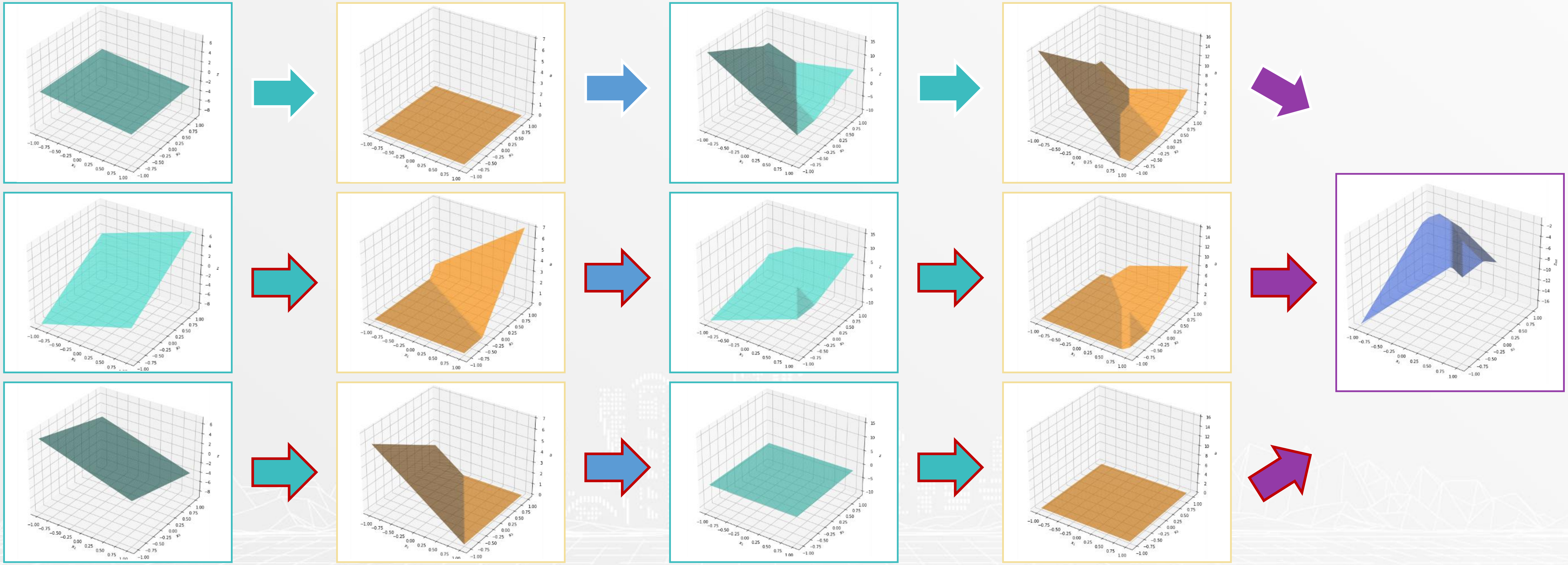
Cost Function & Cost Landscape

$$w_{2,2}^{[1]} = 5, \qquad w_{2,3}^{[1]} = 2$$



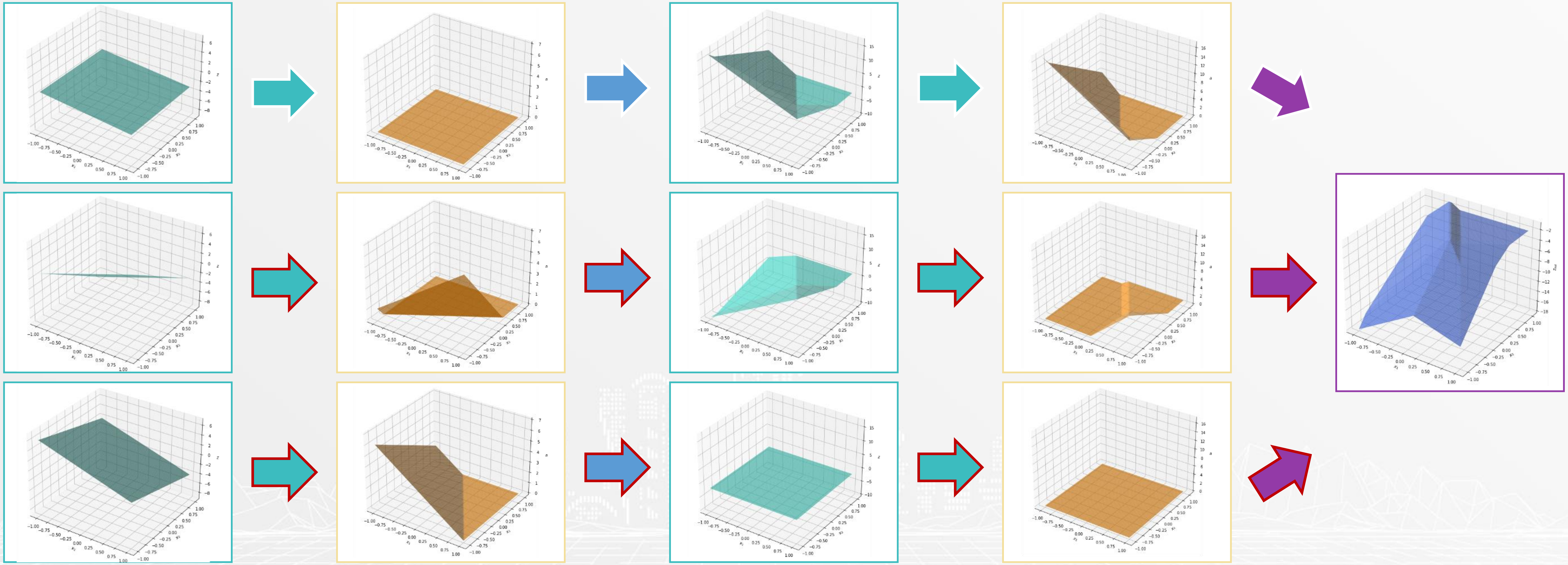
Cost Function & Cost Landscape

$$w_{2,2}^{[1]} = 5, \qquad w_{2,3}^{[1]} = -2$$



Cost Function & Cost Landscape

$$w_{2,2}^{[1]} = -2, \qquad w_{2,3}^{[1]} = 5$$



Cost Function & Cost Landscape

เปรียบเทียบ $\hat{y}$ กับ y เพื่อคำนวณ cost function ($Cost = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$)

	$w_{2,2}^{[1]} = -15$ $w_{2,3}^{[1]} = -5$	$w_{2,2}^{[1]} = -14$ $w_{2,3}^{[1]} = -5$	$w_{2,2}^{[1]} = -13$ $w_{2,3}^{[1]} = -5$	$w_{2,2}^{[1]} = -12$ $w_{2,3}^{[1]} = -5$	…	$w_{2,2}^{[1]} = 12$ $w_{2,3}^{[1]} = 5$	$w_{2,2}^{[1]} = 13$ $w_{2,3}^{[1]} = 5$	$w_{2,2}^{[1]} = 14$ $w_{2,3}^{[1]} = 5$	$w_{2,2}^{[1]} = 15$ $w_{2,3}^{[1]} = 5$
$\hat{y}_1$	-8	-8	-8	-8		-17	-17	-17	-17
$\hat{y}_2$	-13	-12	-11	-11		-8	-8	-8	-8
$\hat{y}_3$	-21	-20	-19	-18	…	-2	-2	-2	-2
$\hat{y}_4$	-11	-11	-11	-11		-11	-11	-11	-11
$\hat{y}_5$	-2	-2	-2	-2		-2	-2	-2	-2

Cost Function & Cost Landscape

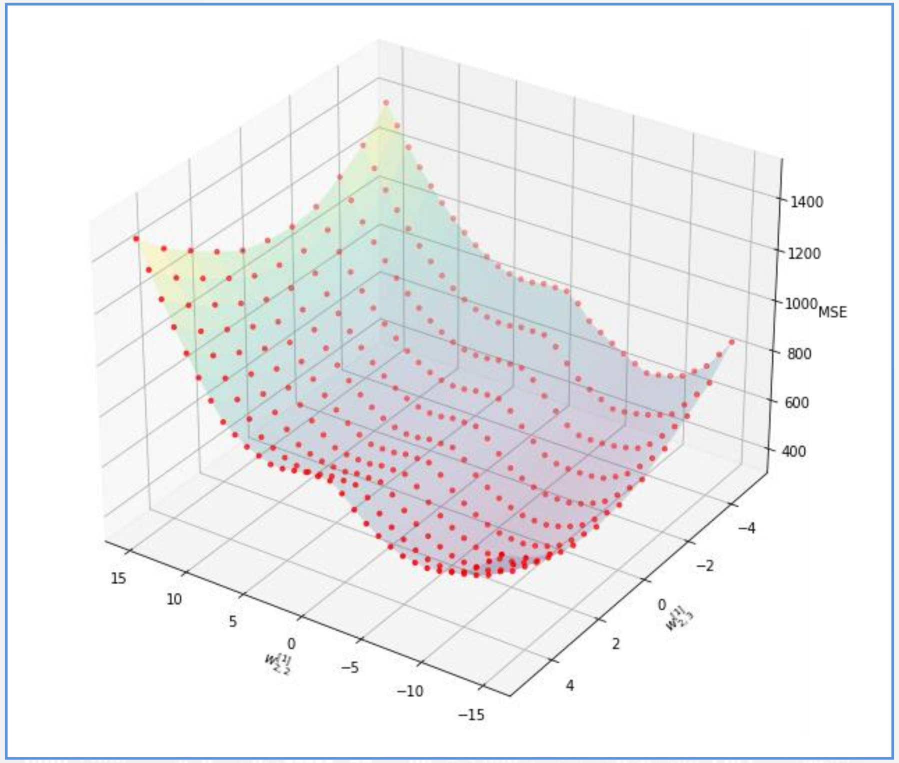
เปรียบเทียบ $\hat{y}$ กับ y เพื่อคำนวณ cost function ($Cost = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$)

	$w_{2,2}^{[1]} = -15$ $w_{2,3}^{[1]} = -5$	$w_{2,2}^{[1]} = -14$ $w_{2,3}^{[1]} = -5$	$w_{2,2}^{[1]} = -13$ $w_{2,3}^{[1]} = -5$	$w_{2,2}^{[1]} = -12$ $w_{2,3}^{[1]} = -5$	…	$w_{2,2}^{[1]} = 12$ $w_{2,3}^{[1]} = 5$	$w_{2,2}^{[1]} = 13$ $w_{2,3}^{[1]} = 5$	$w_{2,2}^{[1]} = 14$ $w_{2,3}^{[1]} = 5$	$w_{2,2}^{[1]} = 15$ $w_{2,3}^{[1]} = 5$
$\hat{y}_6$	-4	-4	-4	-4		-4	-4	-4	-4
$\hat{y}_7$	-5	-5	-5	-5		-10	-11	-12	-13
$\hat{y}_8$	-2	-2	-2	-2	…	-10	-11	-12	-13
$\hat{y}_9$	-2	-2	-2	-2		-10	-11	-12	-13

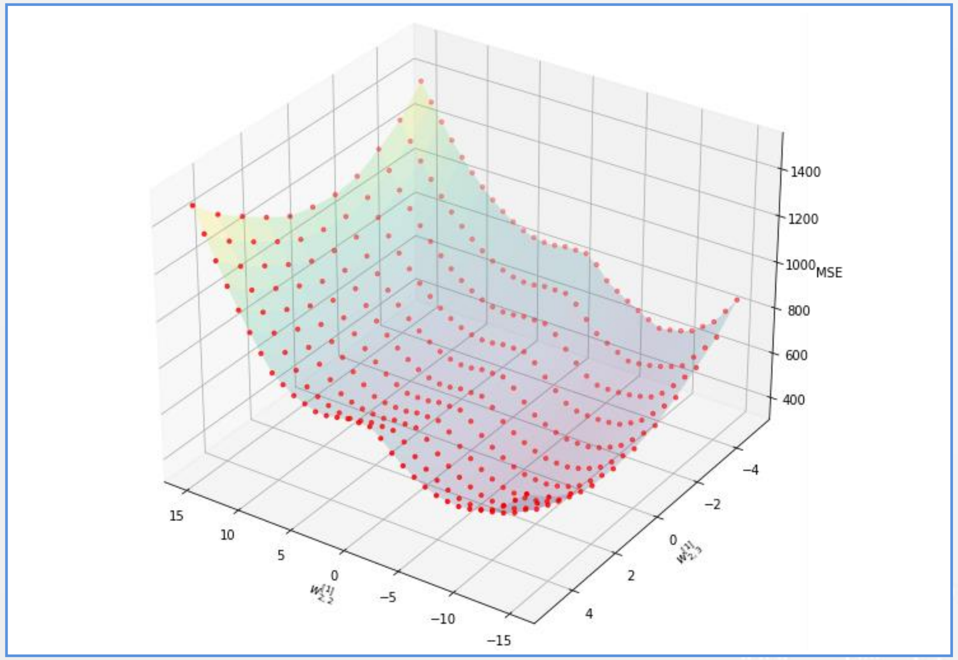
Cost Function & Cost Landscape

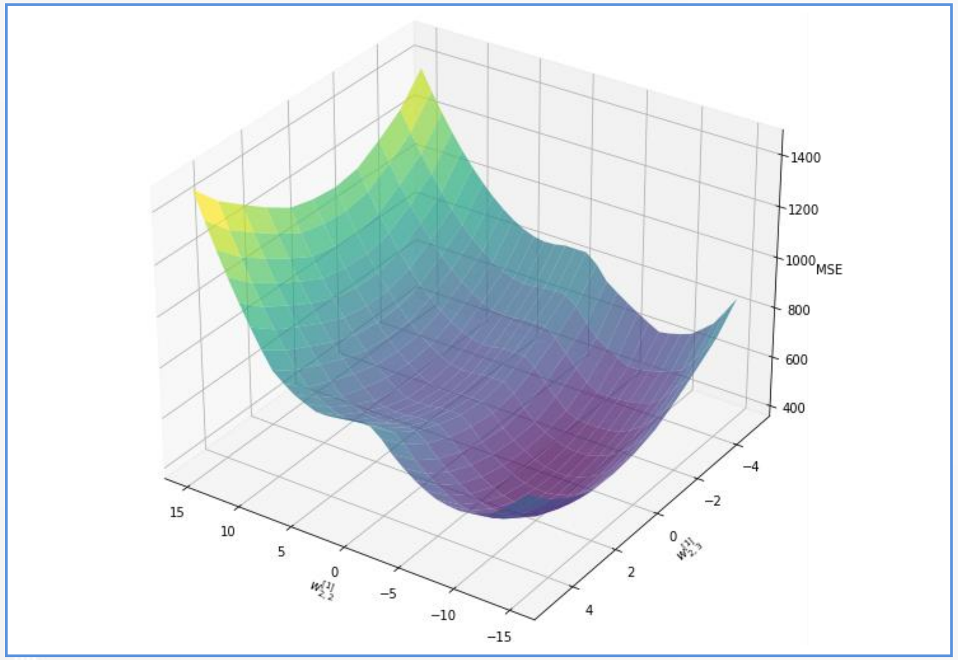
	$w_{2,2}^{[1]} = -15$ $w_{2,3}^{[1]} = -5$	$w_{2,2}^{[1]} = -14$ $w_{2,3}^{[1]} = -5$	$w_{2,2}^{[1]} = -13$ $w_{2,3}^{[1]} = -5$	$w_{2,2}^{[1]} = -12$ $w_{2,3}^{[1]} = -5$	$\cdots$	$w_{2,2}^{[1]} = 12$ $w_{2,3}^{[1]} = 5$	$w_{2,2}^{[1]} = 13$ $w_{2,3}^{[1]} = 5$	$w_{2,2}^{[1]} = 14$ $w_{2,3}^{[1]} = 5$	$w_{2,2}^{[1]} = 15$ $w_{2,3}^{[1]} = 5$
$Cost$	19170.0	1768.5	1629.0	1545.75	$\cdots$	2659.5	2864.25	3082.5	3314.25

Cost Function & Cost Landscape

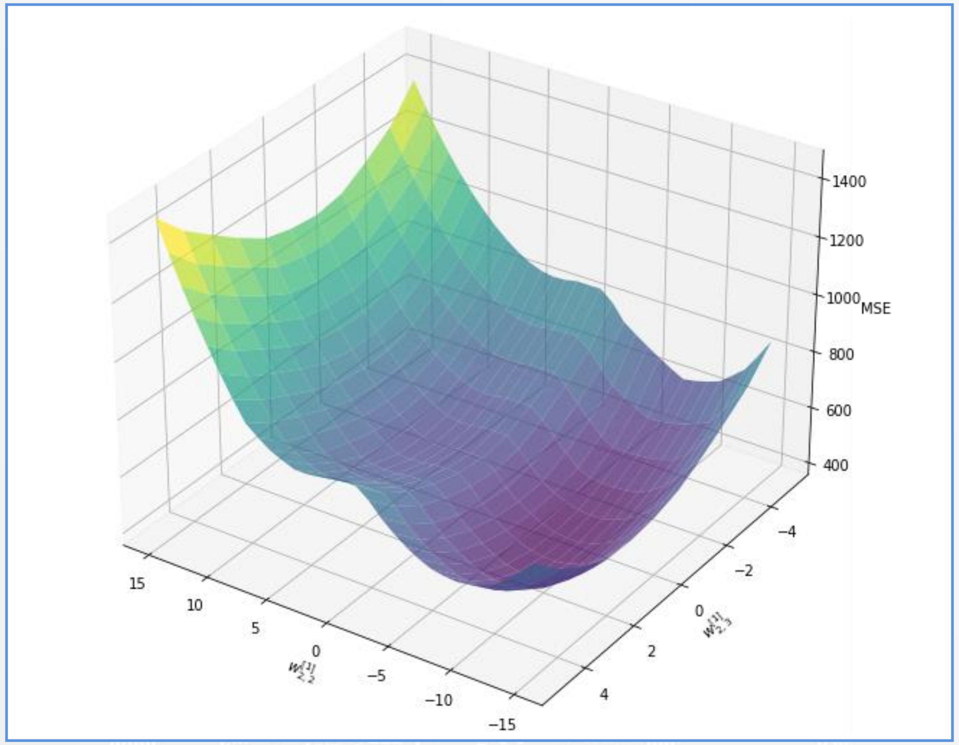


Cost Function & Cost Landscape



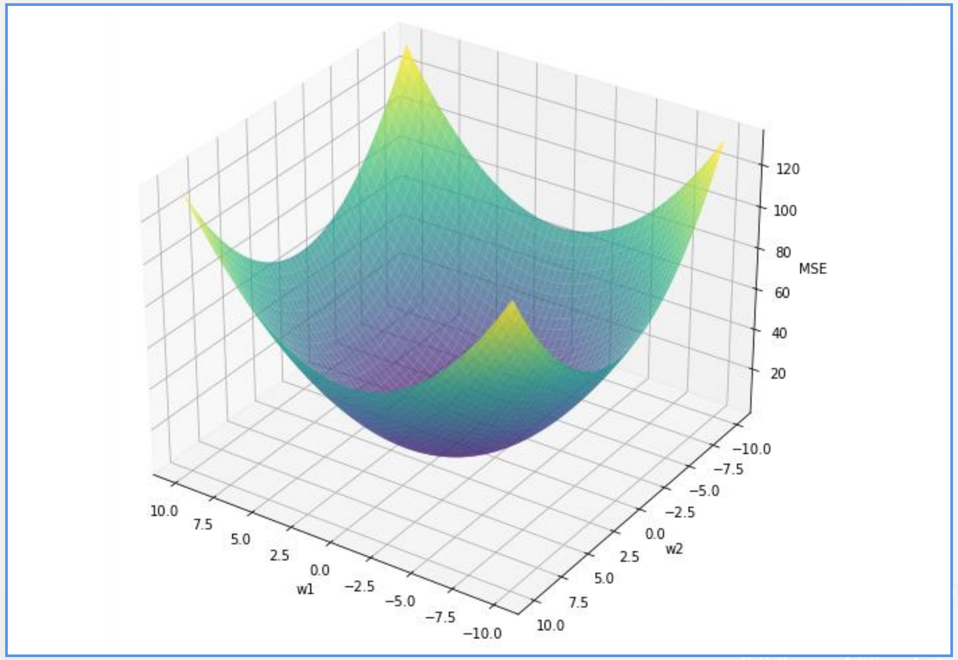


Cost Function & Cost Landscape

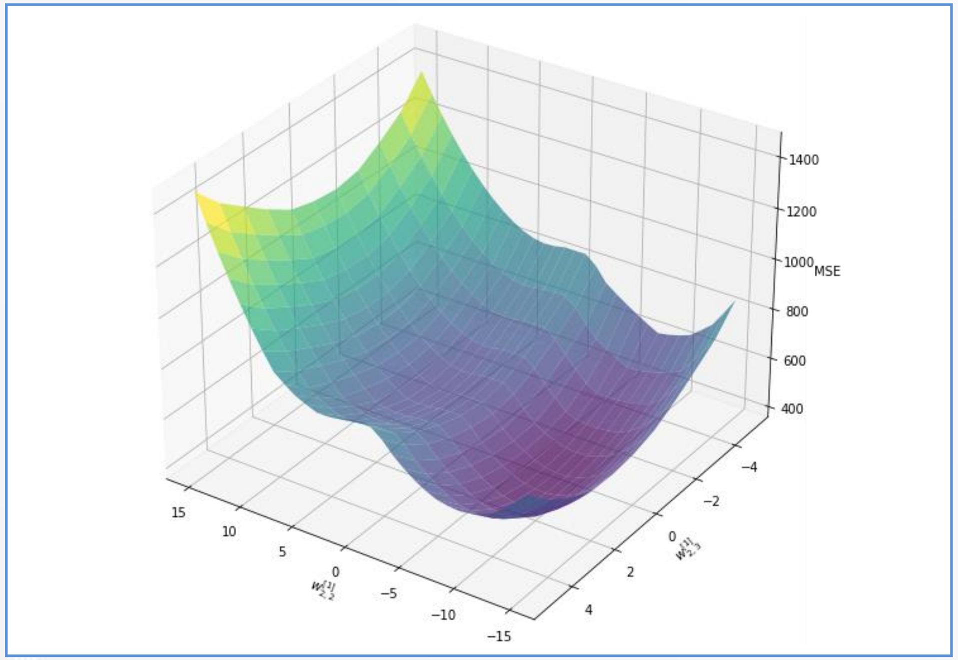


กราฟแสดง cost landscape ของ deep learning
โดยที่ cost function เป็น MSE

Cost Function & Cost Landscape



VS



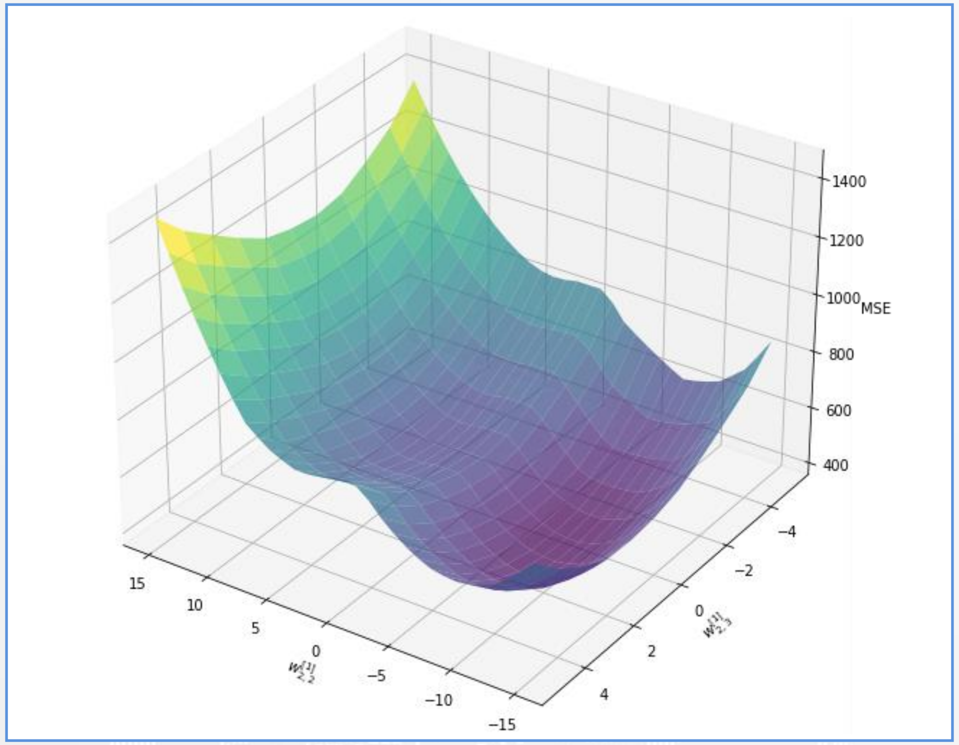
กราฟแสดง cost landscape ของ linear regression โดยที่ cost function เป็น MSE

กราฟแสดง cost landscape ของ deep learning โดยที่ cost function เป็น MSE

Cost Function & Cost Landscape

Cost function ของ deep learning เป็น non-convex
ซึ่งมีจุดต่ำสุดหลายตำแหน่ง

Cost Function & Cost Landscape



กราฟแสดง cost landscape ของ deep learning
โดยที่ cost function เป็น MSE

Model Creation

Assumption

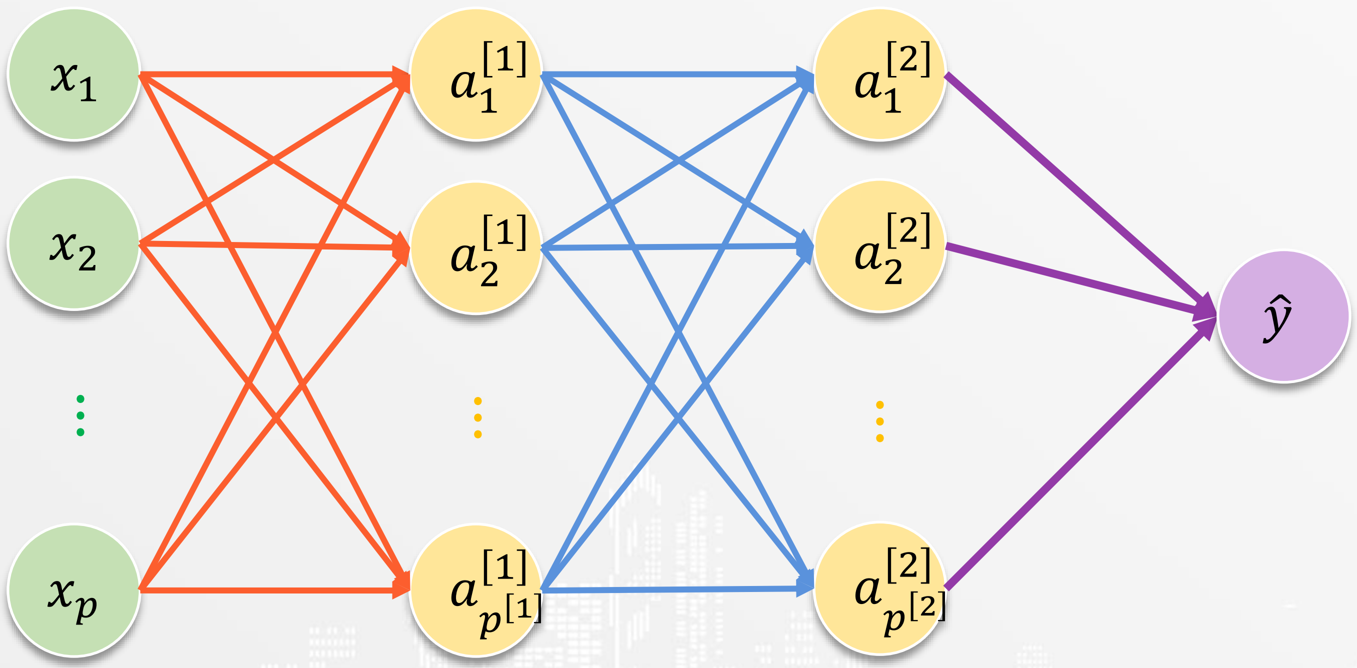
Real Face of the Model

Cost Function and Cost Landscape

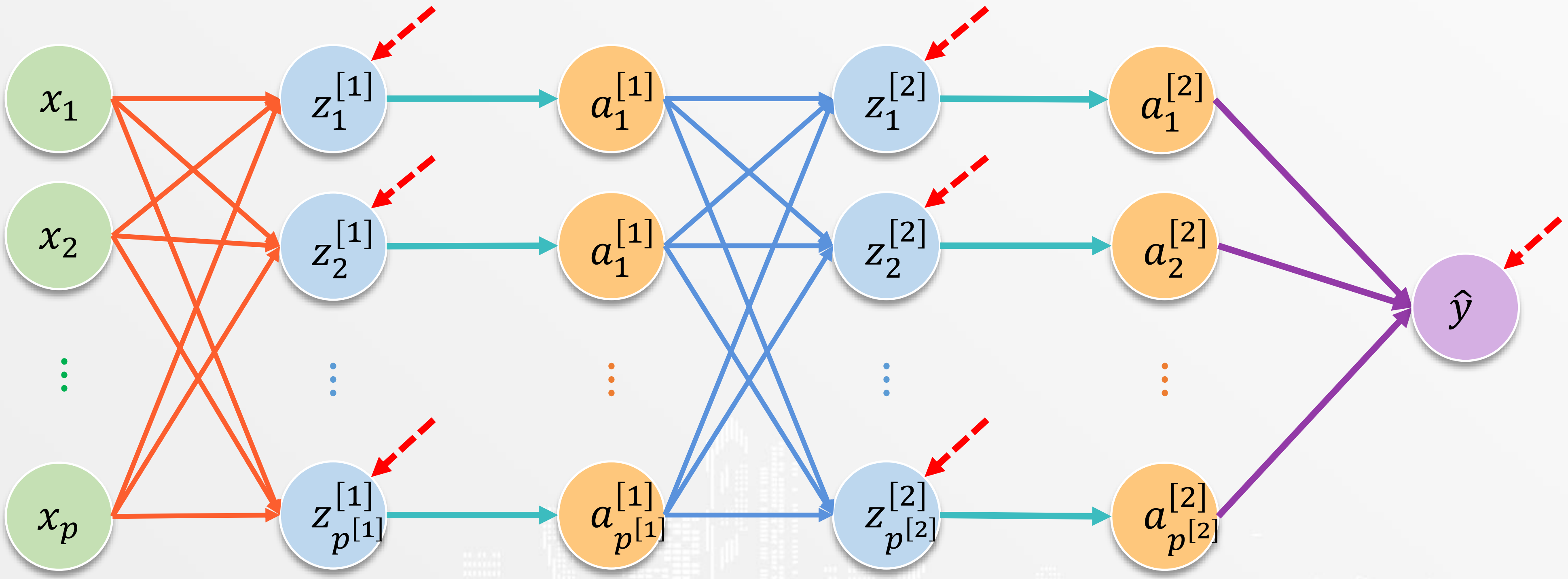
How to Create Model (Math)

How to Create Model (Code)

How to Create Model (Math)



How to Create Model (Math)



How to Create Model (Math)

เราต้องการหา $b^{[1]}, b^{[2]}, \ldots, b^{[L]}, b^{[out]}$ และ $W^{[1]}, W^{[2]}, \ldots, W^{[L]}, W^{[out]}$ ที่ทำให้ cost function ต่ำที่สุด

How to Create Model (Math)

Cost function ที่เราจะใช้ในการสร้าง model คือ

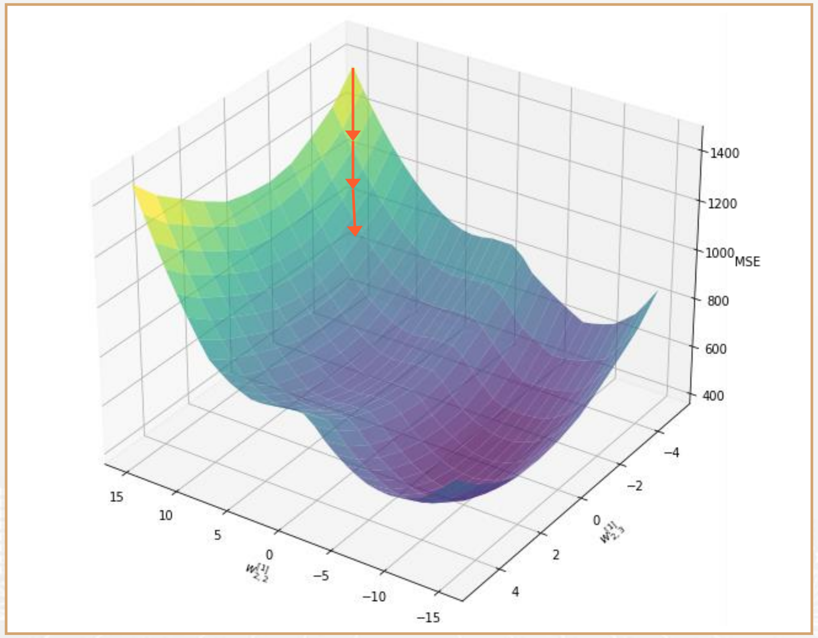
$$-\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

โดยสูตรข้างต้นมีชื่อว่า mean square error หรือ MSE

How to Create Model (Math)

เครื่องมือที่เราจะใช้ในการหาคำตอบ คือ

" gradient descent "



How to Create Model (Math)

Equation of Gradient Descent

$$W = W - \alpha \nabla Cost$$

โดย

- α คือ ค่าที่ใช้ควบคุม step size ของ W

How to Create Model (Math)

$$b^{[1]} = b^{[1]} - \alpha \nabla Cost$$

$$b^{[2]} = b^{[2]} - \alpha \nabla Cost$$

$$\vdots$$

$$b^{[L]} = b^{[L]} - \alpha \nabla Cost$$

$$b^{[out]} = b^{[out]} - \alpha \nabla Cost$$

How to Create Model (Math)

$$W^{[1]} = W^{[1]} - \alpha \nabla Cost$$

$$W^{[2]} = W^{[2]} - \alpha \nabla Cost$$

$$\vdots$$

$$W^{[L]} = W^{[L]} - \alpha \nabla Cost$$

$$W^{[out]} = W^{[out]} - \alpha \nabla Cost$$

Model Creation

- Assumption
- Real Face of the Model
- Cost Function and Cost Landscape
- How to Create Model (Math)
- How to Create Model (Code)

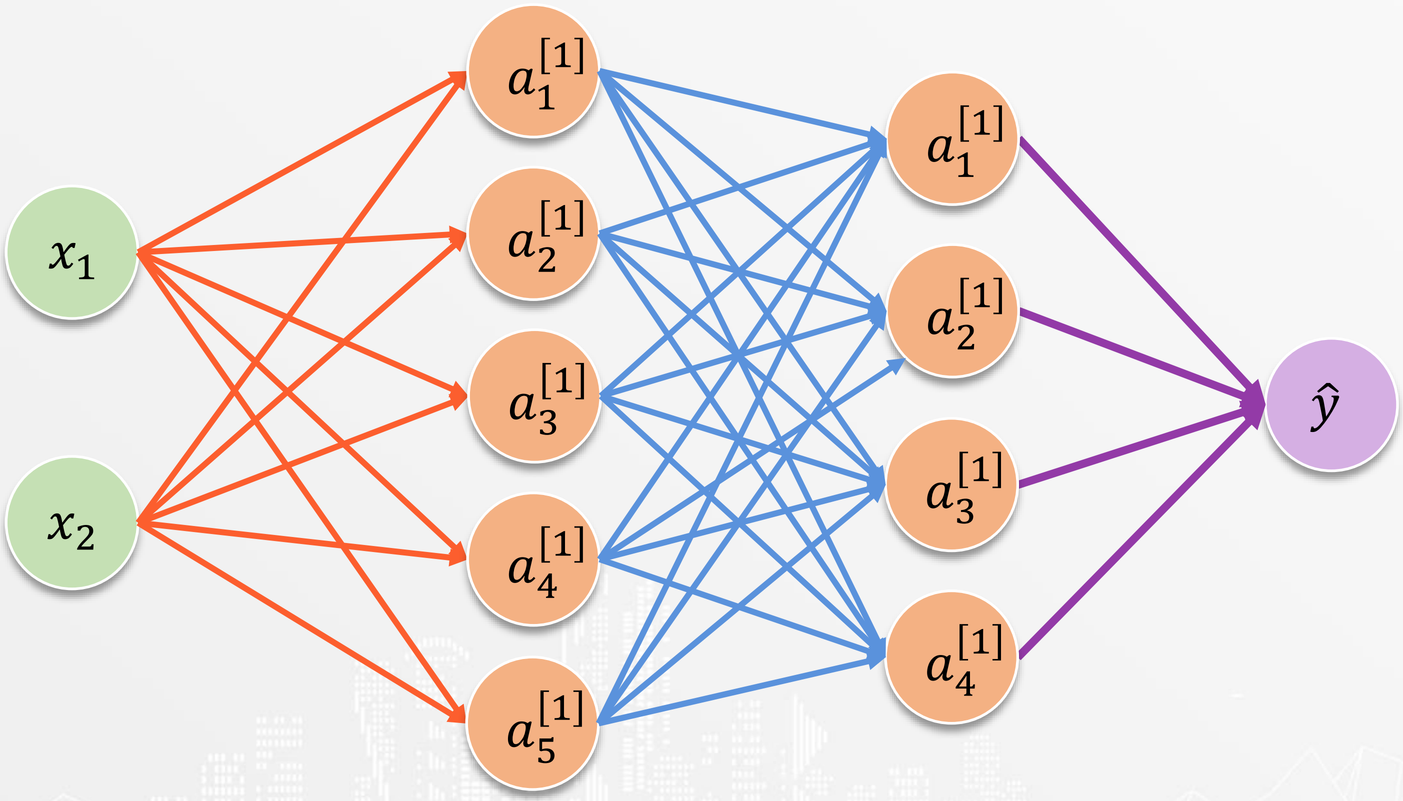
How to Create Model (Code)

ตัวอย่างการหา weight สำหรับ deep learning

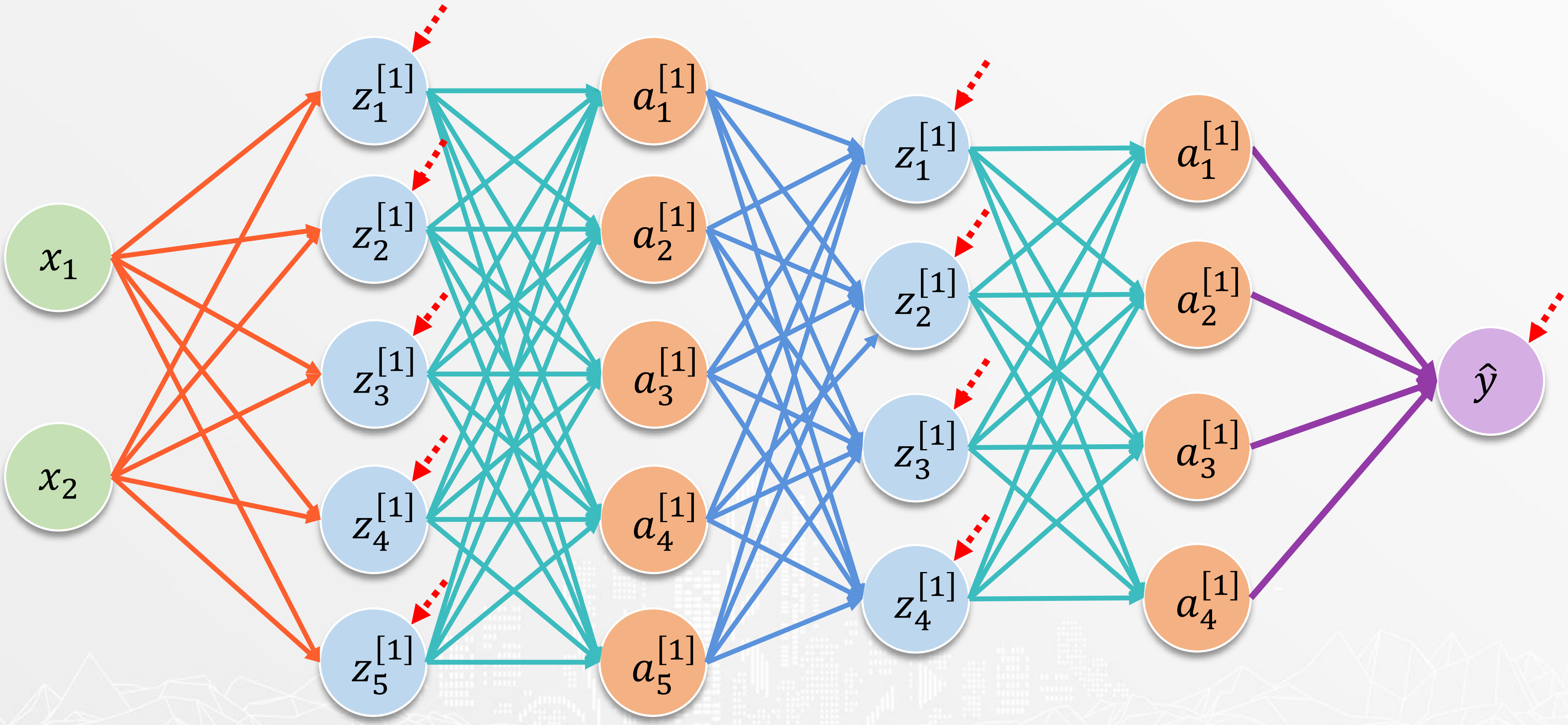
x_1	x_2	y
2	1	9
2	−1	1
−2	2	6
1	2	11
−2	3	9
2	0	5
−1	−1	−2
−2	1	3
0	0	2

x_1	x_2	y
1	−1	0
−1	0	1
−1	1	4
1	3	15
2	2	13
2	3	17
1	1	7
0	2	9
−1	3	11

How to Create Model (Code)



How to Create Model (Code)



How to Create Model (Code)

$$X = \begin{bmatrix} 2 & 1 \\ 2 & -1 \\ -2 & 2 \\ 1 & 2 \\ \vdots & \vdots \\ 0 & 2 \\ -1 & 3 \end{bmatrix}, \qquad y = \begin{bmatrix} 9 \\ 1 \\ 6 \\ 11 \\ \vdots \\ 9 \\ 11 \end{bmatrix}$$

How to Create Model (Code)

```
reg = MLPRegressor(
    hidden_layer_sizes=(5, 4),
    activation='relu',
    solver='sgd',
    alpha=0,
    learning_rate_init=0.01,
    max_iter=10000,
    momentum=0
)

reg.fit(X, y)
```

How to Create Model (Code)

Code for this section

Open File

Regression/Model Creation.ipynb

How to Create Model (Code)

$$b^{[1]} = \begin{bmatrix} 0.461 & 1.079 & -0.924 & -0.729 & -0.393 \end{bmatrix}$$

$$W^{[1]} = \begin{bmatrix} 0.724 & -0.03 & -0.565 & -0.549 & 0.458 \\ 0.831 & 1.11 & 0.207 & 0.48 & 0.436 \end{bmatrix}$$

How to Create Model (Code)

$$b^{[2]} = \begin{bmatrix} 0 & 0 & -0.73 & -0.42 \end{bmatrix}$$

$$W^{[2]} = \begin{bmatrix} 0.369 & 0.663 & 0.624 & 0.912 \\ 0.695 & 0.672 & 0.363 & 0.331 \\ -0.323 & -0.146 & 0.364 & 0.767 \\ 0.224 & 0.395 & -0.557 & -0.836 \\ 0.592 & 0.794 & -0.765 & 0.106 \end{bmatrix}$$

How to Create Model (Code)

$$b^{[out]} = [-1.128]$$

$$W^{[out]} = \begin{bmatrix} 0.877 \\ 1.084 \\ 0.142 \\ 0.789 \end{bmatrix}$$

How to Create Model (Code)

$$a_1^{[1]} = ReLU(0.461 + 0.724x_1 + 0.663x_2)$$

$$a_2^{[1]} = ReLU(1.079 - 0.03x_1 + 1.11x_2)$$

$$a_3^{[1]} = ReLU(-0.924 - 0.565x_1 + 0.207x_2)$$

$$a_4^{[1]} = ReLU(-0.729 - 0.549x_1 + 0.48x_2)$$

$$a_5^{[1]} = ReLU(-0.393 + 0.458x_1 + 0.436x_2)$$

How to Create Model (Code)

$$a_1^{[2]} = ReLU(0 + 0.369a_1^{[1]} + 0.695a_2^{[1]} - 0.323a_3^{[1]} + 0.224a_4^{[1]} + 0.592a_5^{[1]})$$
$$a_2^{[2]} = ReLU(0 + 0.663a_1^{[1]} + 0.672a_2^{[1]} - 0.146a_3^{[1]} + 0.395a_4^{[1]} + 0.794a_5^{[1]})$$
$$a_3^{[2]} = ReLU(-0.73 + 0.624a_1^{[1]} + 0.323a_2^{[1]} + 0.364a_3^{[1]} - 0.554a_4^{[1]} - 0.765a_5^{[1]})$$
$$a_4^{[2]} = ReLU(-0.42 + 0.912a_1^{[1]} + 0.331a_2^{[1]} + 0.767a_3^{[1]} - 0.836a_4^{[1]} + 0.106a_5^{[1]})$$

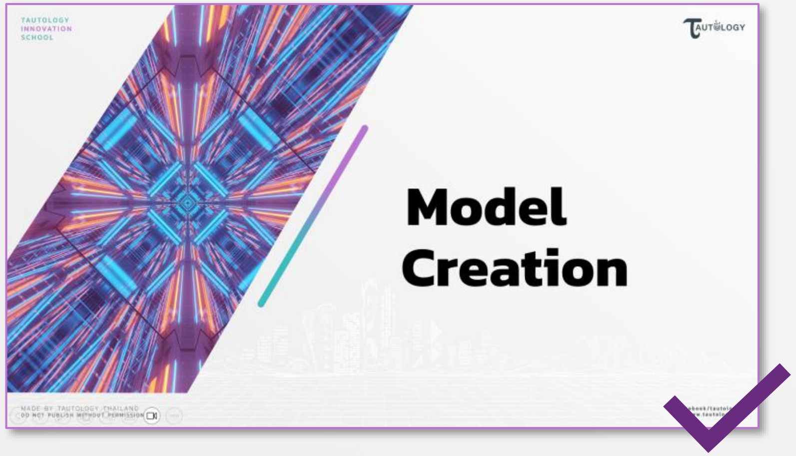
How to Create Model (Code)

$$\hat{y} = -1.128 + 0.877a_1^{[3]} + 1.084a_2^{[3]} + 0.142a_3^{[3]} + 0.789a_4^{[3]}$$

Model Creation

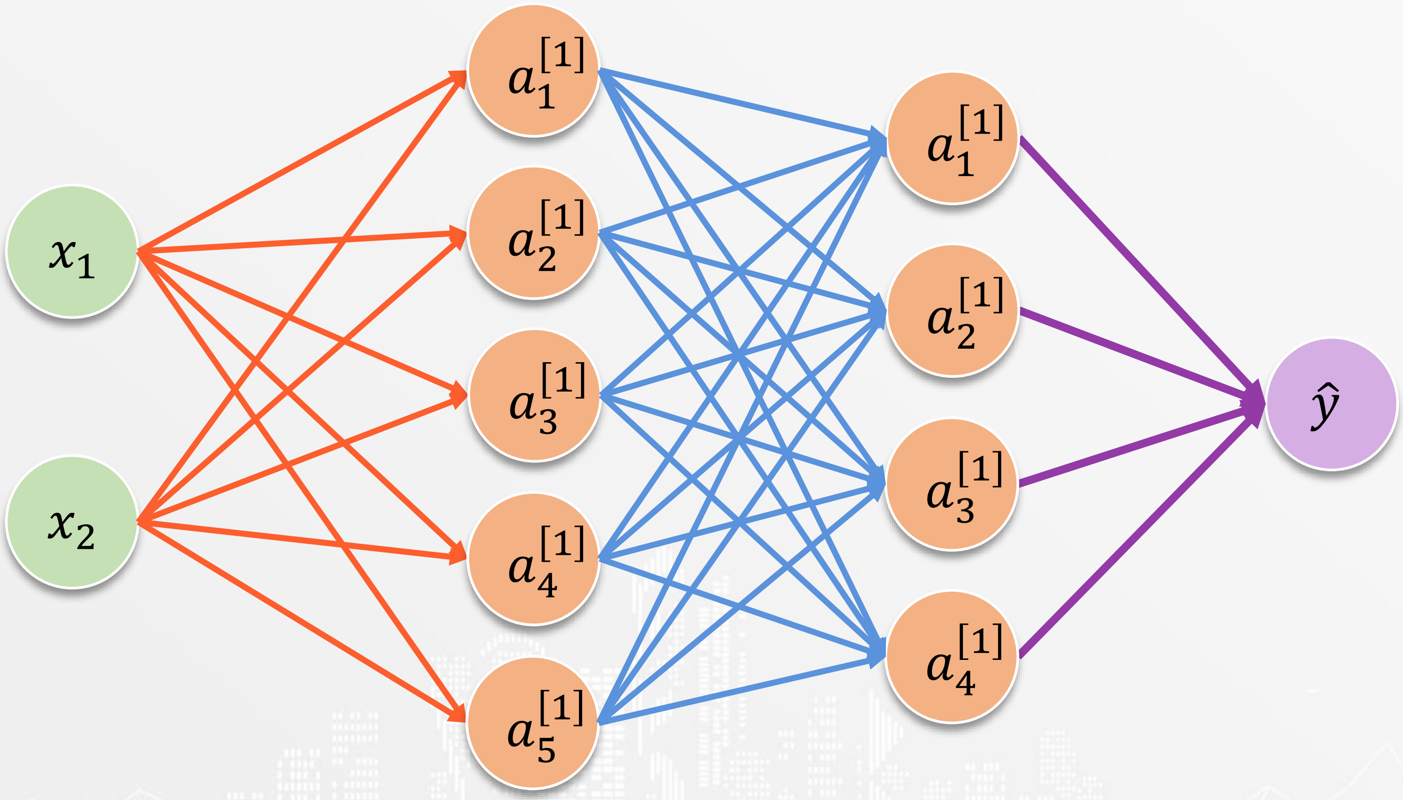
- Assumption
- Real Face of the Model
- Cost Function and Cost Landscape
- How to Create Model (Math)
- How to Create Model (Code)

Deep Learning for Regression

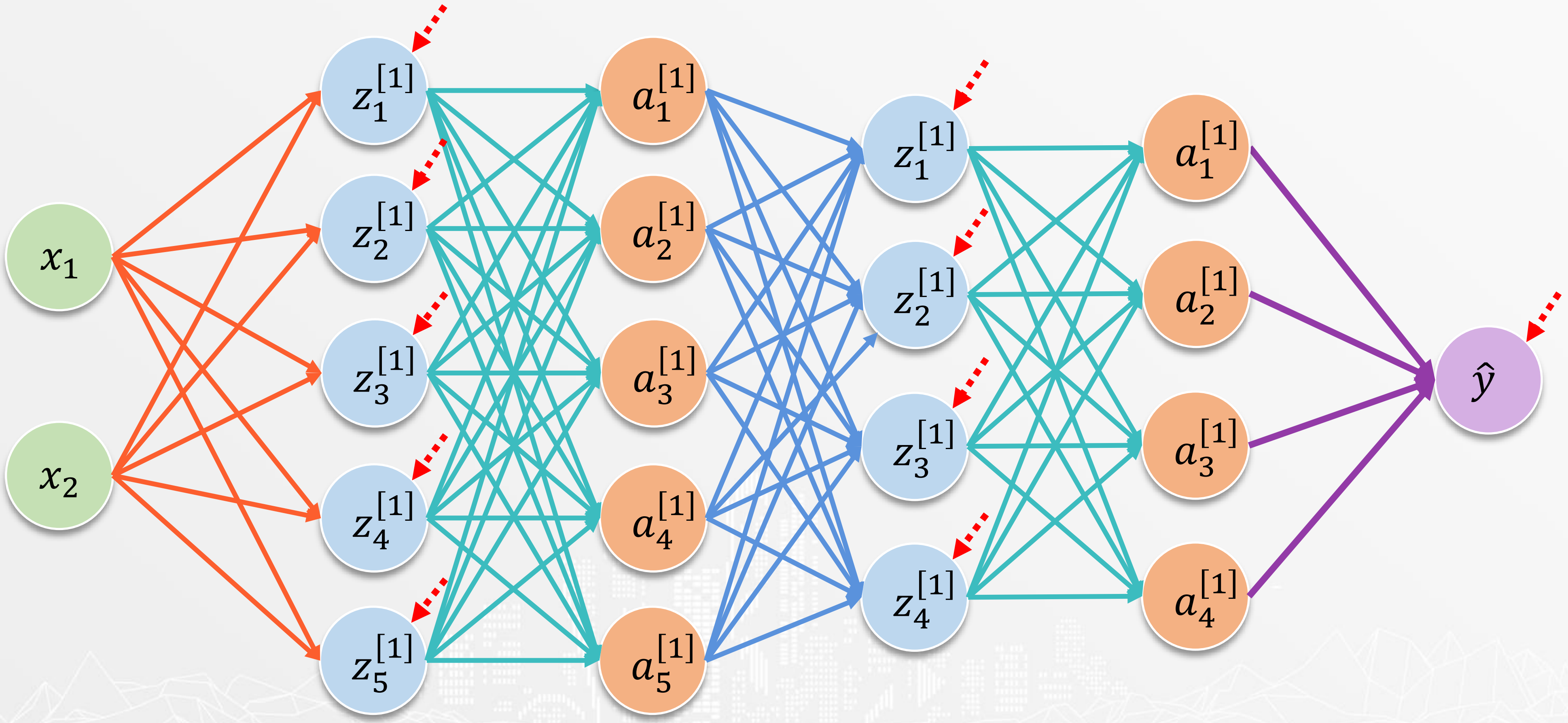


Prediction

Prediction



Prediction


x_1
x_2
$z_1^{[1]}$
$z_2^{[1]}$
$z_3^{[1]}$
$z_4^{[1]}$
$z_5^{[1]}$
$a_1^{[1]}$
$a_2^{[1]}$
$a_3^{[1]}$
$a_4^{[1]}$
$a_5^{[1]}$
$z_1^{[1]}$
$z_2^{[1]}$
$z_3^{[1]}$
$z_4^{[1]}$
$a_1^{[1]}$
$a_2^{[1]}$
$a_3^{[1]}$
$a_4^{[1]}$
$\hat{y}$

Prediction

$$b^{[1]} \quad b^{[2]} \quad b^{[out]}$$

$$w^{[1]} \quad w^{[2]} \quad w^{[out]}$$

Prediction

- ☐ 1-Sample
- ☐ Multi-Sample

Prediction

1-Sample

Multi-Sample

1-Sample

ตัวอย่างการคำนวณ $\hat{y}$

x_1	x_2
0	3

→

$\hat{y}$
?

1-Sample

- สมมติว่า weight ของปัญหานี้ที่เราหามาได้คือ

$$b^{[1]} = \begin{bmatrix} 0.461 & 1.079 & -0.924 & -0.729 & -0.393 \end{bmatrix}$$

$$W^{[1]} = \begin{bmatrix} 0.724 & -0.03 & -0.565 & -0.549 & 0.458 \\ 0.831 & 1.11 & 0.207 & 0.48 & 0.436 \end{bmatrix}$$

1-Sample

- สมมติว่า weight ของปัญหานี้ที่เราหามาได้คือ

$$b^{[2]} = \begin{bmatrix} 0 & 0 & -0.73 & -0.42 \end{bmatrix}$$

$$W^{[2]} = \begin{bmatrix} 0.369 & 0.663 & 0.624 & 0.912 \\ 0.695 & 0.672 & 0.363 & 0.331 \\ -0.323 & -0.146 & 0.364 & 0.767 \\ 0.224 & 0.395 & -0.557 & -0.836 \\ 0.592 & 0.794 & -0.765 & 0.106 \end{bmatrix}$$

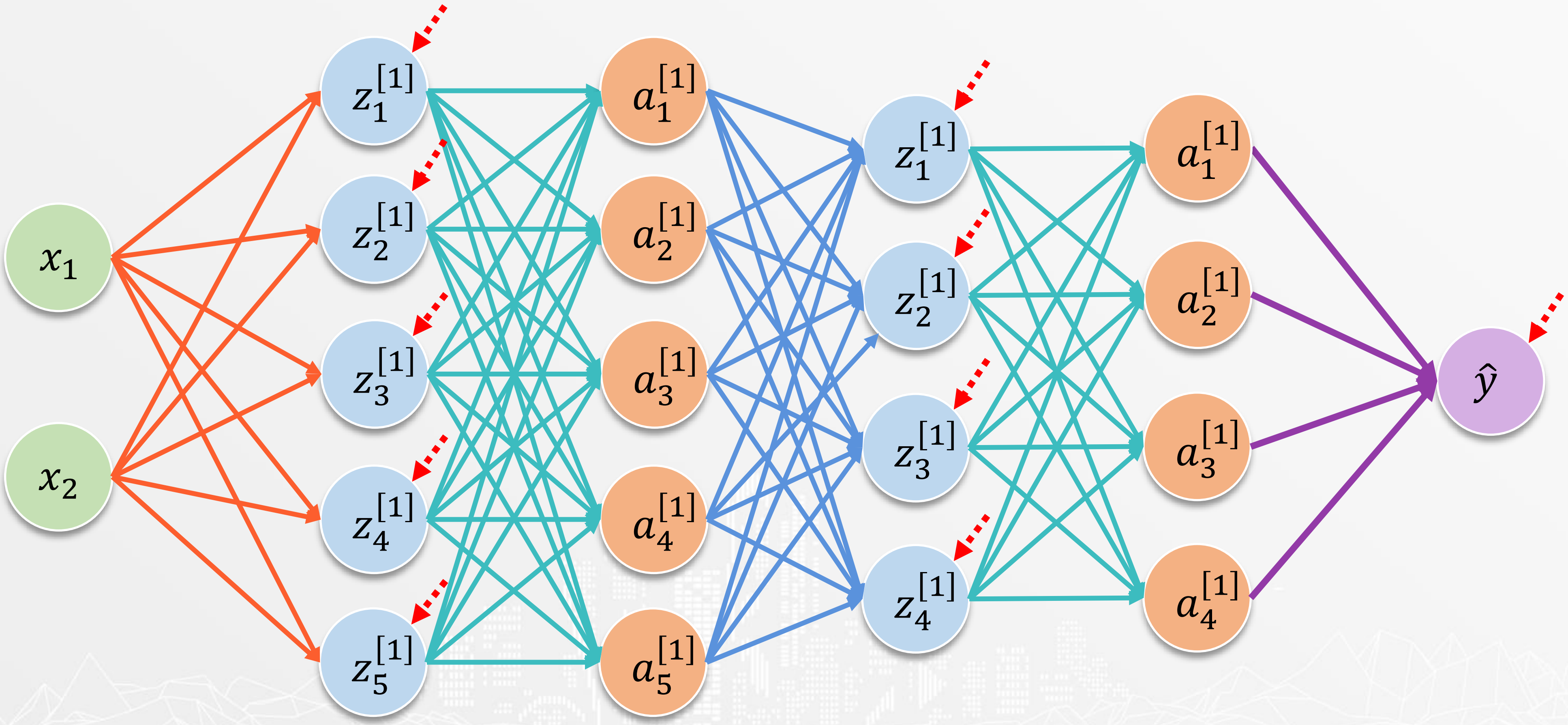
1-Sample

- สมมติว่า weight ของปัญหานี้ที่เราหามาได้คือ

$$b^{[out]} = [-1.128]$$

$$W^{[out]} = \begin{bmatrix} 0.877 \\ 1.084 \\ 0.142 \\ 0.789 \end{bmatrix}$$

1-Sample


x_1
x_2
$z_1^{[1]}$
$z_2^{[1]}$
$z_3^{[1]}$
$z_4^{[1]}$
$z_5^{[1]}$
$a_1^{[1]}$
$a_2^{[1]}$
$a_3^{[1]}$
$a_4^{[1]}$
$a_5^{[1]}$
$z_1^{[1]}$
$z_2^{[1]}$
$z_3^{[1]}$
$z_4^{[1]}$
$a_1^{[1]}$
$a_2^{[1]}$
$a_3^{[1]}$
$a_4^{[1]}$
$\hat{y}$

1-Sample

$$a_1^{[1]} = ReLU(0.461 + 0.724x_1 + 0.831x_2) = 2.955$$

$$a_2^{[1]} = ReLU(1.079 - 0.03x_1 + 1.11x_2) = 4.409$$

$$a_3^{[1]} = ReLU(-0.924 - 0.565x_1 + 0.207x_2) = 0$$

$$a_4^{[1]} = ReLU(-0.729 - 0.549x_1 + 0.48x_2) = 0.711$$

$$a_5^{[1]} = ReLU(-0.393 + 0.458x_1 + 0.436x_2) = 0.915$$

1-Sample

$$a_1^{[2]} = ReLU\left(0 + 0.369a_1^{[1]} + 0.695a_2^{[1]} - 0.323a_3^{[1]} + 0.224a_4^{[1]} + 0.592a_5^{[1]}\right) = 4.856$$

$$a_2^{[2]} = ReLU\left(0 + 0.663a_1^{[1]} + 0.672a_2^{[1]} - 0.146a_3^{[1]} + 0.395a_4^{[1]} + 0.794a_5^{[1]}\right) = 5.929$$

$$a_3^{[2]} = ReLU\left(-0.73 + 0.624a_1^{[1]} + 0.323a_2^{[1]} + 0.364a_3^{[1]} - 0.554a_4^{[1]} - 0.765a_5^{[1]}\right) = 1.618$$

$$a_4^{[2]} = ReLU\left(-0.42 + 0.912a_1^{[1]} + 0.331a_2^{[1]} + 0.767a_3^{[1]} - 0.836a_4^{[1]} + 0.106a_5^{[1]}\right) = 4.077$$

1-Sample

$$\hat{y} = -1.128 + 0.877a_1^{[3]} + 1.084a_2^{[3]} + 0.142a_3^{[3]} + 0.789a_4^{[3]}$$
$$= 13.004$$

1-Sample

ดังนั้น เราจะได้ $\hat{y}$ สำหรับข้อมูลชุดนี้คือ

x_1	x_2
0	3

→

$\hat{y}$
13.004

Prediction

1-Sample ✓

Multi-Sample

Multi-Sample

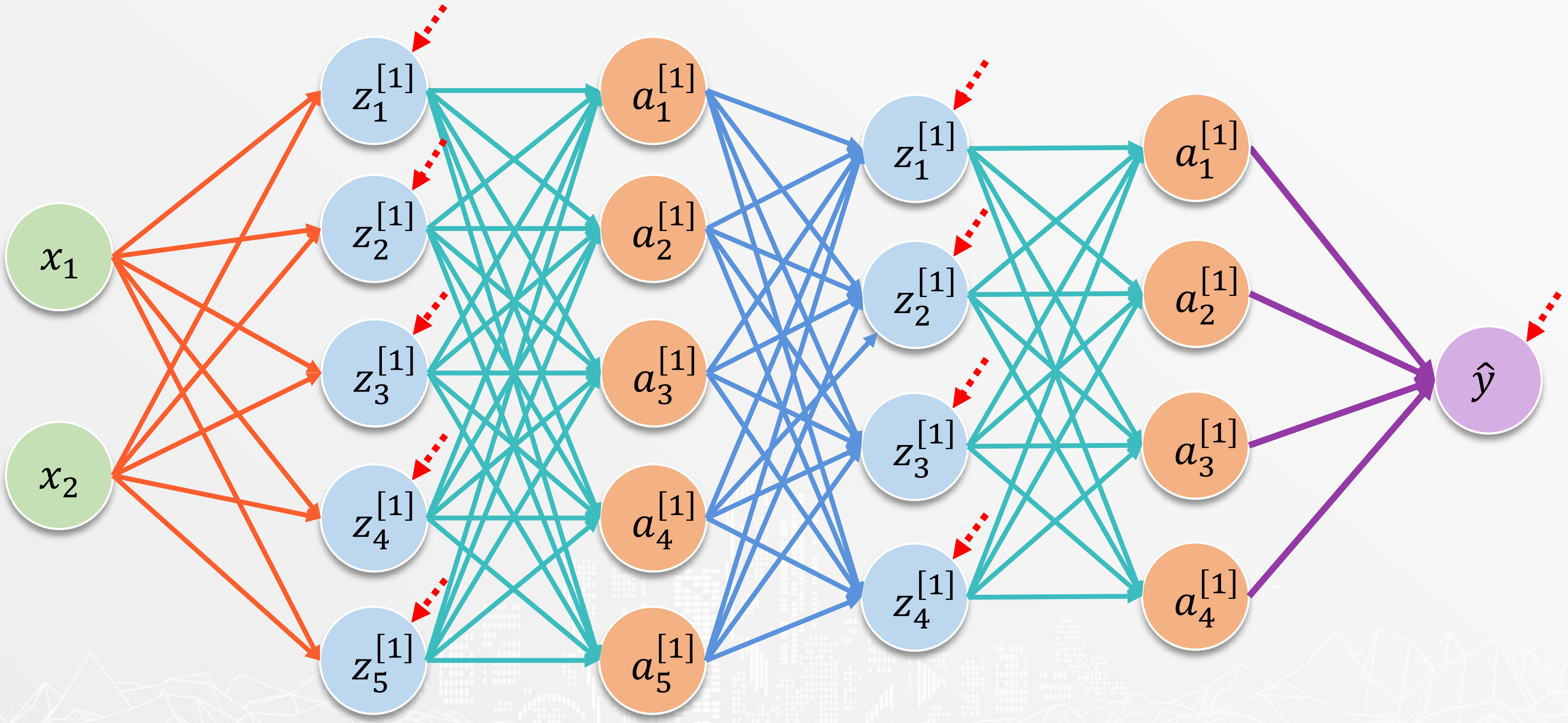
ตัวอย่างการคำนวณ $\hat{y}$

$\mathbf{x_1}$	$\mathbf{x_2}$
0	3
-2	-1
-2	1
0	-1

→

$\hat{\mathbf{y}}$
?
?
?
?

Multi-Sample



Multi-Sample

$$X \rightarrow Z^{[1]} \rightarrow A^{[1]} \rightarrow Z^{[2]} \rightarrow A^{[2]} \rightarrow \hat{\mathbf{y}}$$

Multi-Sample

$$Z^{[1]} = XW^{[1]} + b^{[1]}$$

$$Z^{[1]} = \begin{bmatrix} 0 & 3 \\ -2 & -1 \\ -2 & 1 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} 0.724 & -0.03 & -0.565 & -0.549 & 0.458 \\ 0.831 & 1.11 & 0.207 & 0.48 & 0.436 \end{bmatrix} + \begin{bmatrix} 0.461 & 1.079 & -0.924 & -0.729 & -0.393 \end{bmatrix}$$

$$= \begin{bmatrix} 2.494 & 3.329 & 0.62 & 1.439 & 1.307 \\ -2.28 & -1.05 & 0.924 & 0.619 & -1.351 \\ -0.813 & 1.11 & 0.207 & 0.48 & 0.436 \\ -0.831 & -1.11 & -0.207 & -0.48 & -0.436 \end{bmatrix} + \begin{bmatrix} 0.462 & 1.079 & -0.924 & -0.729 & -0.393 \\ 0.462 & 1.079 & -0.924 & -0.729 & -0.393 \\ 0.462 & 1.079 & -0.924 & -0.729 & -0.393 \\ 0.462 & 1.079 & -0.924 & -0.729 & -0.393 \end{bmatrix}$$

Multi-Sample

$$Z^{[1]} = XW^{[1]} + b^{[1]}$$

$$Z^{[1]} = \begin{bmatrix} 2.956 & 4.408 & -0.304 & 0.71 & 0.914 \\ -1.818 & 0.029 & 0 & -0.11 & -1.744 \\ 1.293 & 2.189 & -0.717 & -0.249 & -0.043 \\ -0.369 & -0.031 & -1.131 & -1.209 & -0.829 \end{bmatrix}$$

Multi-Sample

$$A^{[1]} = ReLU(Z^{[1]})$$

$$A^{[1]} = ReLU\left(\begin{bmatrix} 2.956 & 4.408 & -0.304 & 0.71 & 0.914 \\ -1.818 & 0.029 & 0 & -0.11 & -1.744 \\ 1.293 & 2.189 & -0.717 & -0.249 & -0.043 \\ -0.369 & -0.031 & -1.131 & -1.209 & -0.829 \end{bmatrix}\right)$$

$$= \begin{bmatrix} 2.956 & 4.408 & 0 & 0.71 & 0.914 \\ 0 & 0.029 & 0 & 0 & 0 \\ 1.293 & 2.189 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Multi-Sample

$$Z^{[2]} = A^{[1]}W^{[2]} + b^{[2]}$$

$$Z^{[2]} = \begin{bmatrix} 2.956 & 4.408 & 0 & 0.71 & 0.914 \\ 0 & 0.029 & 0 & 0 & 0 \\ 1.293 & 2.189 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0.369 & 0.663 & 0.624 & 0.912 \\ 0.695 & 0.672 & 0.363 & 0.331 \\ -0.323 & -0.146 & 0.364 & 0.767 \\ 0.224 & 0.395 & -0.557 & -0.836 \\ 0.592 & 0.794 & -0.765 & 0.106 \end{bmatrix} + \begin{bmatrix} 0 & 0 & -0.73 & -0.42 \end{bmatrix}$$

$$= \begin{bmatrix} 4.853 & 5.93 & 2.347 & 3.656 \\ 0.02 & 0.019 & 0.011 & 0.01 \\ 2.023 & 2.363 & 1.567 & 1.908 \\ 0 & 0 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & -0.73 & -0.42 \\ 0 & 0 & -0.73 & -0.42 \\ 0 & 0 & -0.73 & -0.42 \\ 0 & 0 & -0.73 & -0.42 \end{bmatrix}$$

Multi-Sample

$$Z^{[2]} = A^{[1]}W^{[2]} + b^{[2]}$$

$$Z^{[2]} = \begin{bmatrix} 4.853 & 5.93 & 1.617 & 4.076 \\ 0.02 & 0.019 & -0.719 & 0.43 \\ 2.023 & 2.363 & 0.837 & 2.328 \\ 0 & 0 & -0.73 & 0.42 \end{bmatrix}$$

Multi-Sample

$$A^{[2]} = ReLU(Z^{[2]})$$

$$A^{[2]} = ReLU\left(\begin{bmatrix} 4.853 & 5.93 & 1.617 & 4.076 \\ 0.02 & 0.019 & -0.719 & 0.43 \\ 2.023 & 2.363 & 0.837 & 2.328 \\ 0 & 0 & -0.73 & 0.42 \end{bmatrix}\right)$$

$$= \begin{bmatrix} 4.853 & 5.93 & 1.617 & 4.076 \\ 0.02 & 0.019 & 0 & 0.43 \\ 2.023 & 2.363 & 0.837 & 2.328 \\ 0 & 0 & 0 & 0.42 \end{bmatrix}$$

Multi-Sample

$$\hat{\mathbf{y}} = A^{[2]}W^{[out]} + b^{[out]}$$

$$\hat{\mathbf{y}} = \begin{bmatrix} 4.853 & 5.93 & 1.617 & 4.076 \\ 0.02 & 0.019 & 0 & 0.43 \\ 2.023 & 2.363 & 0.837 & 2.328 \\ 0 & 0 & 0 & 0.42 \end{bmatrix} \begin{bmatrix} 0.877 \\ 1.084 \\ 0.142 \\ 0.789 \end{bmatrix} + [-1.128]$$

$$= \begin{bmatrix} 14.131 \\ 0.377 \\ 6.292 \\ 0.331 \end{bmatrix} + \begin{bmatrix} -1.128 \\ -1.128 \\ -1.128 \\ -1.128 \end{bmatrix} = \begin{bmatrix} 13.003 \\ -0.751 \\ 5.164 \\ -0.797 \end{bmatrix}$$

Multi-Sample

ดังนั้น เราจะได้ $\hat{y}$ สำหรับข้อมูลชุดนี้คือ

$\mathbf{x_1}$	$\mathbf{x_2}$
0	3
-2	-1
-2	1
0	-1

$\hat{\mathbf{y}}$
13.003
-0.751
5.164
-0.797

Multi-Sample

```
reg.predict(X)
```

```
array([13.00237175, -0.75090167,  5.1624261 , -0.79658003])
```

Multi-Sample

Code for this section

Open File

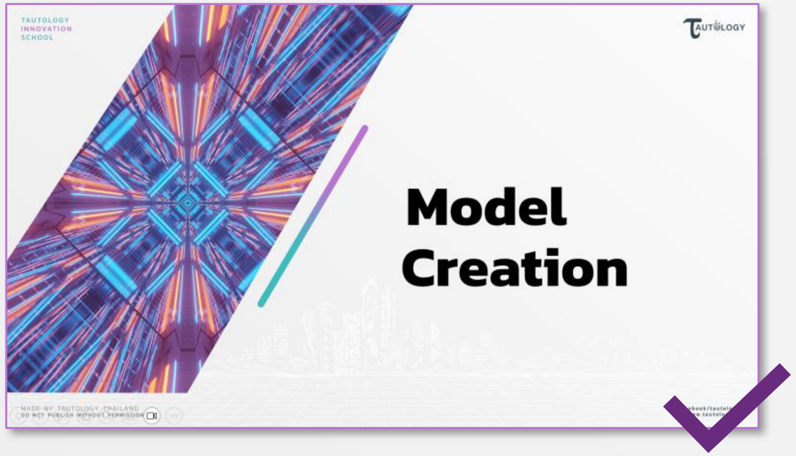
Regression/Model Creation.ipynb

Prediction

1-Sample

Multi-Sample

Deep Learning for Regression



Neural Network & Deep Learning

Neural Network ✓

Deep Learning ✓

Deep Learning for Regression ✓

Deep Learning for Classification

Workshop

Deep Learning for Classification

Deep Learning for
Binary Classification

Deep Learning for
Multi-Class Classification

Deep Learning for Binary Classification

Deep Learning เป็นหนึ่งใน algorithm ประเภท supervised learning

Machine Leaning

Supervised Learning

Unsupervised Learning

Reinforcement Learning

Concept of Supervised Learning

Data → Model → Prediction

Deep Learning for Binary Classification

Data

Data

MATH

อายุ	female	male	เป็นโรคหัวใจ
42	1	0	True
57	0	1	True
58	0	1	False
59	1	0	False

อายุ	female	male	เป็นโรคหัวใจ
42	1	0	1
57	0	1	1
58	0	1	0
59	1	0	0

Data

CODE

อายุ	female	male	เป็นโรคหัวใจ
42	1	0	True
57	0	1	True
58	0	1	False
59	1	0	False

อายุ	female	male	เป็นโรคหัวใจ
42	1	0	1
57	0	1	1
58	0	1	0
59	1	0	0

Data

อายุ	female	male	เป็นโรคหัวใจ
42	1	0	True
57	0	1	True
58	0	1	False
59	1	0	False

อายุ	female	male	เป็นโรคหัวใจ
42	1	0	1
57	0	1	1
58	0	1	0
59	1	0	0

scikit learn

Model

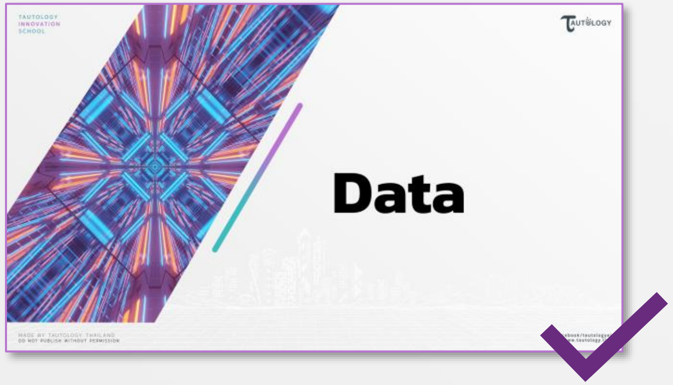
Prediction

เป็นโรคหัวใจ
1
0
1
0

Prediction

เป็นโรคหัวใจ
True
False
True
False

Deep Learning for Binary Classification



Model Creation

Model Creation

Assumption

Real Face of the Model

Cost Function and Cost Landscape

How to Create Model (Math)

How to Create Model (Code)

Assumption

1. Nonlinear Relationship to log odds
2. No Missing Features
3. No Multicollinearity

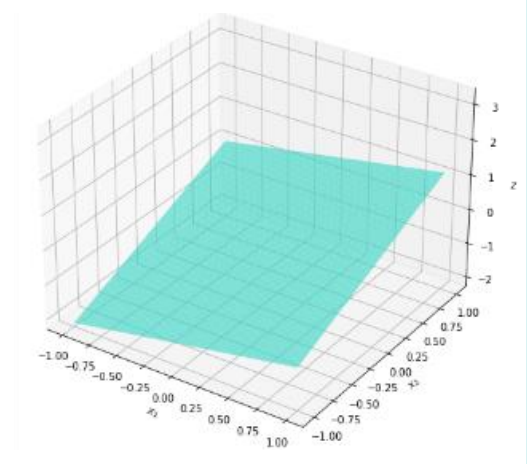
Model Creation

- **Assumption**
- Real Face of the Model
- Cost Function and Cost Landscape
- How to Create Model (Math)
- How to Create Model (Code)

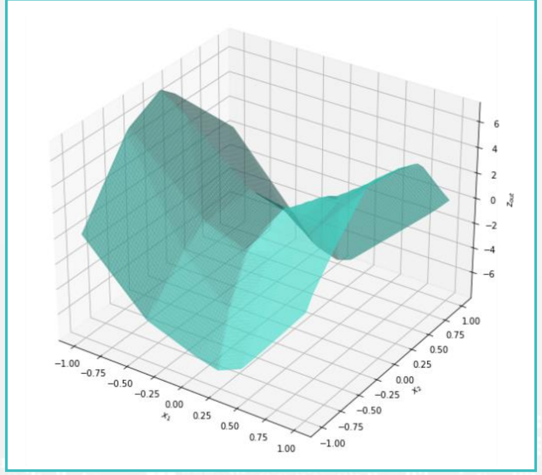
Real Face of the Model

แนวคิดของ deep learning คือการนำ nonlinear function มาประกอบกันเพื่อประมาณ nonlinear function ที่ซับซ้อนได้

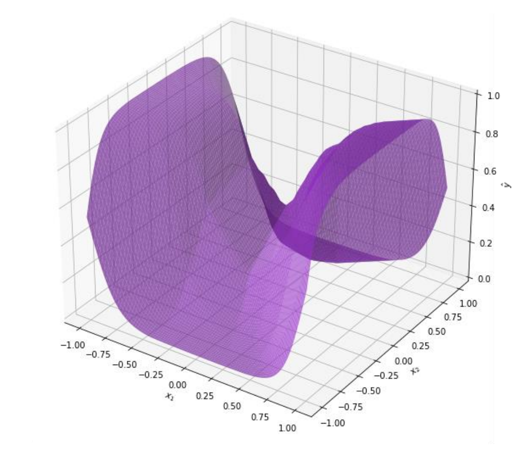
Linear Regression



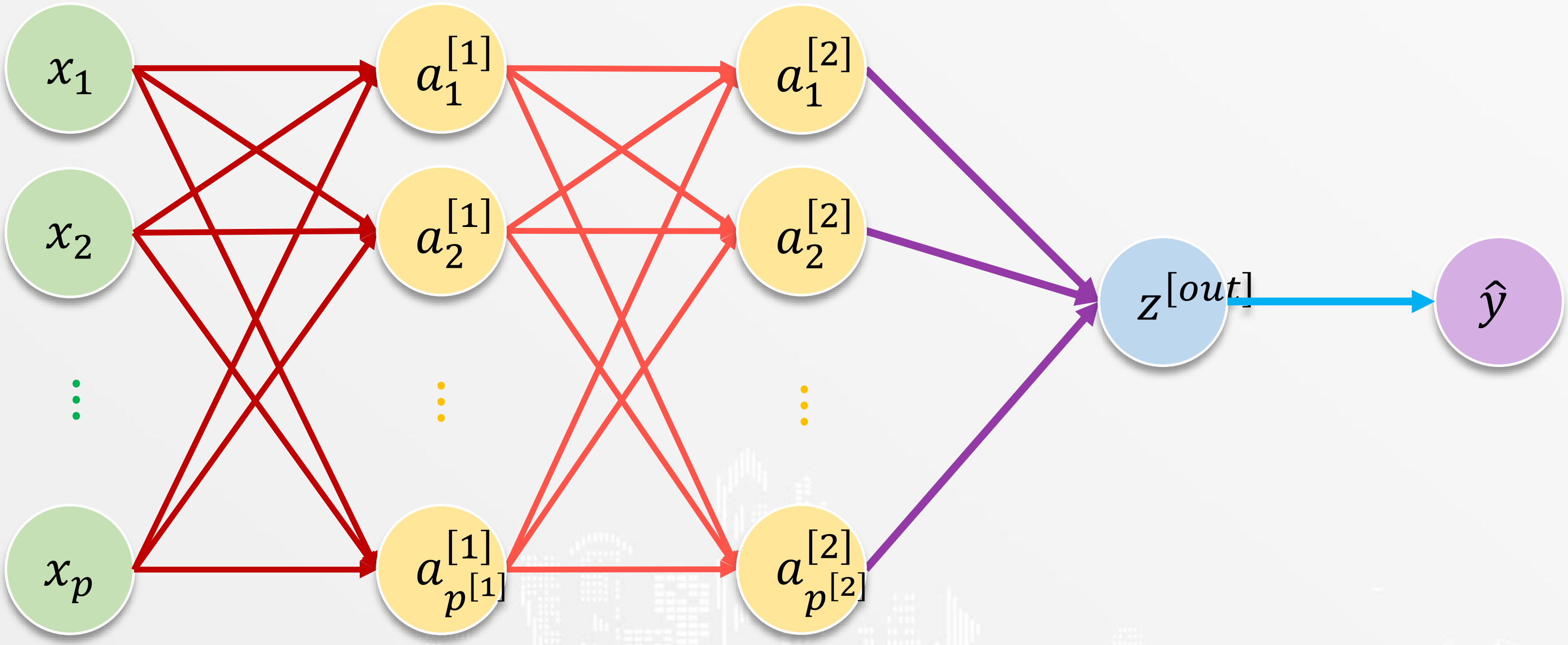
Deep Learning (Regression)



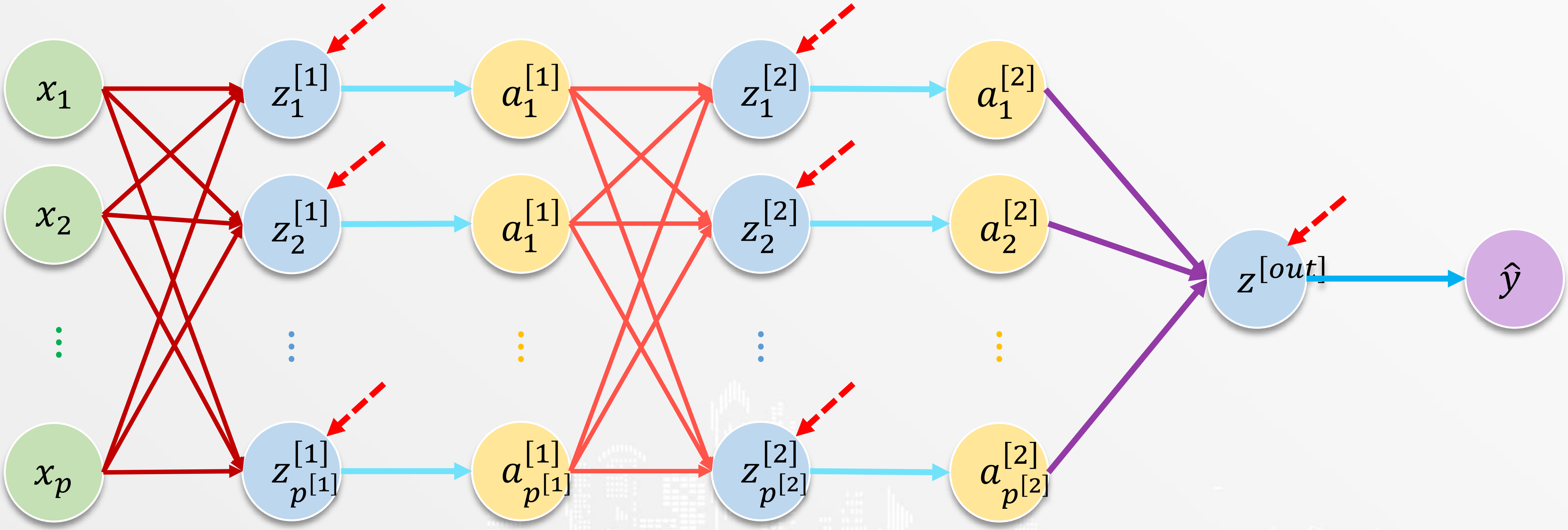
Deep Learning (Classification)



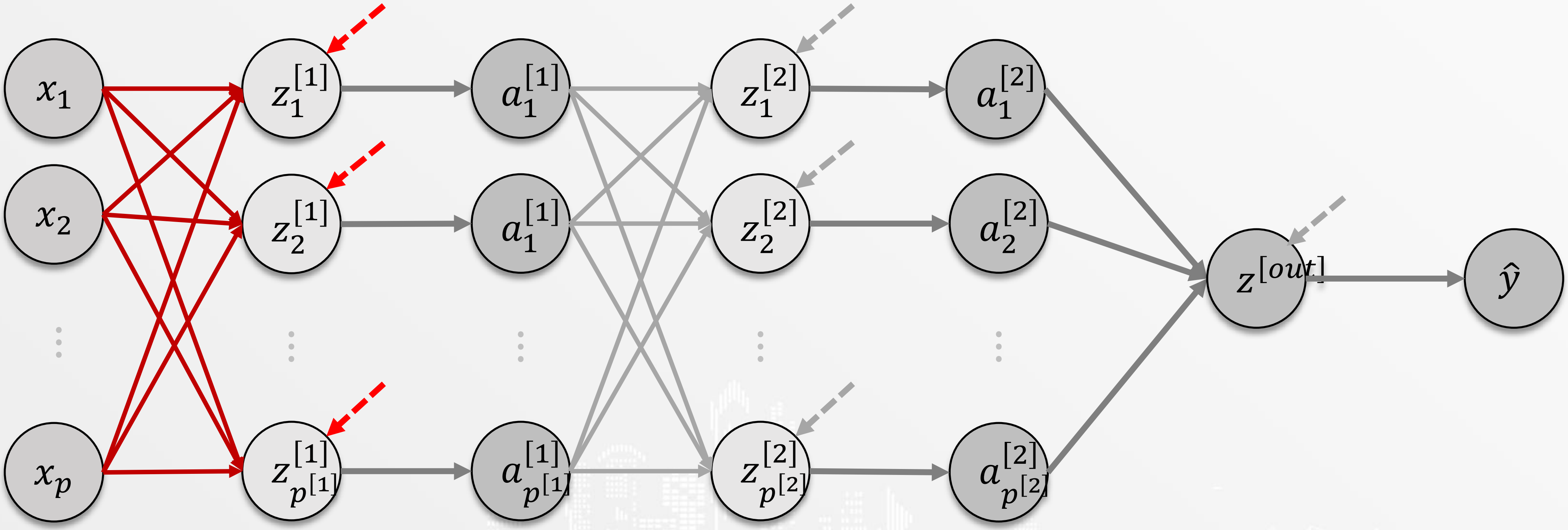
Real Face of the Model



Real Face of the Model



Real Face of the Model

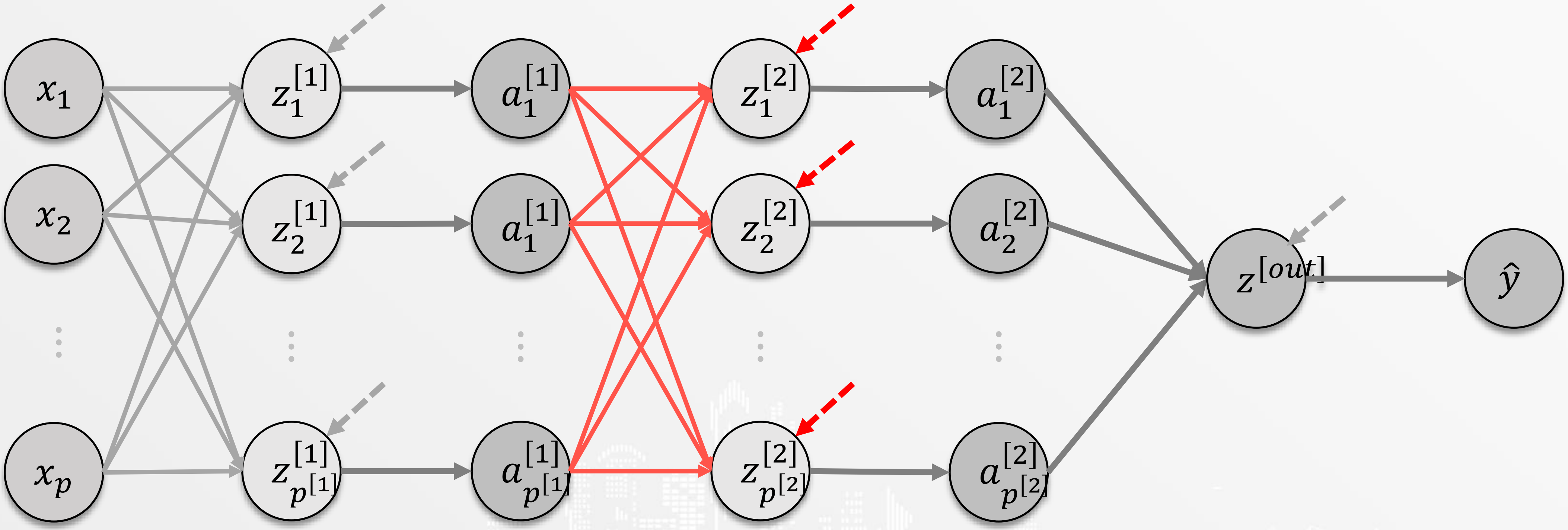


Real Face of the Model

$$\mathbf{b}^{[\mathbf{1}]} = \begin{bmatrix} b_1^{[1]} & b_2^{[1]} & \cdots & b_{p^{[1]}}^{[1]} \end{bmatrix}$$

$$W^{[1]} = \begin{bmatrix} w_{1,1}^{[1]} & w_{1,2}^{[1]} & \cdots & w_{1,p^{[1]}}^{[1]} \\ w_{2,1}^{[1]} & w_{2,2}^{[1]} & \cdots & w_{2,p^{[1]}}^{[1]} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p,1}^{[1]} & w_{p,2}^{[1]} & \cdots & w_{p,p^{[1]}}^{[1]} \end{bmatrix}$$

Real Face of the Model

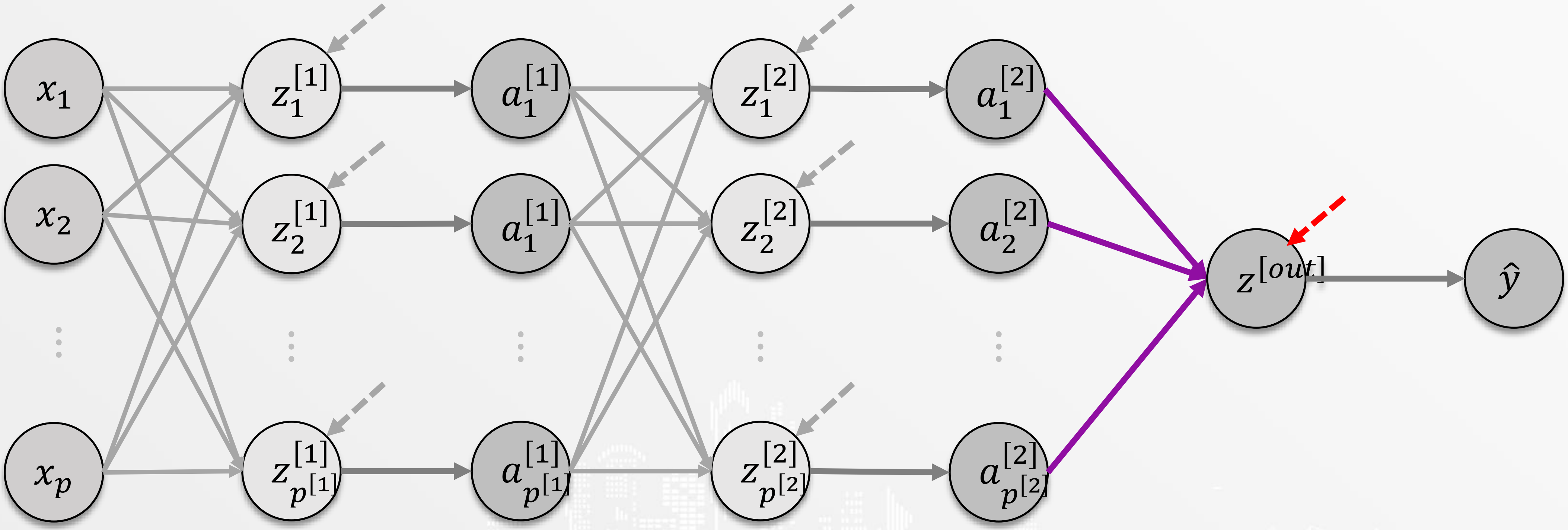


Real Face of the Model

$$\mathbf{b}^{[2]} = \begin{bmatrix} b_1^{[2]} & b_2^{[2]} & \cdots & b_{p^{[2]}}^{[2]} \end{bmatrix}$$

$$W^{[2]} = \begin{bmatrix} w_{1,1}^{[2]} & w_{1,2}^{[2]} & \cdots & w_{1,p^{[2]}}^{[2]} \\ w_{2,1}^{[2]} & w_{2,2}^{[2]} & \cdots & w_{2,p^{[2]}}^{[2]} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p^{[1]},1}^{[2]} & w_{p^{[1]},2}^{[2]} & \cdots & w_{p^{[1]},p^{[2]}}^{[2]} \end{bmatrix}$$

Real Face of the Model



Real Face of the Model

$$\mathbf{b}^{[out]} = \left[b^{[out]} \right]$$

$$W^{[out]} = \begin{bmatrix} w_1^{[out]} \\ w_2^{[out]} \\ \vdots \\ w_{p^{[2]}}^{[out]} \end{bmatrix}$$

Real Face of the Model

$$\mathbf{b}^{[1]}, \mathbf{b}^{[2]}, \mathbf{b}^{[out]}$$

$$W^{[1]}, W^{[2]}, W^{[out]}$$

Real Face of the Model

$$\mathbf{b}^{[1]}, \mathbf{b}^{[2]}, \ldots, \mathbf{b}^{[\mathrm{L}]}, \mathbf{b}^{[out]}$$

$$W^{[1]}, W^{[2]}, \ldots, W^{[L]}, W^{[out]}$$

Real Face of the Model

" เราต้องการหา

$\mathbf{b}^{[1]}, \mathbf{b}^{[2]}, \ldots, \mathbf{b}^{[L]}, \mathbf{b}^{[out]}$ และ

$W^{[1]}, W^{[2]}, \ldots, W^{[L]}, W^{[out]}$

ที่ทำให้ cost function ต่ำที่สุด "

Model Creation

Assumption

Real Face of the Model

Cost Function and Cost Landscape

How to Create Model (Math)

How to Create Model (Code)

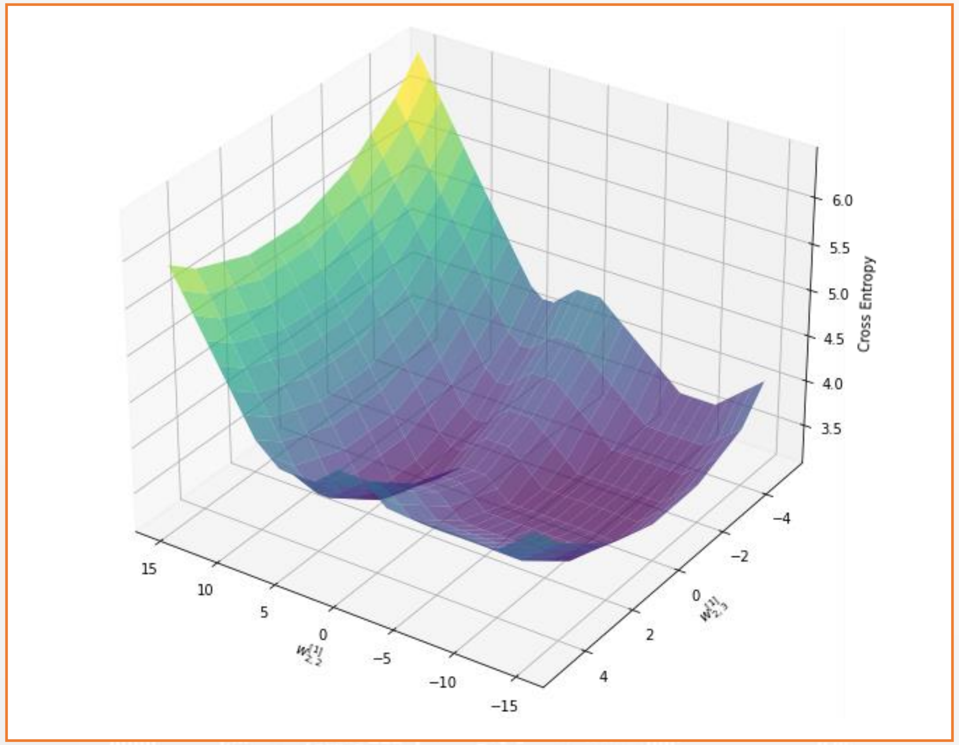
Cost Function & Cost Landscape

Cost function ที่เราจะใช้ในการสร้าง model คือ

$$-\frac{1}{n}\sum_{i=1}^{n}(y_i \log(\hat{y}_i) + (1-y_i)\log(1-\hat{y}_i))$$

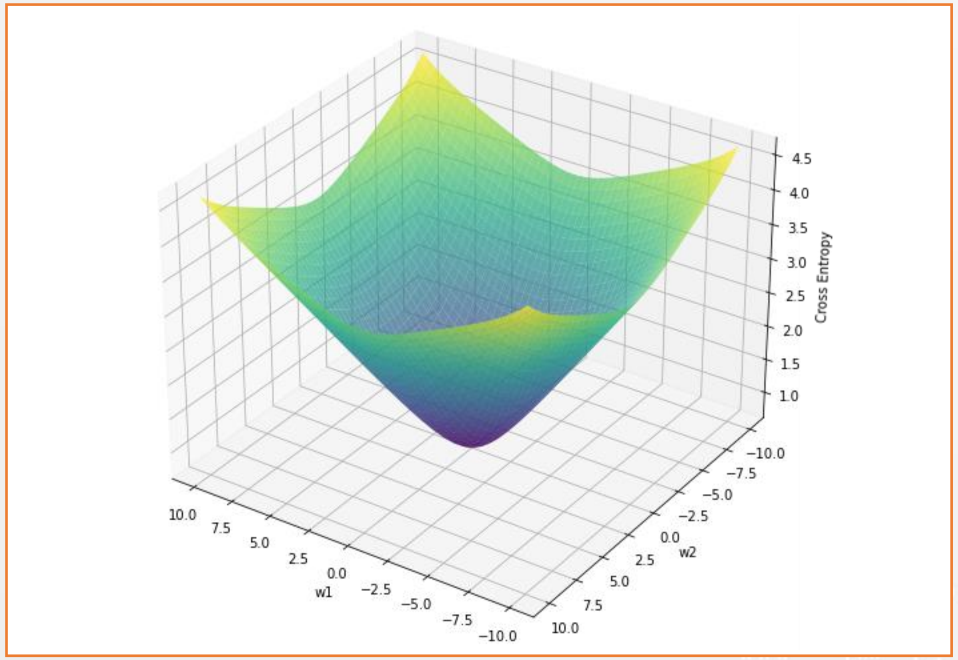
โดยสูตรข้างต้นมีชื่อว่า Cross Entropy

Cost Function & Cost Landscape

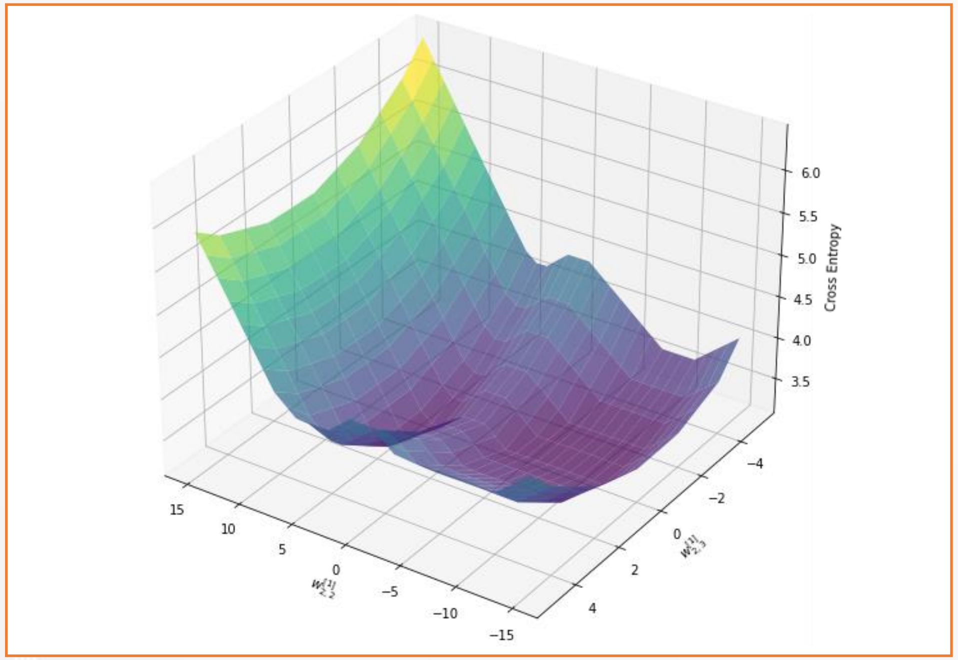


กราฟแสดง cost landscape ของ deep learning
โดยที่ cost function เป็น cross entropy

Cost Function & Cost Landscape



VS



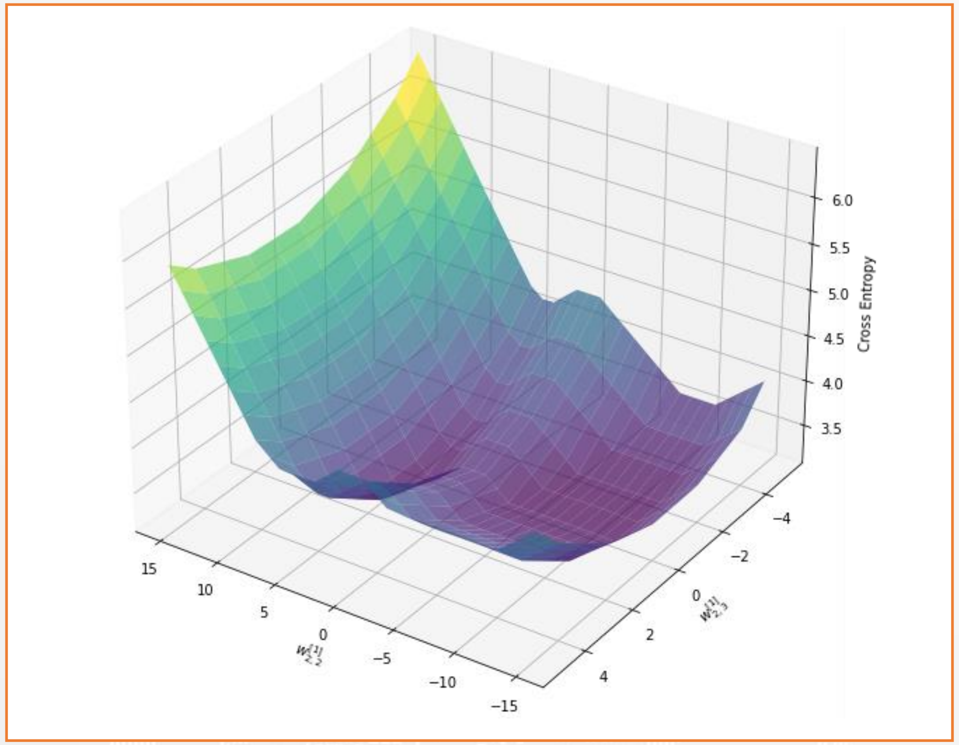
กราฟแสดง cost landscape ของ logistic regression โดยที่ cost function เป็น cross entropy

กราฟแสดง cost landscape ของ deep learning โดยที่ cost function เป็น cross entropy

Cost Function & Cost Landscape

“ **Cost landscape** ของ deep learning เป็น non-convex ซึ่งมีจุดต่ำสุดหลายตำแหน่ง ”

Cost Function & Cost Landscape



กราฟแสดง cost landscape ของ deep learning
โดยที่ cost function เป็น cross entropy

Model Creation

Assumption

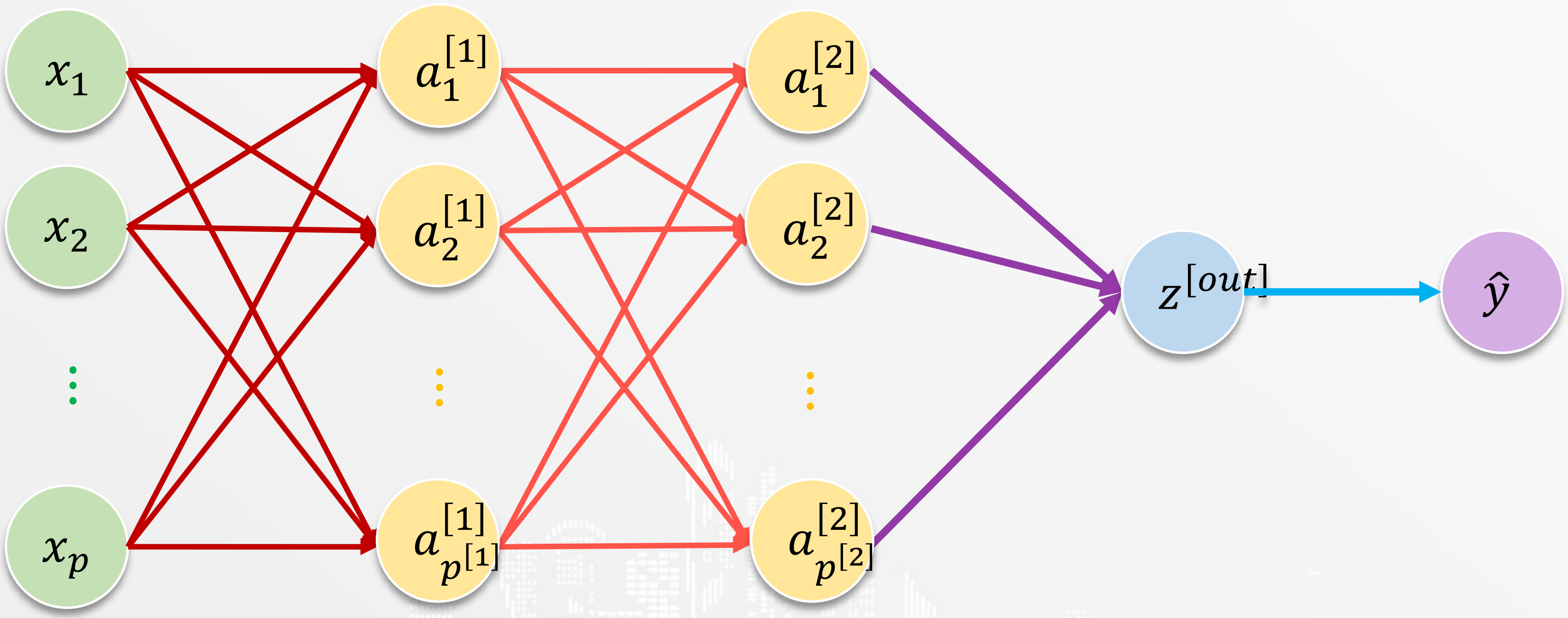
Real Face of the Model

Cost Function and Cost Landscape

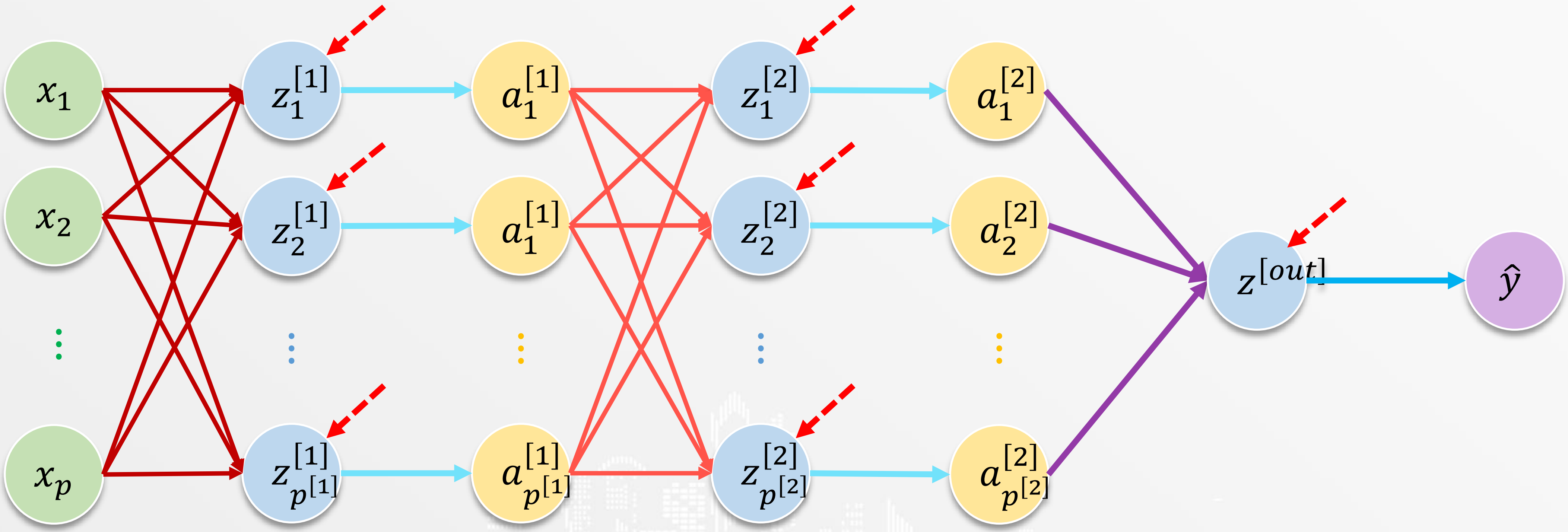
How to Create Model (Math)

How to Create Model (Code)

How to Create Model (Math)



How to Create Model (Math)



How to Create Model (Math)

❝ เราต้องการหา

$\mathbf{b}^{[1]}, \mathbf{b}^{[2]}, \dots, \mathbf{b}^{[L]}, \mathbf{b}^{[out]}$ และ

$W^{[1]}, W^{[2]}, \dots, W^{[L]}, W^{[out]}$

ที่ทำให้ cost function ต่ำที่สุด ❞

How to Create Model (Math)

Cost function ที่เราจะใช้ในการสร้าง model คือ

$$-\frac{1}{n}\sum_{i=1}^{n}(y_i \log(\hat{y}_i) + (1 - y_i) \log(1 - \hat{y}_i))$$

โดยสูตรข้างต้นมีชื่อว่า Cross Entropy

How to Create Model (Math)

เครื่องมือที่เราจะใช้ในการหาคำตอบ คือ

" Gradient Descent "

How to Create Model (Math)

Equation of Gradient Descent

$$W = W - \alpha \nabla Cost$$

โดย

- α คือ ค่าที่ใช้ควบคุม step size ของ W

How to Create Model (Math)

$$\mathbf{b}^{[1]} = \mathbf{b}^{[1]} - \alpha \nabla Cost$$
$$\mathbf{b}^{[2]} = \mathbf{b}^{[2]} - \alpha \nabla Cost$$
$$\vdots$$
$$\mathbf{b}^{[L]} = \mathbf{b}^{[L]} - \alpha \nabla Cost$$
$$\mathbf{b}^{[out]} = \mathbf{b}^{[out]} - \alpha \nabla Cost$$

How to Create Model (Math)

$$W^{[1]} = W^{[1]} - \alpha \nabla Cost$$
$$W^{[2]} = W^{[2]} - \alpha \nabla Cost$$
$$\vdots$$
$$W^{[L]} = W^{[L]} - \alpha \nabla Cost$$
$$W^{[out]} = W^{[out]} - \alpha \nabla Cost$$

Model Creation

- Assumption
- Real Face of the Model
- Cost Function and Cost Landscape
- How to Create Model (Math)
- How to Create Model (Code)

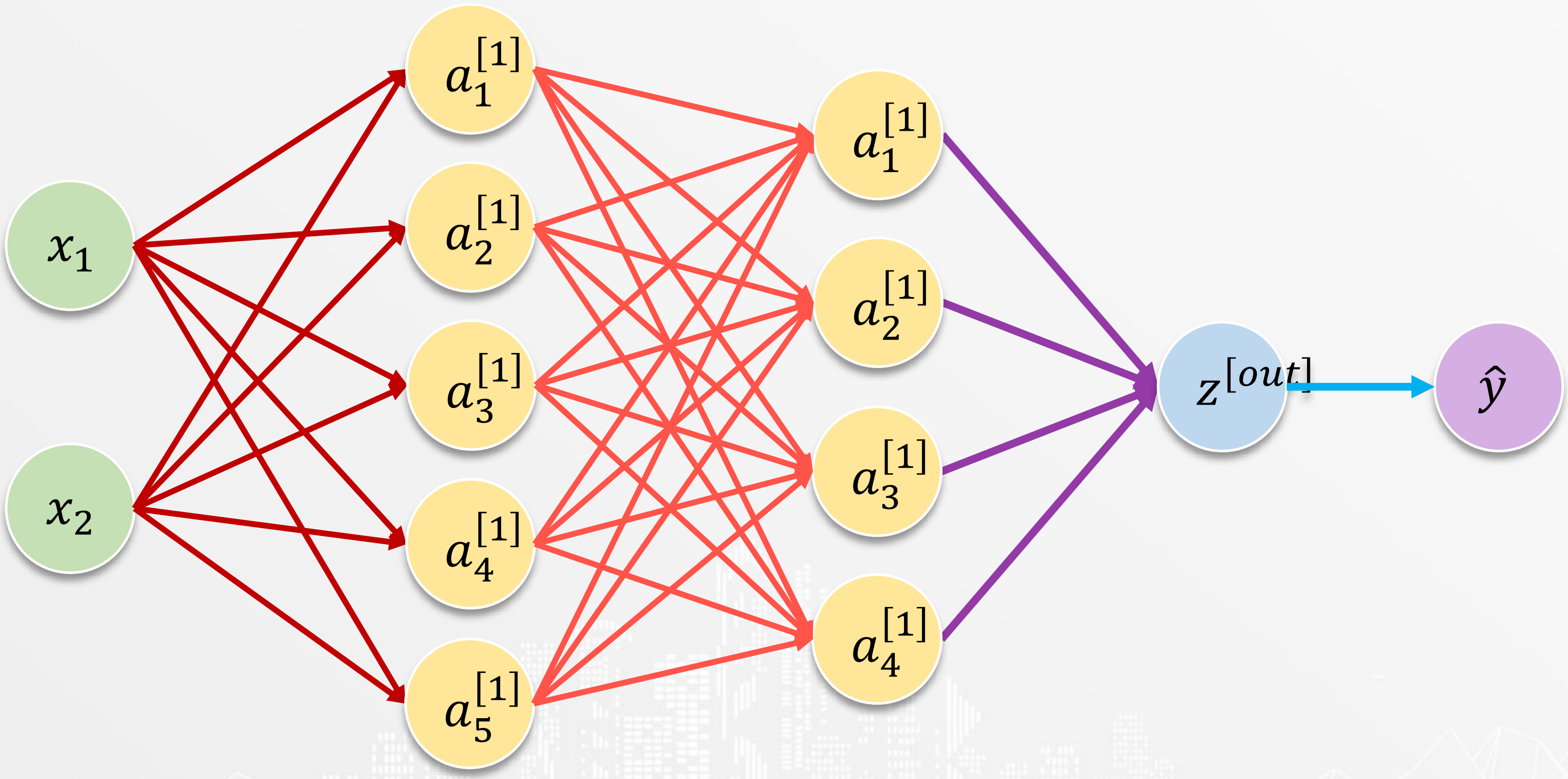
How to Create Model (Code)

ตัวอย่างการหา weight สำหรับ deep learning

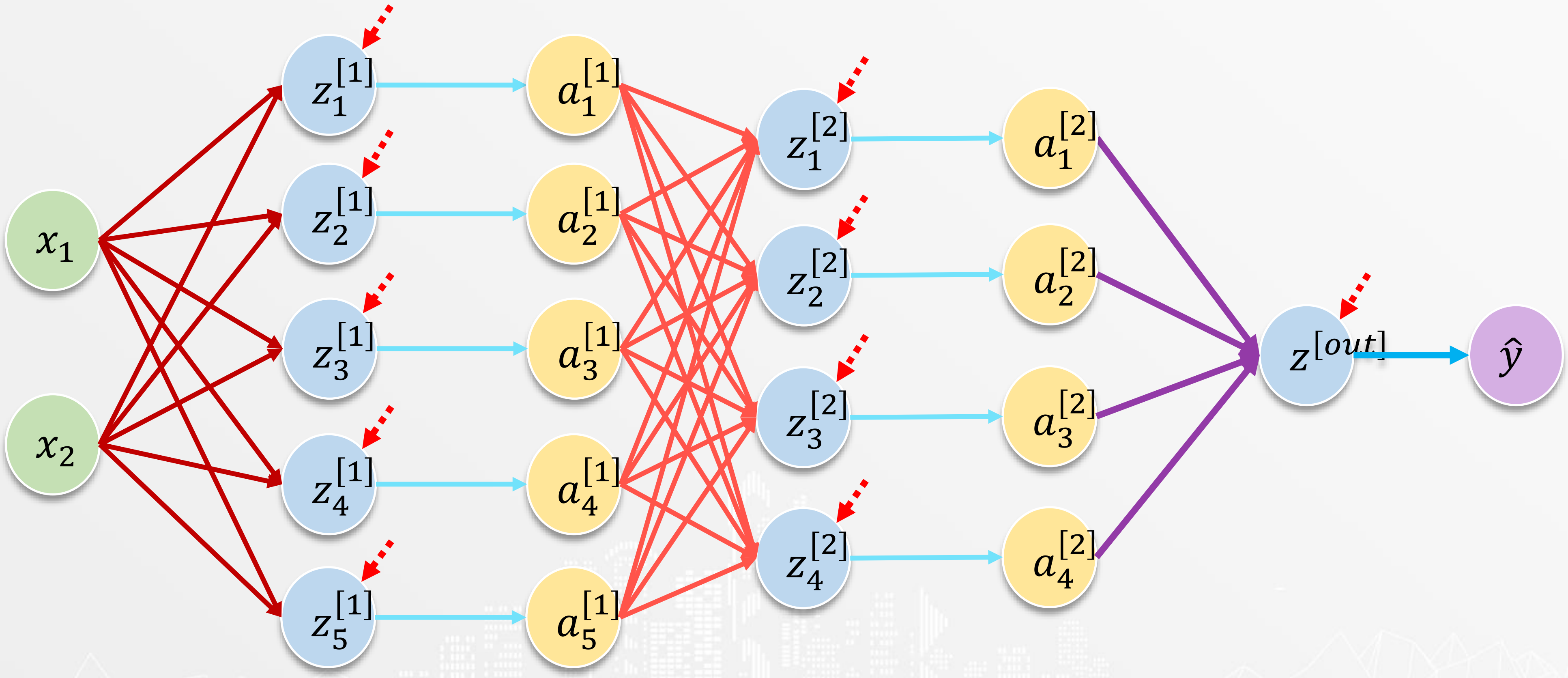
x_1	x_2	y
2	1	B
2	-1	B
-2	2	A
1	2	B
-2	3	B
2	0	B
-1	-1	A
-2	1	A
0	0	A

x_1	x_2	y
1	-1	A
-1	0	A
-1	1	A
1	3	B
2	2	B
2	3	B
1	1	B
0	2	B
-1	3	B

How to Create Model (Code)



How to Create Model (Code)



How to Create Model (Code)

$$X = \begin{bmatrix} 2 & 1 \\ 2 & -1 \\ -2 & 2 \\ 1 & 2 \\ \vdots & \vdots \\ 0 & 2 \\ -1 & 3 \end{bmatrix}, \qquad \mathbf{y} = \begin{bmatrix} B \\ B \\ A \\ B \\ \vdots \\ B \\ B \end{bmatrix}$$

TAUTOLOGY

How to Create Model (Code)

```
clf = MLPClassifier(
    hidden_layer_sizes=(5, 4),
    activation='relu',
    solver='sgd',
    alpha=0,
    learning_rate_init=1,
    max_iter=1000,
    momentum=0
)

clf.fit(X, y)
```

How to Create Model (Code)

Code for this section

Open File

Binary Classification/Model Creation.ipynb

How to Create Model (Code)

$$\mathbf{b}^{[\mathbf{1}]} = [0.002 \quad -0.596 \quad 0.007 \quad 1.308 \quad 0.69]$$

$$W^{[1]} = \begin{bmatrix} 1.321 & -0.377 & -0.273 & -1.071 & 0.769 \\ 1.324 & 0.685 & 0.7 & -0.928 & -0.737 \end{bmatrix}$$

How to Create Model (Code)

$$\mathbf{b}^{[2]} = \begin{bmatrix} -0.028 & -0.138 & 0.696 & 1.072 \end{bmatrix}$$

$$W^{[2]} = \begin{bmatrix} -0.763 & -0.585 & 1.35 & -0.848 \\ -0.472 & -0.124 & 0.475 & 0.414 \\ -0.458 & -0.431 & 0.313 & -0.459 \\ 0.58 & 0.161 & -0.95 & 1.393 \\ -0.746 & -0.718 & 0.408 & 0.099 \end{bmatrix}$$

How to Create Model (Code)

$$\mathbf{b}^{[out]} = [0.403]$$

$$W^{[out]} = \begin{bmatrix} -0.096 \\ 1.065 \\ 1.682 \\ -1.779 \end{bmatrix}$$

How to Create Model (Code)

$$a_1^{[1]} = ReLU(0.002 + 1.321x_1 + 1.324x_2)$$

$$a_2^{[1]} = ReLU(-0.596 - 0.377x_1 + 0.685x_2)$$

$$a_3^{[1]} = ReLU(0.007 - 0.273x_1 + 0.7x_2)$$

$$a_4^{[1]} = ReLU(1.308 - 1.071x_1 - 0.928x_2)$$

$$a_5^{[1]} = ReLU(0.69 + 0.769x_1 - 0.737x_2)$$

How to Create Model (Code)

$$a_1^{[2]} = ReLU\left(-0.028 - 0.763a_1^{[1]} - 0.472a_2^{[1]} - 0.458a_3^{[1]} + 0.58a_4^{[1]} - 0.746a_5^{[1]}\right)$$

$$a_2^{[2]} = ReLU\left(-0.138 - 0.585a_1^{[1]} - 0.124a_2^{[1]} - 0.431a_3^{[1]} + 0.161a_4^{[1]} - 0.718a_5^{[1]}\right)$$

$$a_3^{[2]} = ReLU\left(0.696 + 1.35a_1^{[1]} + 0.475a_2^{[1]} + 0.313a_3^{[1]} - 0.95a_4^{[1]} + 0.408a_5^{[1]}\right)$$

$$a_4^{[2]} = ReLU\left(1.072 - 0.848a_1^{[1]} + 0.414a_2^{[1]} - 0.459a_3^{[1]} + 1.393a_4^{[1]} + 0.099a_5^{[1]}\right)$$

How to Create Model (Code)

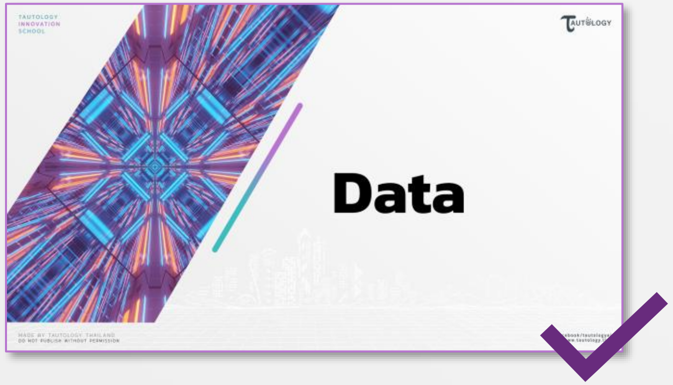
$$z^{[out]} = 0.403 - 0.096a_1^{[3]} + 1.065a_2^{[3]} + 1.682a_3^{[3]} - 1.779a_4^{[3]}$$

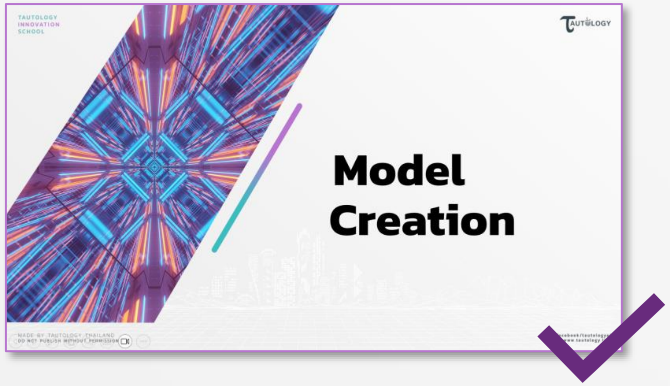
$$\hat{y} = \sigma\left(z^{[out]}\right) = \frac{1}{1 + e^{-z^{[out]}}}$$

Model Creation

- Assumption
- Real Face of the Model
- Cost Function and Cost Landscape
- How to Create Model (Math)
- How to Create Model (Code)

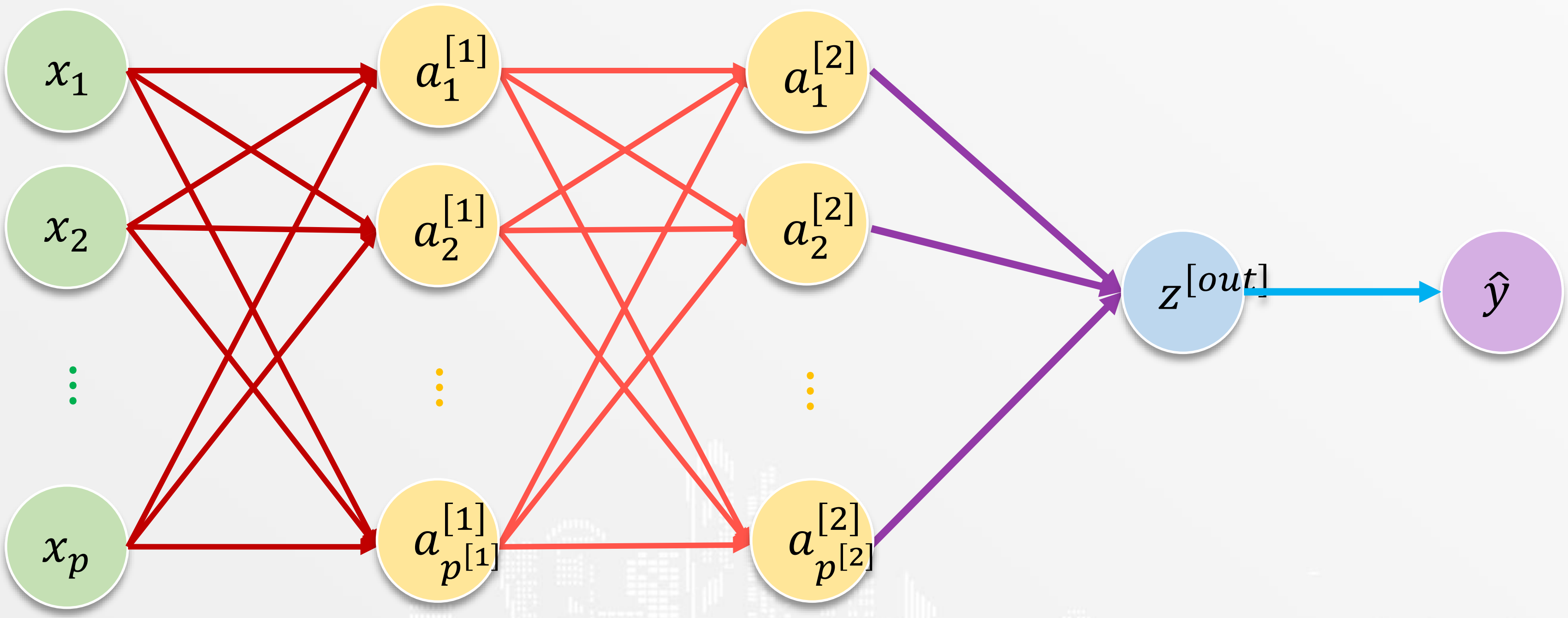
Deep Learning for Binary Classification



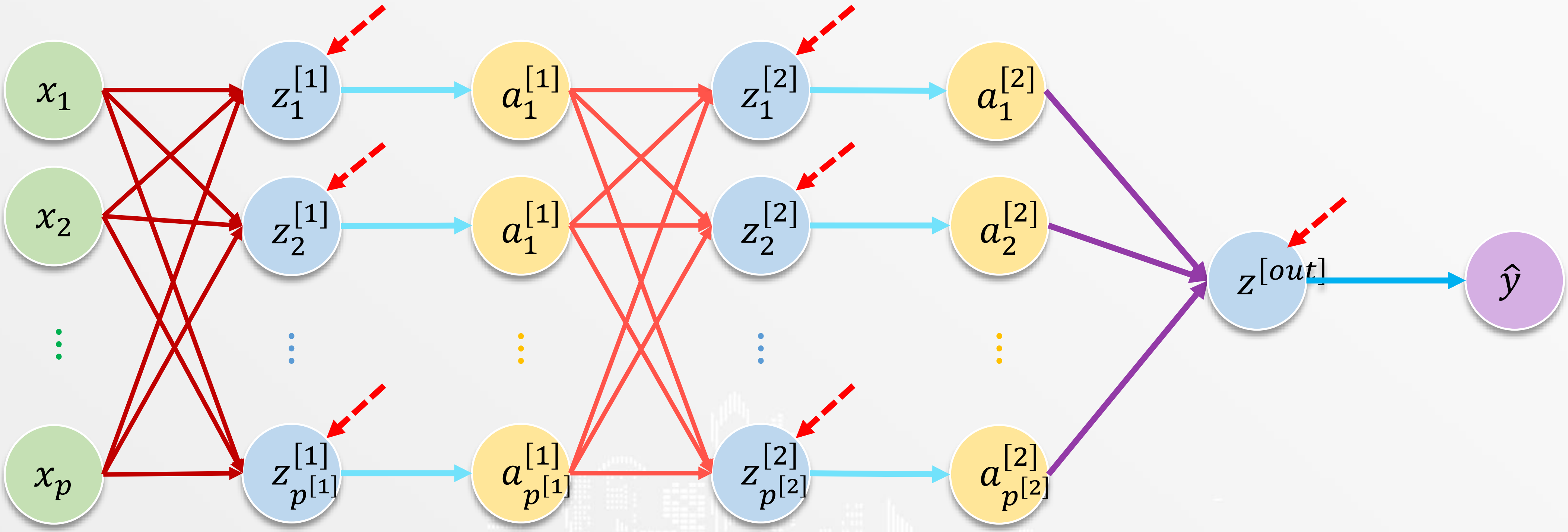


Prediction

Prediction



Prediction


x_1
x_2
x_p
$z_1^{[1]}$
$z_2^{[1]}$
$z_{p^{[1]}}^{[1]}$
$a_1^{[1]}$
$a_1^{[1]}$
$a_{p^{[1]}}^{[1]}$
$z_1^{[2]}$
$z_2^{[2]}$
$z_{p^{[2]}}^{[2]}$
$a_1^{[2]}$
$a_2^{[2]}$
$a_{p^{[2]}}^{[2]}$
$z^{[out]}$
$\hat{y}$

Prediction

$$\mathbf{b}^{[1]} \quad \mathbf{b}^{[2]} \quad \mathbf{b}^{[out]}$$

$$W^{[1]} \quad W^{[2]} \quad W^{[out]}$$

Prediction

1-Sample

Multi-Sample

Code

1-Sample

ตัวอย่างการคำนวณ $\hat{y}$

x_1	x_2
0	3

$\hat{y}$
?

1-Sample

- สมมติว่า weight ของปัญหานี้ที่เราหามาได้คือ

$$\mathbf{b}^{[\mathbf{1}]} = \begin{bmatrix} 0.002 & -0.596 & 0.007 & 1.308 & 0.69 \end{bmatrix}$$

$$W^{[1]} = \begin{bmatrix} 1.321 & -0.377 & -0.273 & -1.071 & 0.769 \\ 1.324 & 0.685 & 0.7 & -0.928 & -0.737 \end{bmatrix}$$

1-Sample

- สมมติว่า weight ของปัญหานี้ที่เราหามาได้คือ

$$\mathbf{b}^{[2]} = \begin{bmatrix} -0.028 & -0.138 & 0.696 & 1.072 \end{bmatrix}$$

$$W^{[2]} = \begin{bmatrix} -0.763 & -0.585 & 1.35 & -0.848 \\ -0.472 & -0.124 & 0.475 & 0.414 \\ -0.458 & -0.431 & 0.313 & -0.459 \\ 0.58 & 0.161 & -0.95 & 1.393 \\ -0.746 & -0.718 & 0.408 & 0.099 \end{bmatrix}$$

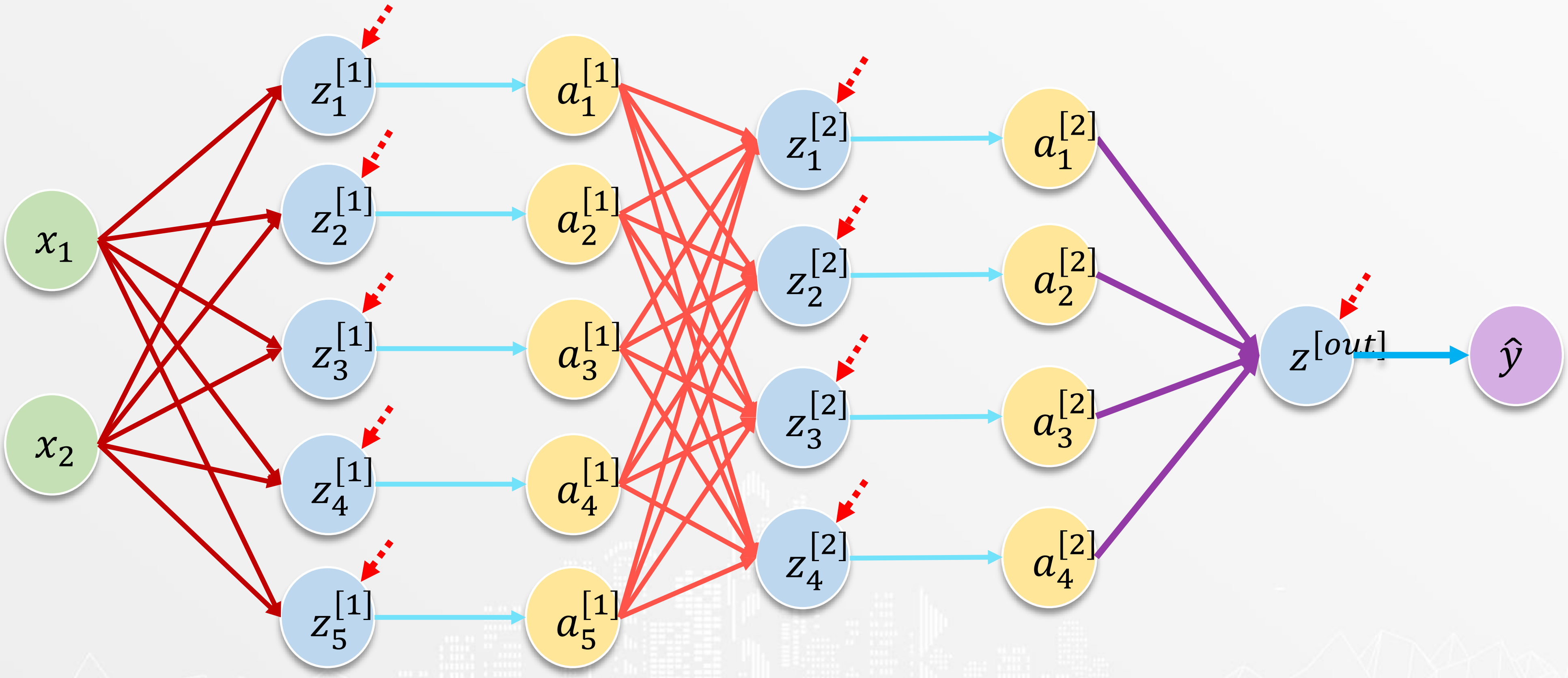
1-Sample

- สมมติว่า weight ของปัญหานี้ที่เราหามาได้คือ

$$\mathbf{b}^{[out]} = [0.403]$$

$$W^{[out]} = \begin{bmatrix} -0.096 \\ 1.065 \\ 1.682 \\ -1.779 \end{bmatrix}$$

1-Sample


x_1
x_2
$z_1^{[1]}$
$z_2^{[1]}$
$z_3^{[1]}$
$z_4^{[1]}$
$z_5^{[1]}$
$a_1^{[1]}$
$a_2^{[1]}$
$a_3^{[1]}$
$a_4^{[1]}$
$a_5^{[1]}$
$z_1^{[2]}$
$z_2^{[2]}$
$z_3^{[2]}$
$z_4^{[2]}$
$a_1^{[2]}$
$a_2^{[2]}$
$a_3^{[2]}$
$a_4^{[2]}$
$z^{[out]}$
$\hat{y}$

1-Sample

$$a_1^{[1]} = ReLU(0.002 + 1.321x_1 + 1.324x_2) = 3.974$$

$$a_2^{[1]} = ReLU(-0.596 - 0.377x_1 + 0.685x_2) = 1.459$$

$$a_3^{[1]} = ReLU(0.007 - 0.273x_1 + 0.7x_2) = 2.107$$

$$a_4^{[1]} = ReLU(1.308 - 1.071x_1 - 0.928x_2) = 0$$

$$a_5^{[1]} = ReLU(0.69 + 0.769x_1 - 0.737x_2) = 0$$

1-Sample

$$a_1^{[2]} = ReLU\left(-0.028 - 0.763a_1^{[1]} - 0.472a_2^{[1]} - 0.458a_3^{[1]} + 0.58a_4^{[1]} - 0.746a_5^{[1]}\right) = 0$$

$$a_2^{[2]} = ReLU\left(-0.138 - 0.585a_1^{[1]} - 0.124a_2^{[1]} - 0.431a_3^{[1]} + 0.161a_4^{[1]} - 0.718a_5^{[1]}\right) = 0$$

$$a_3^{[2]} = ReLU\left(0.696 + 1.35a_1^{[1]} + 0.475a_2^{[1]} + 0.313a_3^{[1]} - 0.95a_4^{[1]} + 0.408a_5^{[1]}\right) = 7.143$$

$$a_4^{[2]} = ReLU\left(1.072 - 0.848a_1^{[1]} + 0.414a_2^{[1]} - 0.459a_3^{[1]} + 1.393a_4^{[1]} + 0.099a_5^{[1]}\right) = 0$$

1-Sample

$$z^{[out]} = 0.403 - 0.096a_1^{[3]} + 1.065a_2^{[3]} + 1.682a_3^{[3]} - 1.779a_4^{[3]} = 12.066$$

$$\hat{y} = \sigma\left(z^{[out]}\right) = \frac{1}{1 + e^{-z^{[out]}}} = \frac{1}{1 + e^{-12.066}} = 1 \quad \Rightarrow \quad B$$

$$\boxed{\begin{array}{ccc} 0 & \Rightarrow & A \\ 1 & \Rightarrow & B \end{array}}$$

1-Sample

ดังนั้น เราจะได้ $\hat{y}$ สำหรับข้อมูลชุดนี้คือ

x_1	x_2
0	3

$\hat{y}$
B

Prediction

- **1-Sample** ✓
- Multi-Sample
- Code

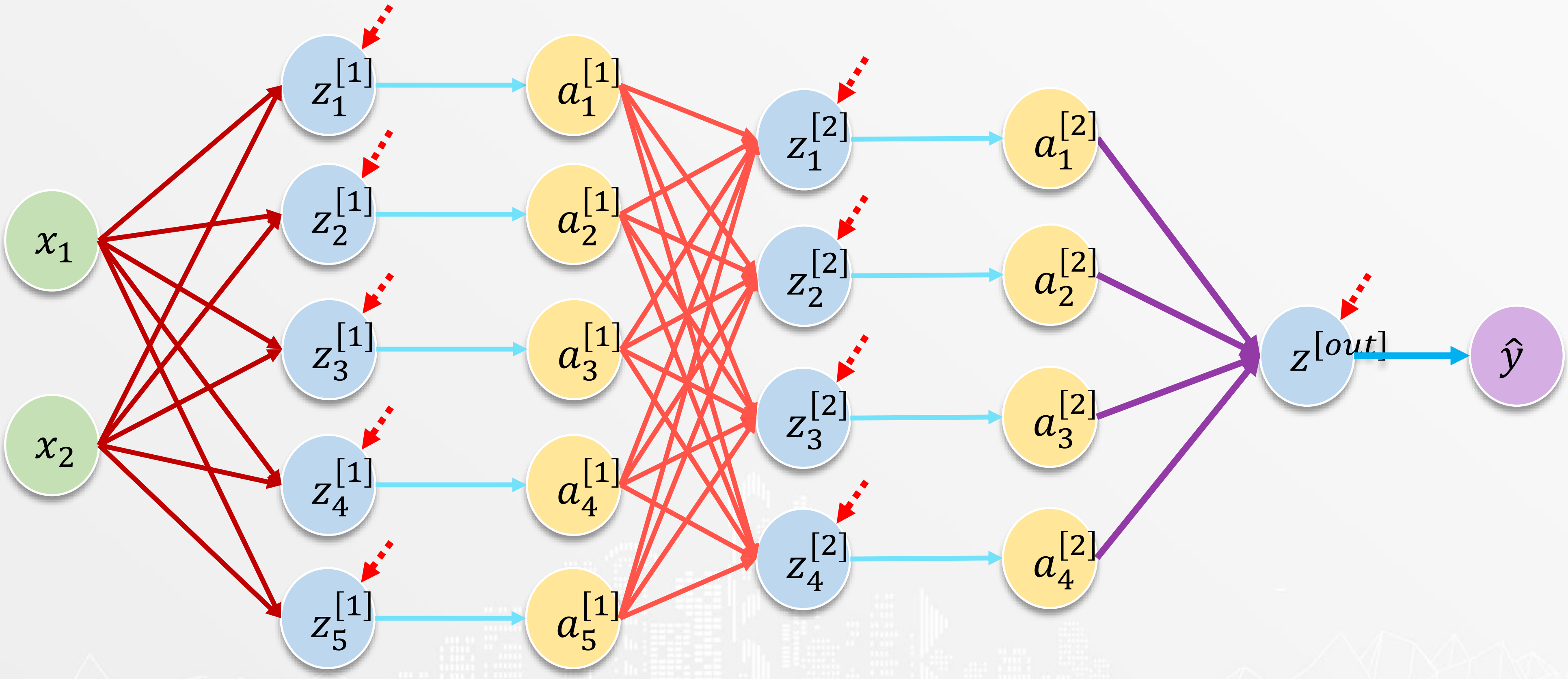
Multi-Sample

ตัวอย่างการคำนวณ $\hat{y}$

$\mathbf{x_1}$	$\mathbf{x_2}$
0	3
-2	-1
-2	1
0	-1

$\hat{\mathbf{y}}$
?
?
?
?

Multi-Sample



Multi-Sample

$$X \rightarrow Z^{[1]} \rightarrow A^{[1]} \rightarrow Z^{[2]} \rightarrow A^{[2]} \rightarrow \mathbf{z}^{[out]} \rightarrow \hat{\mathbf{y}}$$

Multi-Sample

$$Z^{[1]} = XW^{[1]} + \mathbf{b}^{[1]}$$

$$Z^{[1]} = \begin{bmatrix} 0 & 3 \\ -2 & -1 \\ -2 & 1 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} 1.321 & -0.377 & -0.273 & -1.071 & 0.769 \\ 1.324 & 0.685 & 0.7 & -0.928 & -0.737 \end{bmatrix} + \begin{bmatrix} 0.002 & -0.596 & 0.007 & 1.308 & 0.69 \end{bmatrix}$$

$$= \begin{bmatrix} 3.971 & 2.054 & 2.099 & -2.783 & -2.21 \\ -3.965 & 0.068 & -0.155 & 3.07 & -0.801 \\ 1.324 & 0.685 & 0.7 & -0.928 & -0.737 \\ -1.324 & -0.685 & -0.7 & 0.928 & 0.737 \end{bmatrix} + \begin{bmatrix} 0.002 & -0.596 & 0.007 & 1.308 & 0.69 \\ 0.002 & -0.596 & 0.007 & 1.308 & 0.69 \\ 0.002 & -0.596 & 0.007 & 1.308 & 0.69 \\ 0.002 & -0.596 & 0.007 & 1.308 & 0.69 \end{bmatrix}$$

Multi-Sample

$$Z^{[1]} = XW^{[1]} + \mathbf{b}^{[1]}$$

$$Z^{[1]} = \begin{bmatrix} 3.973 & 1.458 & 2.106 & -1.475 & -1.52 \\ -3.963 & -0.528 & -0.148 & 4.378 & -0.111 \\ 1.326 & 0.089 & 0.707 & 0.38 & -0.047 \\ -1.322 & -1.281 & -0.693 & 2.236 & 1.427 \end{bmatrix}$$

Multi-Sample

$$A^{[1]} = ReLU(Z^{[1]})$$

$$A^{[1]} = ReLU\left(\begin{bmatrix} 3.973 & 1.458 & 2.106 & -1.475 & -1.52 \\ -3.963 & -0.528 & -0.148 & 4.378 & -0.111 \\ 1.326 & 0.089 & 0.707 & 0.38 & -0.047 \\ -1.322 & -1.281 & -0.693 & 2.236 & 1.427 \end{bmatrix}\right)$$

$$= \begin{bmatrix} 3.973 & 1.458 & 2.106 & 0 & 0 \\ 0 & 0 & 0 & 4.378 & 0 \\ 1.326 & 0.089 & 0.707 & 0.38 & 0 \\ 0 & 0 & 0 & 2.236 & 1.427 \end{bmatrix}$$

Multi-Sample

$$Z^{[2]} = A^{[1]}W^{[2]} + \mathbf{b}^{[2]}$$

$$Z^{[2]} = \begin{bmatrix} 3.973 & 1.458 & 2.106 & 0 & 0 \\ 0 & 0 & 0 & 4.378 & 0 \\ 1.326 & 0.089 & 0.707 & 0.38 & 0 \\ 0 & 0 & 0 & 2.236 & 1.427 \end{bmatrix} \begin{bmatrix} -0.763 & -0.585 & 1.35 & -0.848 \\ -0.472 & -0.124 & 0.475 & 0.414 \\ -0.458 & -0.431 & 0.313 & -0.459 \\ 0.58 & 0.161 & -0.95 & 1.393 \\ -0.746 & -0.718 & 0.408 & 0.099 \end{bmatrix}$$

$$+ \begin{bmatrix} -0.028 & -0.138 & 0.696 & 1.072 \end{bmatrix}$$

$$= \begin{bmatrix} -4.685 & -3.414 & 6.715 & -3.733 \\ 2.537 & 0.706 & -4.157 & 6.097 \\ -1.157 & -1.031 & 1.693 & -0.883 \\ 0.231 & -0.663 & -1.542 & 3.255 \end{bmatrix} + \begin{bmatrix} -0.028 & -0.138 & 0.696 & 1.072 \\ -0.028 & -0.138 & 0.696 & 1.072 \\ -0.028 & -0.138 & 0.696 & 1.072 \\ -0.028 & -0.138 & 0.696 & 1.072 \end{bmatrix}$$

Multi-Sample

$$Z^{[2]} = A^{[1]}W^{[2]} + \mathbf{b}^{[2]}$$

$$Z^{[2]} = \begin{bmatrix} -4.713 & -3.552 & 7.411 & -2.661 \\ 2.509 & 0.568 & -3.461 & 7.169 \\ -1.185 & -1.169 & 2.389 & 0.189 \\ 0.203 & -0.801 & -0.846 & 4.327 \end{bmatrix}$$

Multi-Sample

$$A^{[2]} = ReLU(z^{[2]})$$

$$A^{[2]} = ReLU\left(\begin{bmatrix} -4.713 & -3.552 & 7.411 & -2.661 \\ 2.509 & 0.568 & -3.461 & 7.169 \\ -1.185 & -1.169 & 2.389 & 0.189 \\ 0.203 & -0.801 & -0.846 & 4.327 \end{bmatrix}\right)$$

$$= \begin{bmatrix} 0 & 0 & 7.411 & 0 \\ 2.509 & 0.568 & 0 & 7.169 \\ 0 & 0 & 2.389 & 0.189 \\ 0.203 & 0 & 0 & 4.327 \end{bmatrix}$$

Multi-Sample

$$\mathbf{z}^{[out]} = A^{[2]}W^{[out]} + \mathbf{b}^{[out]}$$

$$\mathbf{z}^{[out]} = \begin{bmatrix} 0 & 0 & 7.411 & 0 \\ 2.509 & 0.568 & 0 & 7.169 \\ 0 & 0 & 2.389 & 0.189 \\ 0.203 & 0 & 0 & 4.327 \end{bmatrix} \begin{bmatrix} -0.096 \\ 1.065 \\ 1.682 \\ -1.779 \end{bmatrix} + [0.403]$$

$$= \begin{bmatrix} 12.462 \\ -12.388 \\ 3.681 \\ -7.717 \end{bmatrix} + \begin{bmatrix} 0.403 \\ 0.403 \\ 0.403 \\ 0.403 \end{bmatrix} = \begin{bmatrix} 12.059 \\ -12.791 \\ 3.278 \\ -8.12 \end{bmatrix}$$

Multi-Sample

$$\hat{\mathbf{y}} = \sigma\left(\mathbf{z}^{[out]}\right)$$

$$\hat{\mathbf{y}} = \sigma\begin{pmatrix} 12.059 \\ -12.791 \\ 3.278 \\ -8.12 \end{pmatrix}$$

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

$$\begin{array}{ccc} 0 & \Rightarrow & A \\ 1 & \Rightarrow & B \end{array}$$

Multi-Sample

ดังนั้น เราจะได้ $\hat{y}$ สำหรับข้อมูลชุดนี้คือ

$\mathbf{x_1}$	$\mathbf{x_2}$
0	3
-2	-1
-2	1
0	-1

$\hat{\mathbf{y}}$
B
A
B
A

Prediction

1-Sample

Multi-Sample

Code

Code

```
clf.predict(X)
```

```
array(['B', 'A', 'B', 'A'], dtype='<U1')
```

Code

Code for this section

Open File

Binary Classification/Model Creation.ipynb

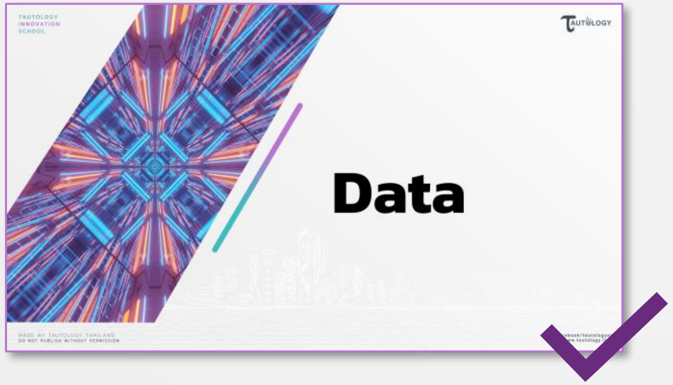
Prediction

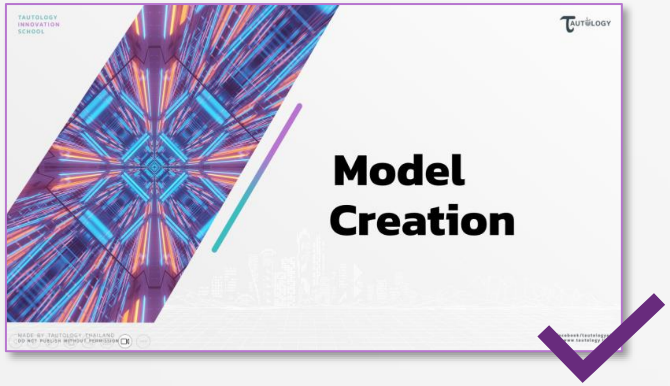
1-Sample

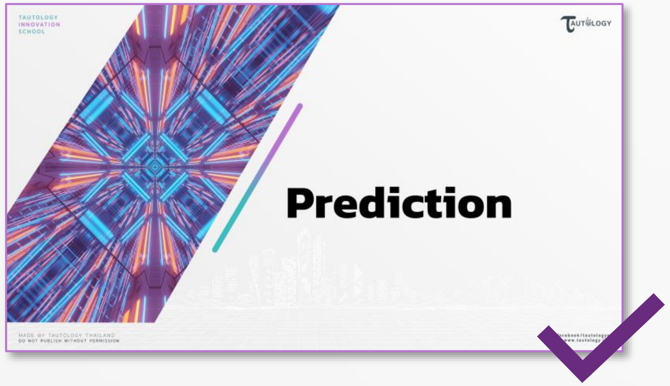
Multi-Sample

Code

Deep Learning for Binary Classification







Deep Learning for Classification

Deep Learning for Binary Classification

Deep Learning for Multi-Class Classification

Deep Learning for Multi-Class Classification

Deep Learning เป็นหนึ่งใน algorithm ประเภท supervised learning

Machine Leaning

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

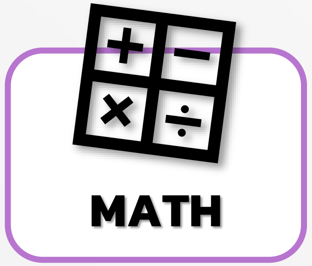
Concept of Supervised Learning

Data ➪ Model ➪ Prediction

Deep Learning for Multi-Class Classification

Data

Data



อายุ	female	male	โรค
42	1	0	เบาหวาน
57	0	1	โควิด
58	0	1	โควิด
59	1	0	หัวใจ

อายุ	female	male	โรค
42	1	0	0
57	0	1	1
58	0	1	1
59	1	2	2

อายุ	female	male	เบาหวาน	โควิด	หัวใจ
42	1	0	1	0	0
57	0	1	0	1	0
58	0	1	0	1	0
59	1	0	0	0	1

**0=เบาหวาน, 1=โควิด, 2=หัวใจ

Data

scikit learn
CODE

อายุ	female	male	โรค
42	1	0	เบาหวาน
57	0	1	โควิด
58	0	1	โควิด
59	1	0	หัวใจ

✓

อายุ	female	male	โรค
42	1	0	0
57	0	1	1
58	0	1	1
59	1	2	2

✓

อายุ	female	male	เบาหวาน	โควิด	หัวใจ
42	1	0	1	0	0
57	0	1	0	1	0
58	0	1	0	1	0
59	1	0	0	0	1

✗

**0=เบาหวาน, 1=โควิด, 2=หัวใจ

Data

อายุ	female	male	โรค
42	1	0	เบาหวาน
57	0	1	โควิด
58	0	1	โควิด
59	1	0	หัวใจ

อายุ	female	male	เบาหวาน	โควิด	หัวใจ
42	1	0	1	0	0
57	0	1	0	1	0
58	0	1	0	1	0
59	1	0	0	0	1

Model

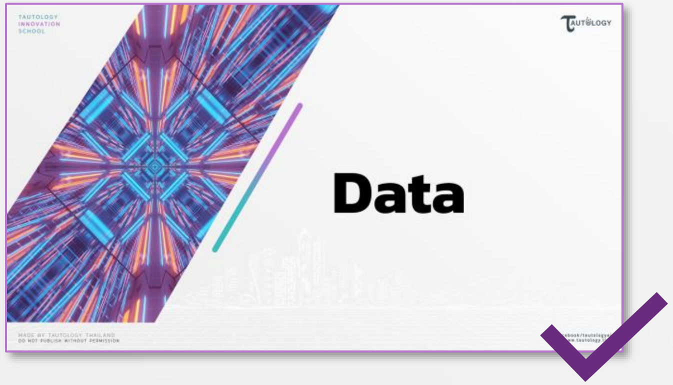
Prediction

เบาหวาน	โควิด	หัวใจ
0	1	0
1	0	0
0	1	0
0	0	1

Prediction

โรค
โควิด
เบาหวาน
โควิด
หัวใจ

Deep Learning for Multi-Class Classification



Model Creation

Model Creation

- Assumption
- Real Face of the Model
- Cost Function and Cost Landscape
- How to Create Model (Math)
- How to Create Model (Code)

TAUTOLOGY

Assumption

1. Nonlinear Relationship to log odds
2. No Missing Features
3. No Multicollinearity

Model Creation

Assumption

Real Face of the Model

Cost Function and Cost Landscape

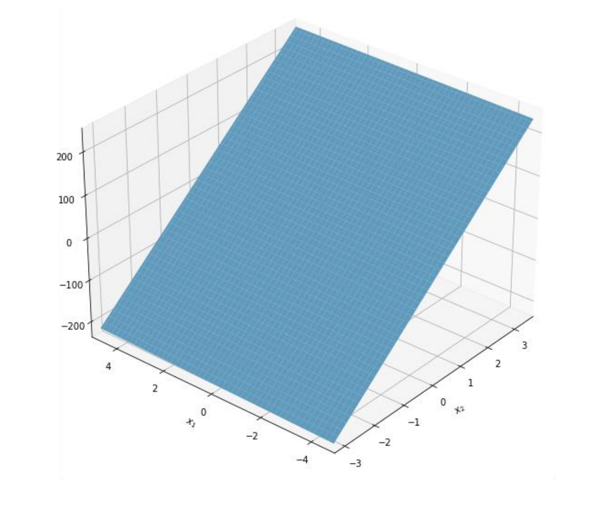
How to Create Model (Math)

How to Create Model (Code)

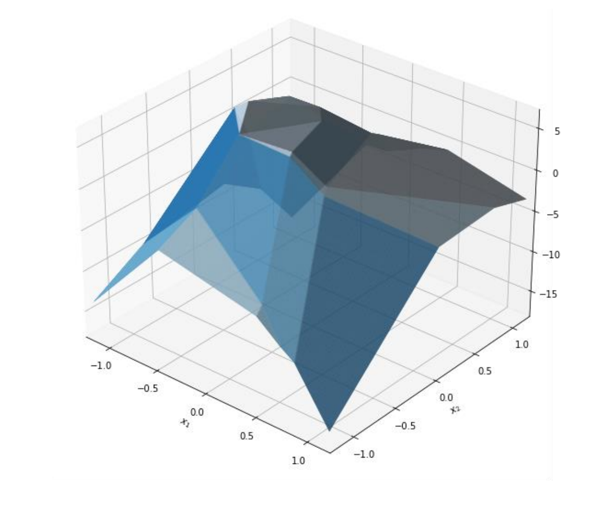
Real Face of the Model

แนวคิดของ deep learning คือการนำ nonlinear function มาประกอบกันเพื่อประมาณ nonlinear function ที่ซับซ้อนได้

Linear Regression

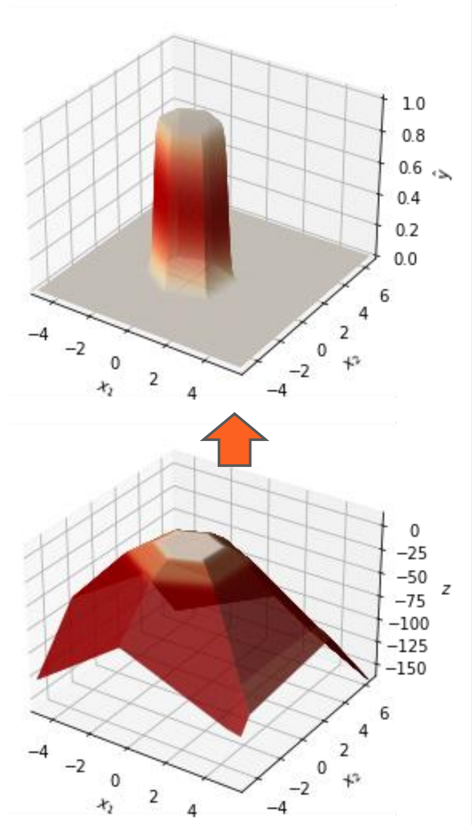


Deep Learning (Regression)

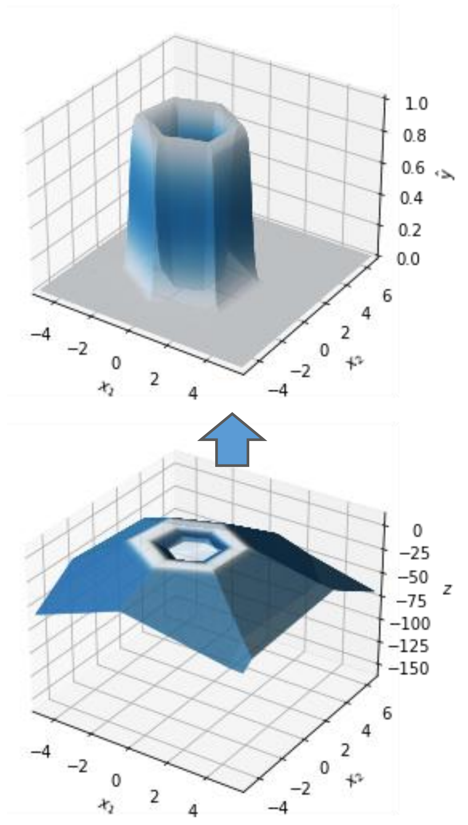


Real Face of the Model

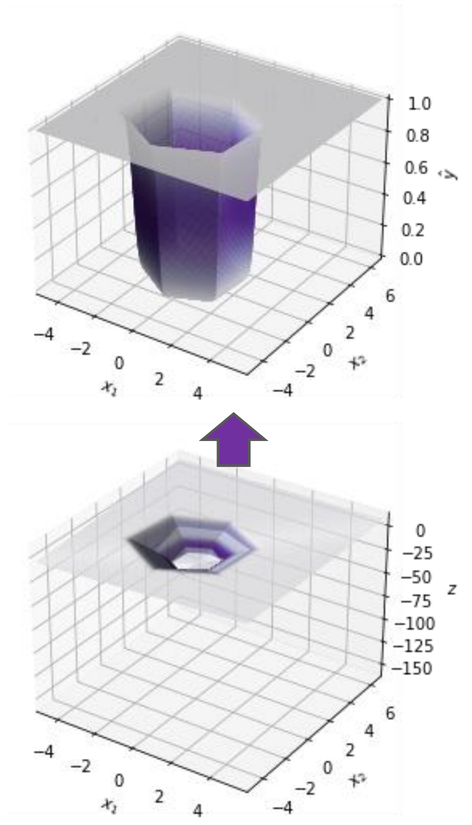
– Class 0 –



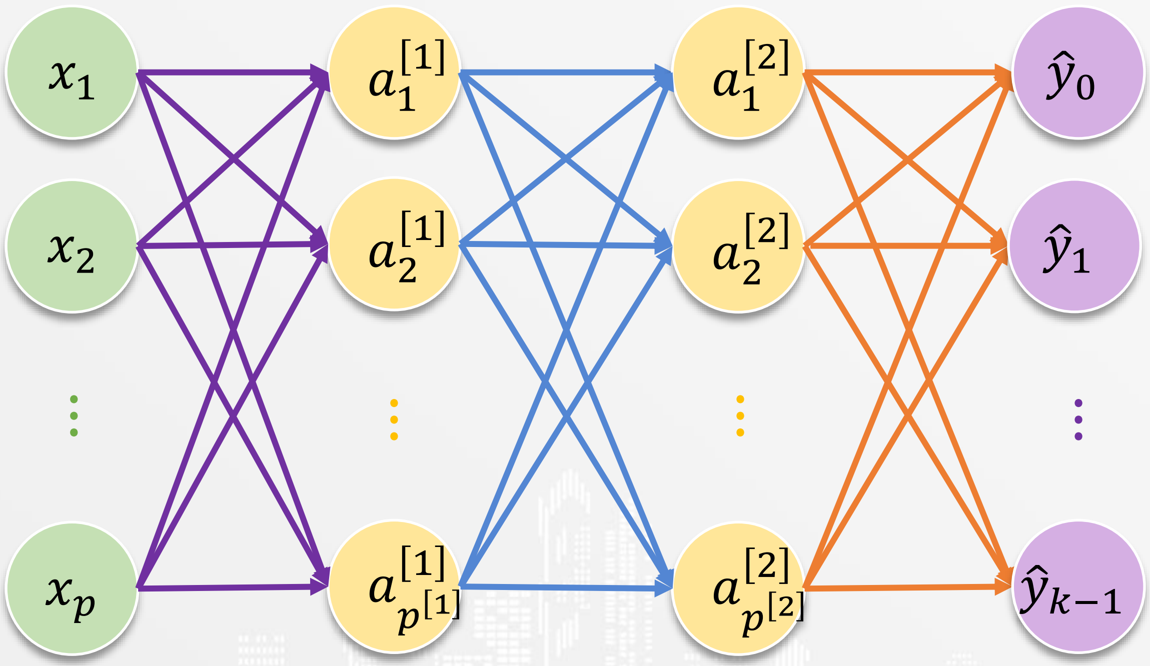
– Class 1 –



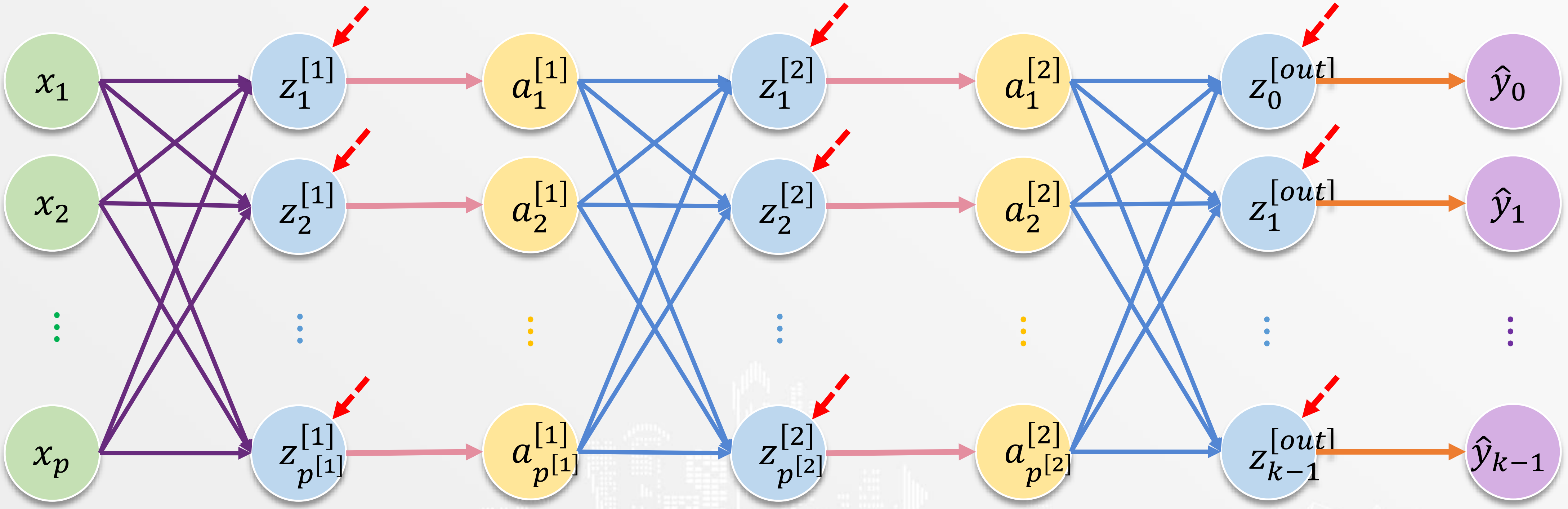
– Class 2 –



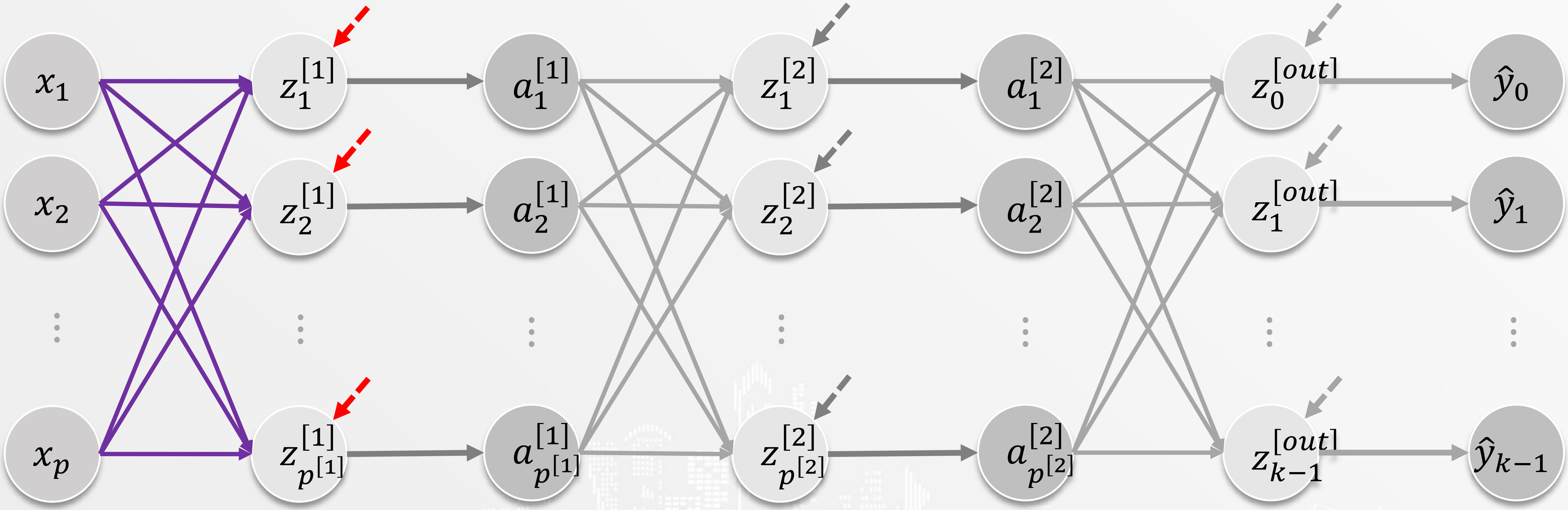
Real Face of the Model



Real Face of the Model



Real Face of the Model

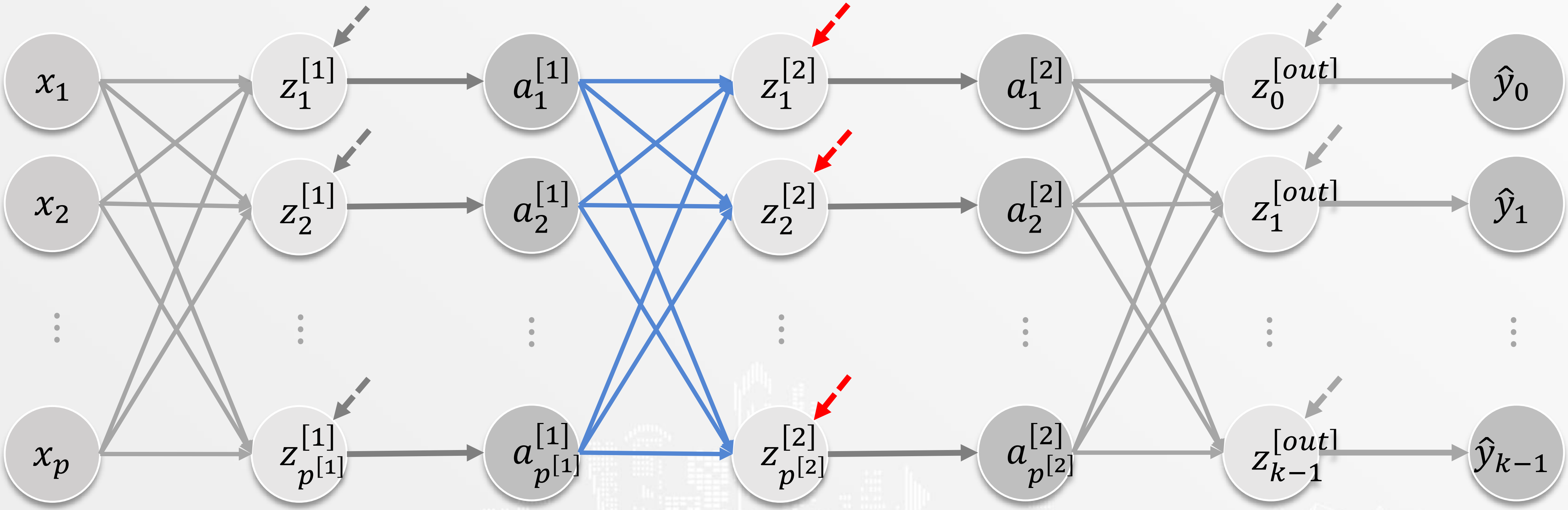


Real Face of the Model

$$\mathbf{b}^{[\mathbf{1}]} = \begin{bmatrix} b_1^{[1]} & b_2^{[1]} & \cdots & b_{p^{[1]}}^{[1]} \end{bmatrix}$$

$$W^{[1]} = \begin{bmatrix} w_{1,1}^{[1]} & w_{1,2}^{[1]} & \cdots & w_{1,p^{[1]}}^{[1]} \\ w_{2,1}^{[1]} & w_{2,2}^{[1]} & \cdots & w_{2,p^{[1]}}^{[1]} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p,1}^{[1]} & w_{p,2}^{[1]} & \cdots & w_{p,p^{[1]}}^{[1]} \end{bmatrix}$$

Real Face of the Model

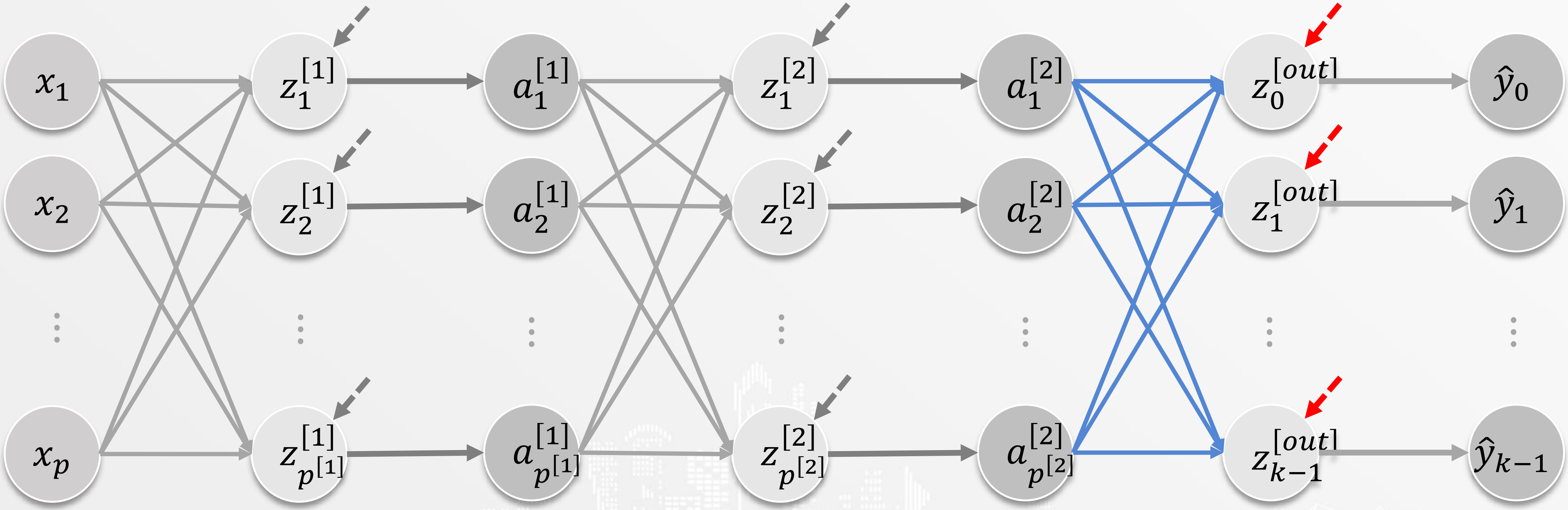


Real Face of the Model

$$\mathbf{b}^{[2]} = \begin{bmatrix} b_1^{[2]} & b_2^{[2]} & \cdots & b_{p^{[2]}}^{[2]} \end{bmatrix}$$

$$W^{[2]} = \begin{bmatrix} w_{1,1}^{[2]} & w_{1,2}^{[2]} & \cdots & w_{1,p^{[2]}}^{[2]} \\ w_{2,1}^{[2]} & w_{2,2}^{[2]} & \cdots & w_{2,p^{[2]}}^{[2]} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p,1}^{[2]} & w_{p,2}^{[2]} & \cdots & w_{p,p^{[2]}}^{[2]} \end{bmatrix}$$

Real Face of the Model



Real Face of the Model

$$\mathbf{b}^{[out]} = \begin{bmatrix} b_1^{[out]} & b_2^{[out]} & \cdots & b_k^{[out]} \end{bmatrix}$$

$$W^{[out]} = \begin{bmatrix} w_{1,1}^{[out]} & w_{1,2}^{[out]} & \cdots & w_{1,k}^{[out]} \\ w_{2,1}^{[out]} & w_{2,2}^{[out]} & \cdots & w_{2,k}^{[out]} \\ \vdots & \vdots & \ddots & \vdots \\ w_{p^{[2]},1}^{[out]} & w_{p^{[2]},2}^{[out]} & \cdots & w_{p^{[2]},k}^{[out]} \end{bmatrix}$$

Real Face of the Model

$$\mathbf{b}^{[1]}, \mathbf{b}^{[2]}, \mathbf{b}^{[out]}$$

$$W^{[1]}, W^{[2]}, W^{[out]}$$

Real Face of the Model

$$\mathbf{b}^{[1]}, \mathbf{b}^{[2]}, \dots, \mathbf{b}^{[L]}, \mathbf{b}^{[out]}$$

$$W^{[1]}, W^{[2]}, \dots, W^{[L]}, W^{[out]}$$

Real Face of the Model

" เราต้องการหา

$\mathbf{b}^{[1]}, \mathbf{b}^{[2]}, \dots, \mathbf{b}^{[L]}, \mathbf{b}^{[out]}$ และ

$W^{[1]}, W^{[2]}, \dots, W^{[L]}, W^{[out]}$

ที่ทำให้ cost function ต่ำที่สุด "

Model Creation

- **Assumption** ✓
- **Real Face of the Model** ✓
- Cost Function and Cost Landscape
- How to Create Model (Math)
- How to Create Model (Code)

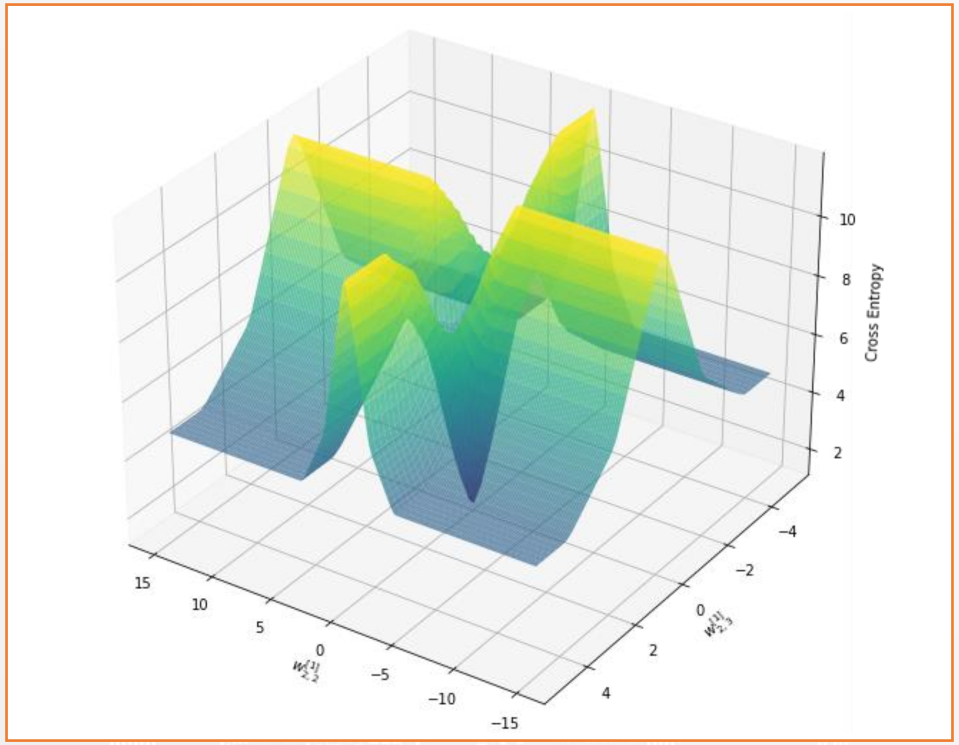
Cost Function & Cost Landscape

Cost function ที่เราจะใช้ในการสร้าง model คือ

$$-\frac{1}{n}\sum_{i=1}^{n}\sum_{c=0}^{k-1} y_{i,c}\log\left(\hat{y}_{i,c}\right)$$

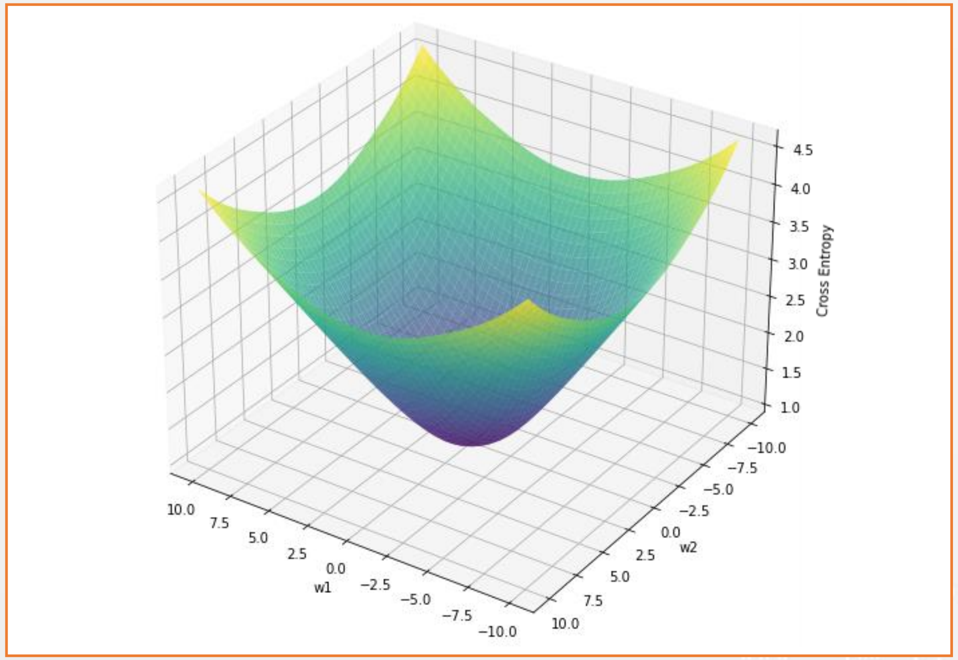
โดยสูตรข้างต้นมีชื่อว่า Cross Entropy

Cost Function & Cost Landscape

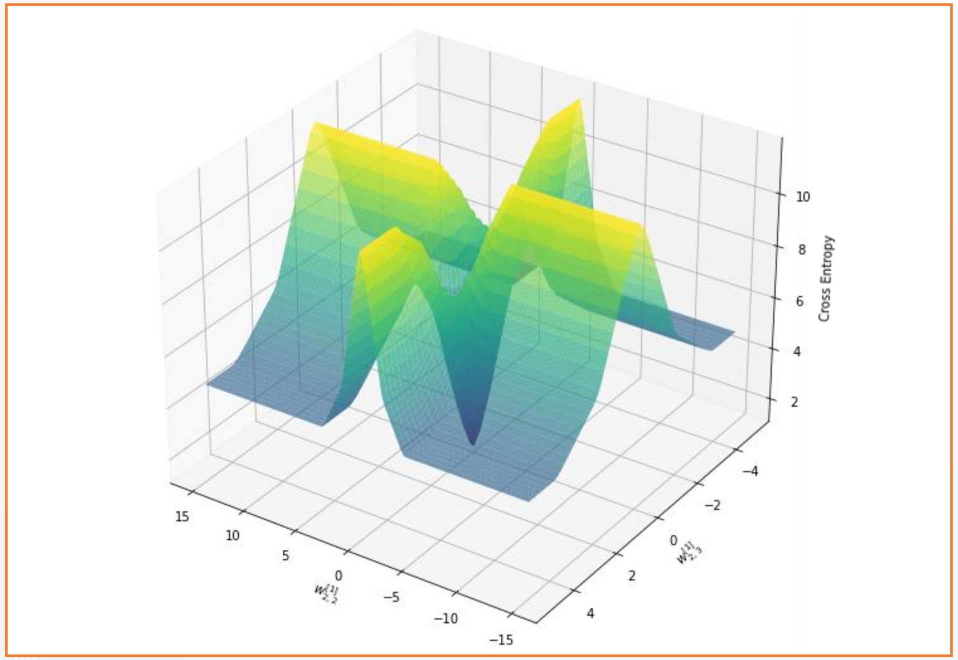


กราฟแสดง cost landscape ของ deep learning
โดยที่ cost function เป็น cross entropy

Cost Function & Cost Landscape



VS



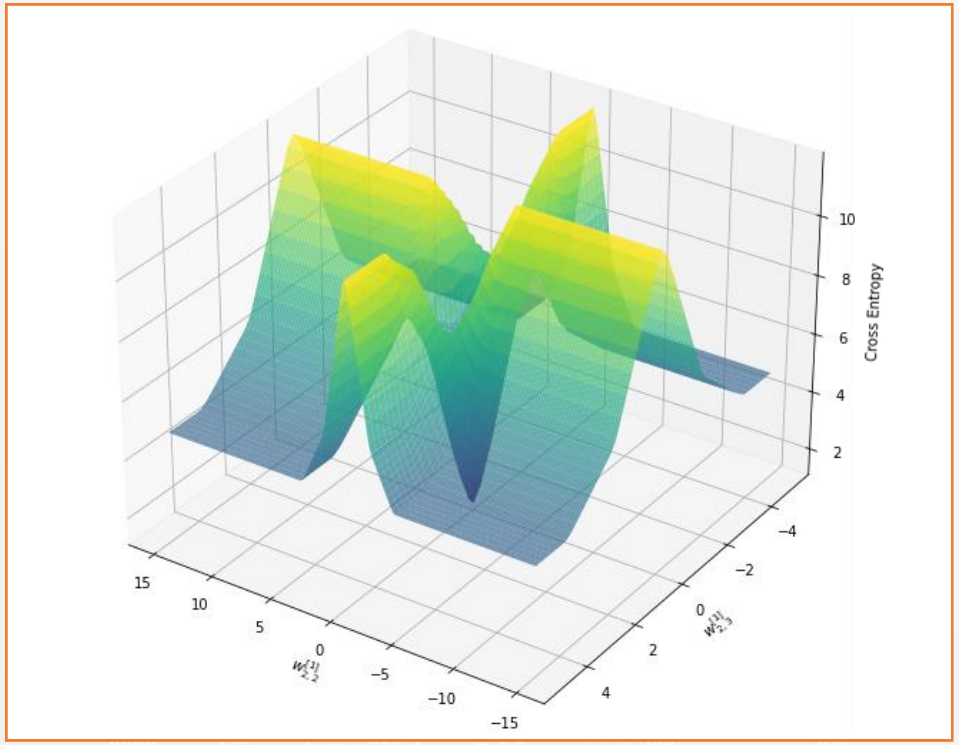
กราฟแสดง cost landscape ของ logistic regression โดยที่ cost function เป็น cross entropy

กราฟแสดง cost landscape ของ deep learning โดยที่ cost function เป็น cross entropy

Cost Function & Cost Landscape

❝ **Cost landscape** ของ deep learning เป็น non-convex ซึ่งมีจุดต่ำสุดหลายตำแหน่ง ❞

Cost Function & Cost Landscape



กราฟแสดง cost landscape ของ deep learning
โดยที่ cost function เป็น cross entropy

Model Creation

Assumption

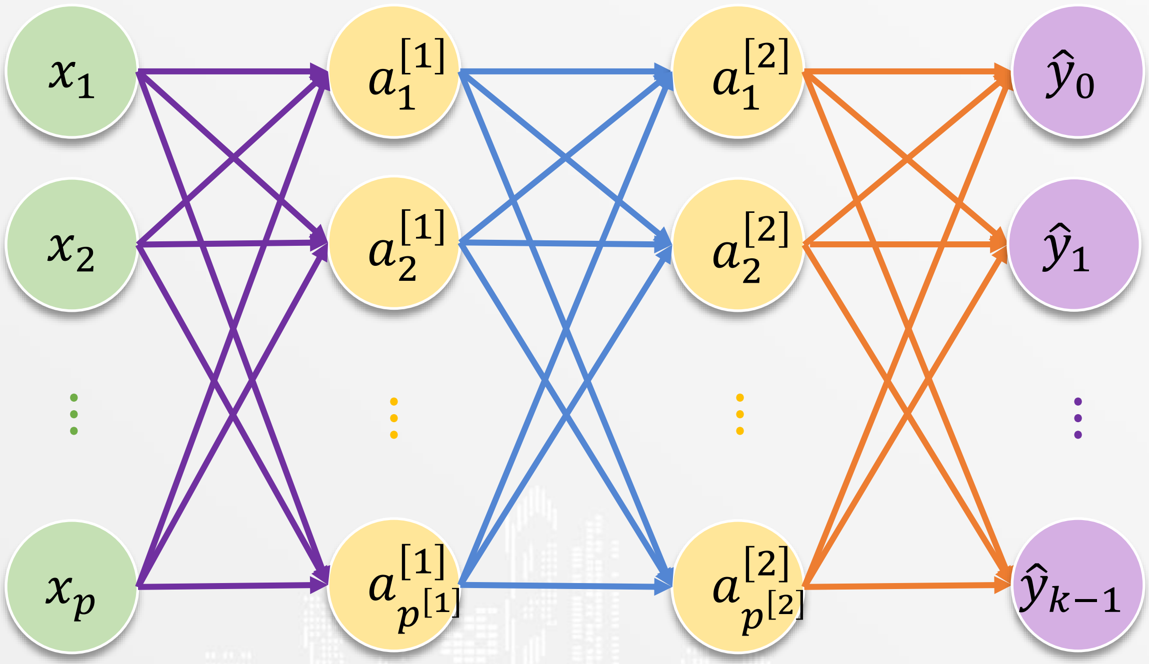
Real Face of the Model

Cost Function and Cost Landscape

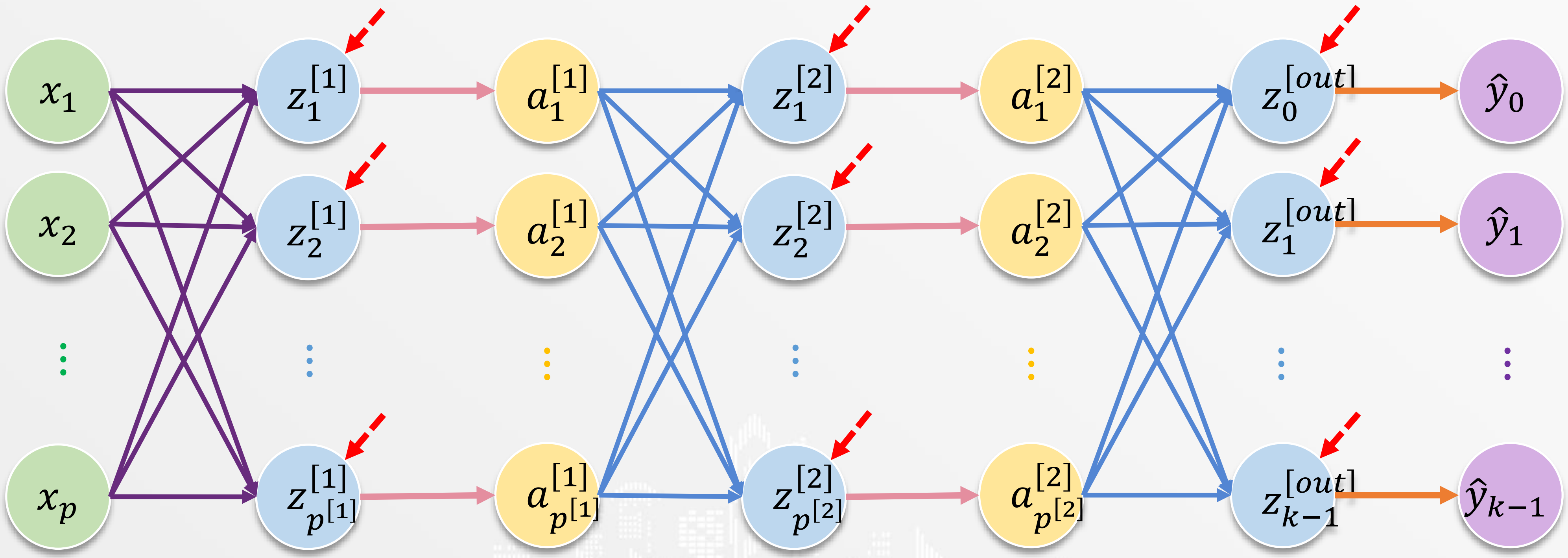
How to Create Model (Math)

How to Create Model (Code)

How to Create Model (Math)



How to Create Model (Math)



How to Create Model (Math)

“ เราต้องการหา

$\mathbf{b}^{[1]}, \mathbf{b}^{[2]}, \dots, \mathbf{b}^{[L]}, \mathbf{b}^{[out]}$ และ

$W^{[1]}, W^{[2]}, \dots, W^{[L]}, W^{[out]}$

ที่ทำให้ cost function ต่ำที่สุด ”

How to Create Model (Math)

Cost function ที่เราจะใช้ในการสร้าง model คือ

$$-\frac{1}{n}\sum_{i=1}^{n}\sum_{c=0}^{k-1} y_{i,c}\log\left(\hat{y}_{i,c}\right)$$

โดยสูตรข้างต้นมีชื่อว่า Cross Entropy

How to Create Model (Math)

เครื่องมือที่เราจะใช้ในการหาคำตอบ คือ

“ Gradient Descent ”

How to Create Model (Math)

Equation of Gradient Descent

$$W = W - \alpha \nabla Cost$$

โดย

- α คือ ค่าที่ใช้ควบคุม step size ของ W

How to Create Model (Math)

$$\mathbf{b}^{[1]} = \mathbf{b}^{[1]} - \alpha \nabla Cost$$
$$\mathbf{b}^{[2]} = \mathbf{b}^{[2]} - \alpha \nabla Cost$$
$$\vdots$$
$$\mathbf{b}^{[L]} = \mathbf{b}^{[L]} - \alpha \nabla Cost$$
$$\mathbf{b}^{[out]} = \mathbf{b}^{[out]} - \alpha \nabla Cost$$

How to Create Model (Math)

$$W^{[1]} = W^{[1]} - \alpha \nabla Cost$$
$$W^{[2]} = W^{[2]} - \alpha \nabla Cost$$
$$\vdots$$
$$W^{[L]} = W^{[L]} - \alpha \nabla Cost$$
$$W^{[out]} = W^{[out]} - \alpha \nabla Cost$$

TAUTOLOGY

Model Creation

- Assumption ✓
- Real Face of the Model ✓
- Cost Function and Cost Landscape ✓
- How to Create Model (Math) ✓
- How to Create Model (Code)

How to Create Model (Code)

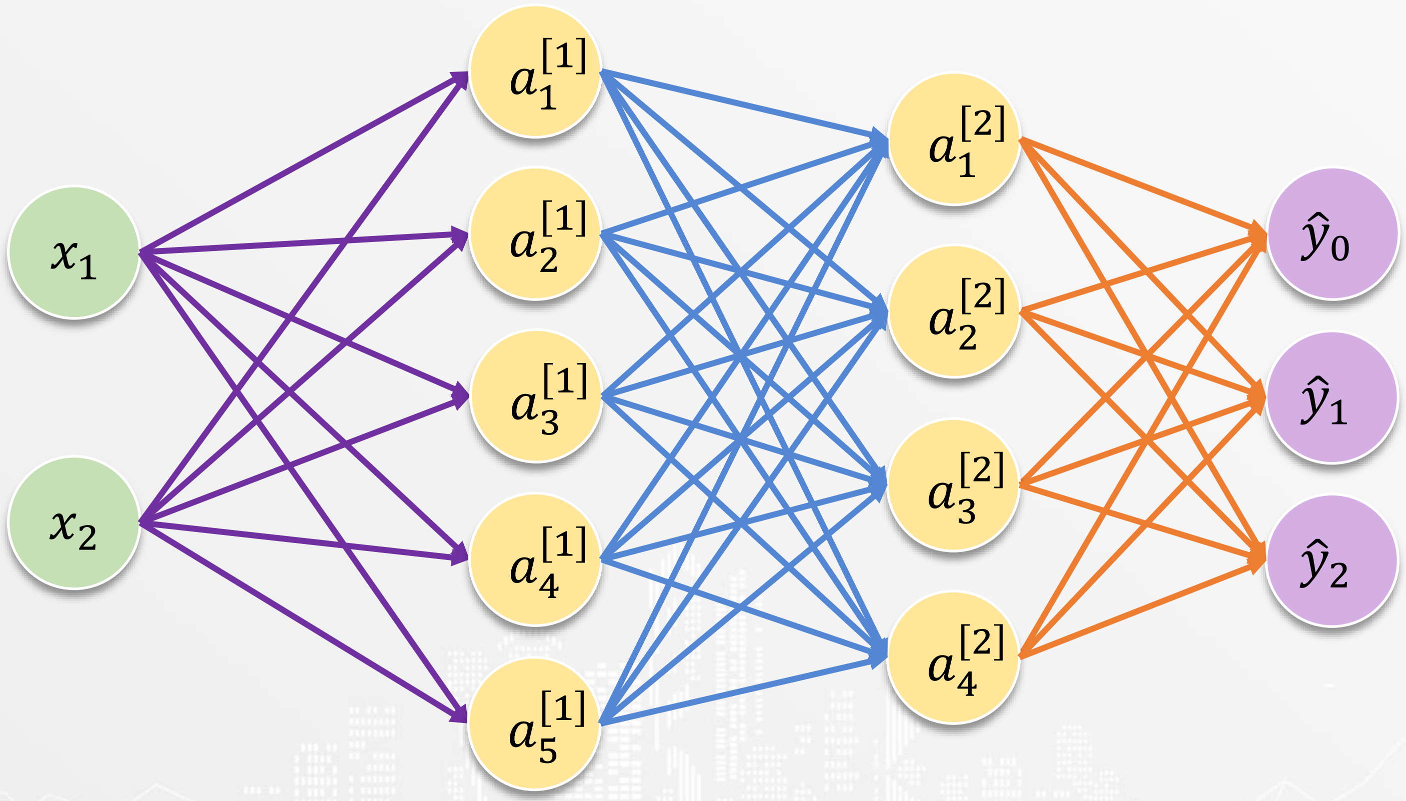
ตัวอย่างการหา weight สำหรับ deep learning

x_1	x_2	y
0	4	A
2	2	B
2	4	A
1	4	A
-1	3	A
0	2	A
3	1	B
-3	1	C
3	3	B

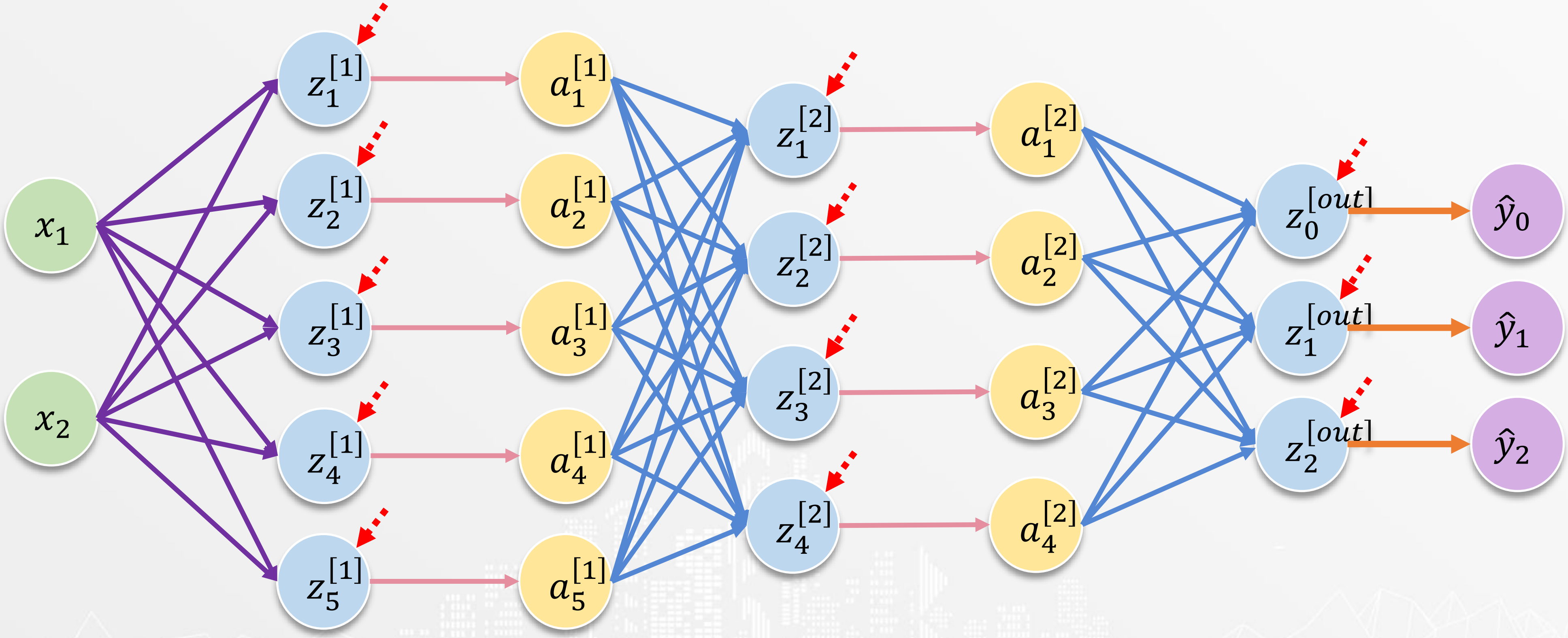
x_1	x_2	y
1	-2	C
1	-1	C
0	-1	C
3	2	B
-2	5	A
4	3	B
1	1	B
1	3	A
-1	-2	C

x_1	x_2	y
3	0	B
-1	-1	C
-2	-2	C
-1	-3	C
-1	4	A
0	-2	C
0	3	A
3	-1	B
4	-1	B

How to Create Model (Code)



How to Create Model (Code)



How to Create Model (Code)

$$X = \begin{bmatrix} 0 & 4 \\ 2 & 2 \\ \vdots & \vdots \\ 0 & -2 \\ 0 & 3 \\ 3 & -1 \\ 4 & -1 \end{bmatrix}, \qquad \mathbf{y} = \begin{bmatrix} A \\ B \\ \vdots \\ C \\ A \\ B \\ B \end{bmatrix}$$

How to Create Model (Code)

```
clf = MLPClassifier(
    hidden_layer_sizes=(5, 4),
    activation='relu',
    solver='sgd',
    alpha=0,
    learning_rate_init=1,
    max_iter=1000,
    momentum=0
)

clf.fit(X, y)
```

How to Create Model (Code)

Code for this section

Open File

Multiclass Classification/ Model Creation.ipynb

How to Create Model (Code)

$$\mathbf{b}^{[\mathbf{1}]} = \begin{bmatrix} 0.936 & 0.391 & 0.403 & 0.639 & 0.774 \end{bmatrix}$$

$$W^{[1]} = \begin{bmatrix} -0.803 & -0.146 & 0.816 & -0.835 & 1.412 \\ -1.7 & 1.283 & -0.367 & 0.832 & -0.348 \end{bmatrix}$$

How to Create Model (Code)

$$\mathbf{b}^{[2]} = \begin{bmatrix} -0.605 & 0.273 & 0.806 & -0.255 \end{bmatrix}$$

$$W^{[2]} = \begin{bmatrix} 0.47 & 0.536 & 1.985 & 0.294 \\ 1.079 & -0.464 & -0.686 & -0.341 \\ -0.224 & 0.621 & 0.189 & 0.232 \\ 1.022 & 0.035 & 0.489 & 0.566 \\ -0.869 & 1.392 & -0.12 & -0.403 \end{bmatrix}$$

How to Create Model (Code)

$$\mathbf{b}^{[out]} = \begin{bmatrix} 0.73 & 0.157 & -0.855 \end{bmatrix}$$

$$W^{[out]} = \begin{bmatrix} 0.365 & -1.025 & -0.716 \\ -0.612 & 1.376 & 0.313 \\ -0.906 & -0.577 & 2.061 \\ 0.408 & 0.697 & 0.905 \end{bmatrix}$$

How to Create Model (Code)

$$a_1^{[1]} = ReLU(0.936 - 0.803x_1 - 1.7x_2)$$

$$a_2^{[1]} = ReLU(0.391 - 0.146x_1 + 1.283x_2)$$

$$a_3^{[1]} = ReLU(0.403 + 0.816\,x_1 - 0.367x_2)$$

$$a_4^{[1]} = ReLU(0.639 - 0.835x_1 + 0.832x_2)$$

$$a_5^{[1]} = ReLU(0.774 + 1.412x_1 - 0.348x_2)$$

How to Create Model (Code)

$$a_1^{[2]} = ReLU(-0.605 + 0.47a_1^{[1]} + 1.079a_2^{[1]} - 0.224a_3^{[1]} + 1.022a_4^{[1]} - 0.869a_5^{[1]})$$

$$a_2^{[2]} = ReLU(0.273 - 0.585a_1^{[1]} - 0.464a_2^{[1]} + 0.621a_3^{[1]} + 0.035a_4^{[1]} + 1.392a_5^{[1]})$$

$$a_3^{[2]} = ReLU(0.806 + 1.35a_1^{[1]} - 0.686a_2^{[1]} + 0.189a_3^{[1]} + 0.489a_4^{[1]} - 0.12a_5^{[1]})$$

$$a_4^{[2]} = ReLU(-0.255 - 0.294a_1^{[1]} - 0.314a_2^{[1]} + 0.232a_3^{[1]} + 0.566a_4^{[1]} - 0.403a_5^{[1]})$$

How to Create Model (Code)

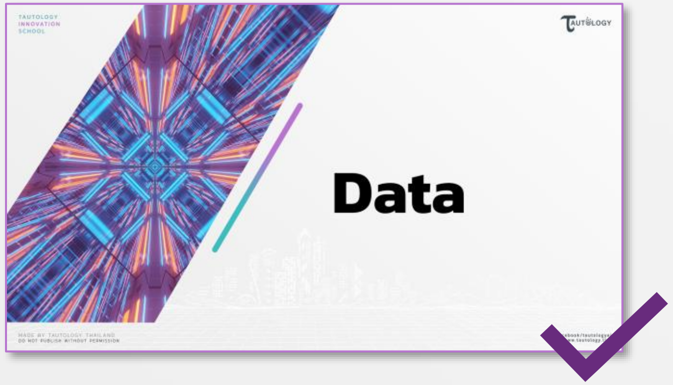
$$z_0^{[out]} = 0.73 + 0.365a_1^{[3]} - 0.612a_2^{[3]} - 0.906a_3^{[3]} + 0.408a_4^{[3]}$$
$$z_1^{[out]} = 0.157 - 1.025a_1^{[3]} + 1.376a_2^{[3]} - 0.577a_3^{[3]} - 0.697a_4^{[3]}$$
$$z_2^{[out]} = -0.855 - 0.716a_1^{[3]} + 0.313a_2^{[3]} + 2.061a_3^{[3]} - 0.905a_4^{[3]}$$

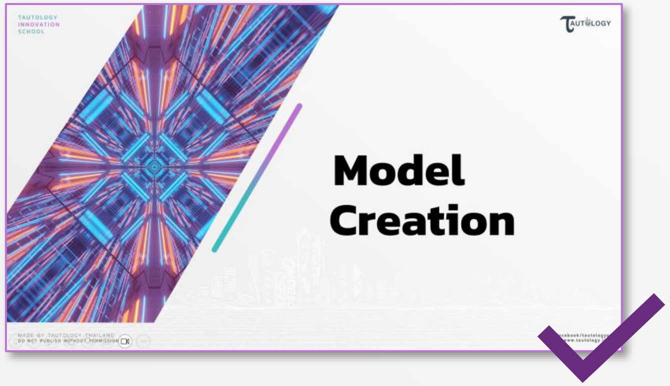
$$\hat{y}_m = \frac{e^{z_m^{[out]}}}{\sum_{c=0}^{2} e^{z_c^{[out]}}}$$

Model Creation

- Assumption
- Real Face of the Model
- Cost Function and Cost Landscape
- How to Create Model (Math)
- How to Create Model (Code)

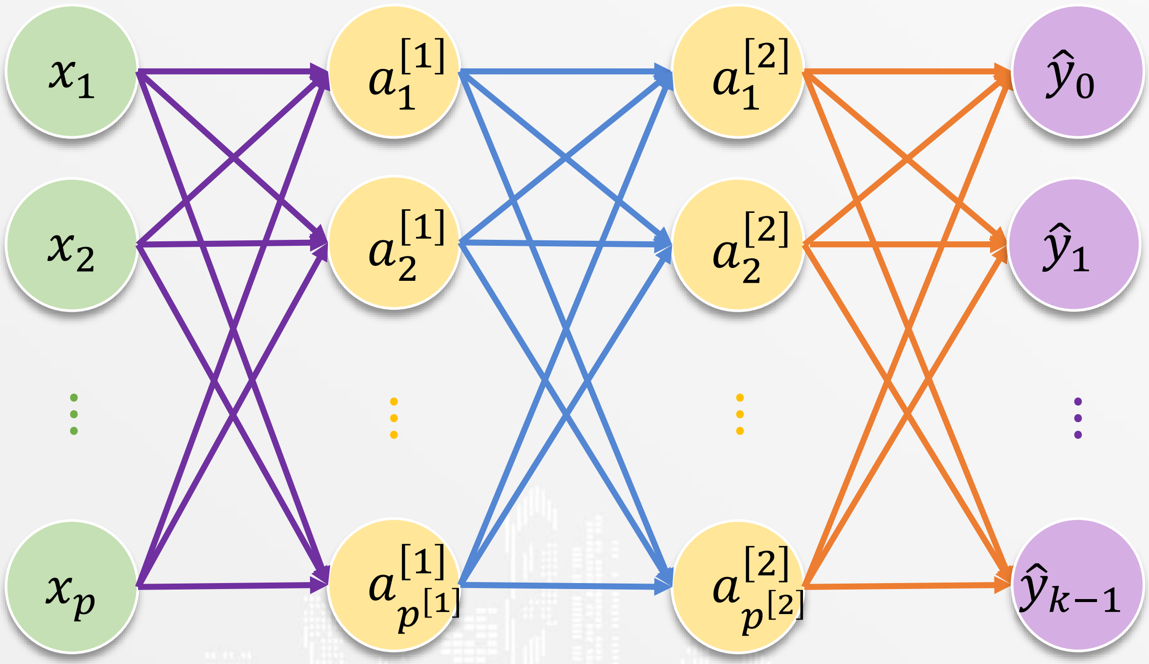
Deep Learning for Multi-Class Classification



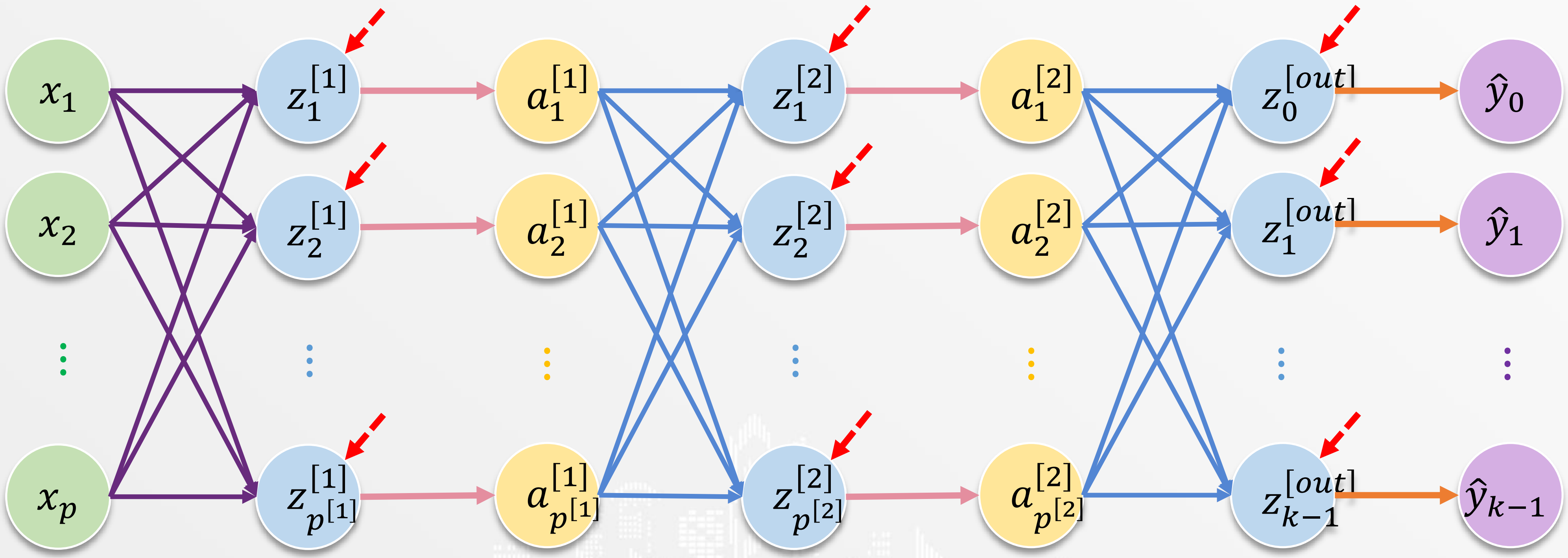


Prediction

Prediction



Prediction


x_1
x_2
x_p
$z_1^{[1]}$
$z_2^{[1]}$
$z_{p^{[1]}}^{[1]}$
$a_1^{[1]}$
$a_2^{[1]}$
$a_{p^{[1]}}^{[1]}$
$z_1^{[2]}$
$z_2^{[2]}$
$z_{p^{[2]}}^{[2]}$
$a_1^{[2]}$
$a_2^{[2]}$
$a_{p^{[2]}}^{[2]}$
$z_0^{[out]}$
$z_1^{[out]}$
$z_{k-1}^{[out]}$
$\hat{y}_0$
$\hat{y}_1$
$\hat{y}_{k-1}$

Prediction

$\mathbf{b}^{[1]}$ $\mathbf{b}^{[2]}$ $\mathbf{b}^{[out]}$

$W^{[1]}$ $W^{[2]}$ $W^{[out]}$

Prediction

1-Sample

Multi-Sample

Code

1-Sample

ตัวอย่างการคำนวณ $\hat{y}$

x_1	x_2
0	3

$\hat{y}$
?

1-Sample

- สมมติว่า weight ของปัญหานี้ที่เราหามาได้คือ

$$\mathbf{b}^{[\mathbf{1}]} = \begin{bmatrix} 0.936 & 0.391 & 0.403 & 0.639 & 0.774 \end{bmatrix}$$

$$W^{[1]} = \begin{bmatrix} -0.803 & -0.146 & 0.816 & -0.835 & 1.412 \\ -1.7 & 1.283 & -0.367 & 0.832 & -0.348 \end{bmatrix}$$

1-Sample

- สมมติว่า weight ของปัญหานี้ที่เราหามาได้คือ

$$\mathbf{b}^{[2]} = \begin{bmatrix} -0.605 & 0.273 & 0.806 & -0.255 \end{bmatrix}$$

$$W^{[2]} = \begin{bmatrix} 0.47 & 0.536 & 1.985 & 0.294 \\ 1.079 & -0.464 & -0.686 & -0.341 \\ -0.224 & 0.621 & 0.189 & 0.232 \\ 1.022 & 0.035 & 0.489 & 0.566 \\ -0.869 & 1.392 & -0.12 & -0.403 \end{bmatrix}$$

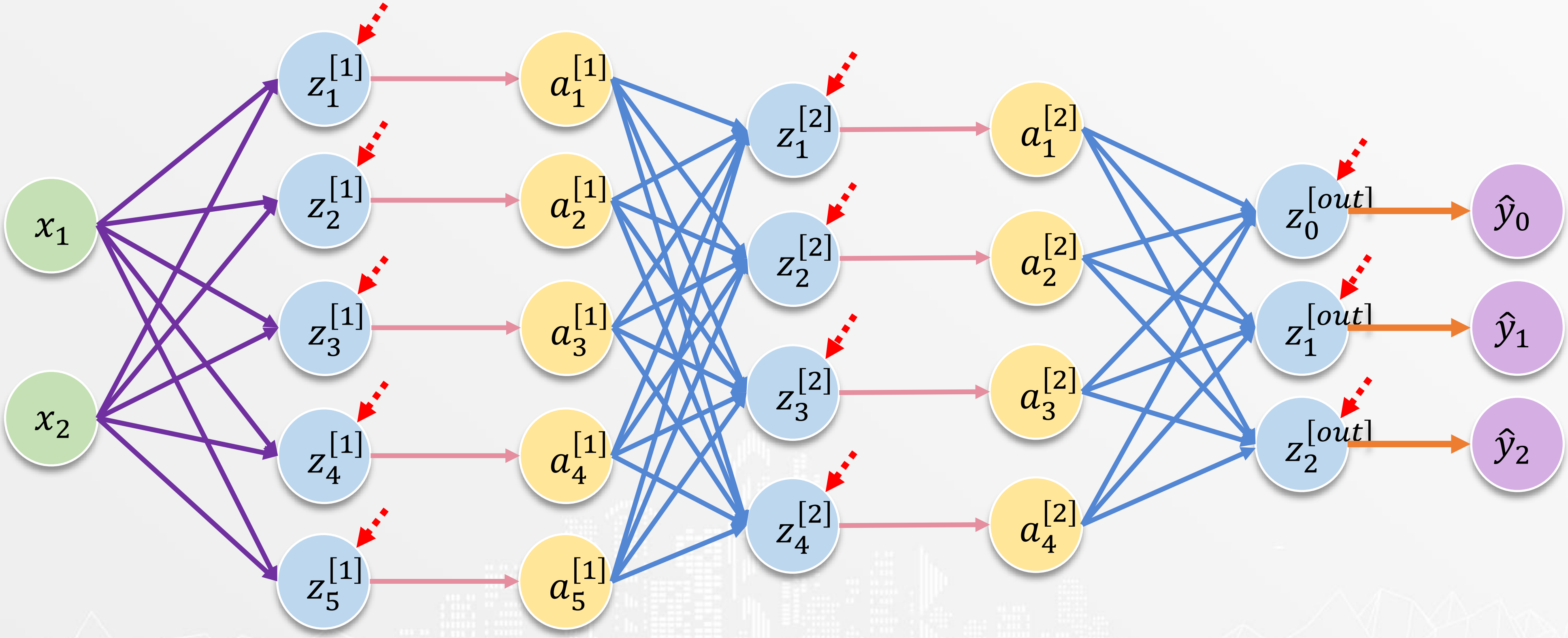
1-Sample

- สมมติว่า weight ของปัญหานี้ที่เราหามาได้คือ

$$\mathbf{b}^{[out]} = \begin{bmatrix} 0.73 & 0.157 & -0.855 \end{bmatrix}$$

$$W^{[out]} = \begin{bmatrix} 0.365 & -1.025 & -0.716 \\ -0.612 & 1.376 & 0.313 \\ -0.906 & -0.577 & 2.061 \\ 0.408 & 0.697 & 0.905 \end{bmatrix}$$

1-Sample


x_1
x_2
$z_1^{[1]}$
$z_2^{[1]}$
$z_3^{[1]}$
$z_4^{[1]}$
$z_5^{[1]}$
$a_1^{[1]}$
$a_2^{[1]}$
$a_3^{[1]}$
$a_4^{[1]}$
$a_5^{[1]}$
$z_1^{[2]}$
$z_2^{[2]}$
$z_3^{[2]}$
$z_4^{[2]}$
$a_1^{[2]}$
$a_2^{[2]}$
$a_3^{[2]}$
$a_4^{[2]}$
$z_0^{[out]}$
$z_1^{[out]}$
$z_2^{[out]}$
$\hat{y}_0$
$\hat{y}_1$
$\hat{y}_2$

1-Sample

$$a_1^{[1]} = ReLU(0.936 - 0.803x_1 - 1.7x_2) = 2.73$$

$$a_2^{[1]} = ReLU(0.391 - 0.146x_1 + 1.283x_2) = 0$$

$$a_3^{[1]} = ReLU(0.403 + 0.816\,x_1 - 0.367x_2) = 2.769$$

$$a_4^{[1]} = ReLU(0.639 - 0.835x_1 + 0.832x_2) = 0$$

$$a_5^{[1]} = ReLU(0.774 + 1.412x_1 - 0.348x_2) = 4.294$$

1-Sample

$$a_1^{[2]} = ReLU\left(-0.605 + 0.47a_1^{[1]} + 1.079a_2^{[1]} - 0.224a_3^{[1]} + 1.022a_4^{[1]} - 0.869a_5^{[1]}\right) = 0$$

$$a_2^{[2]} = ReLU\left(0.273 - 0.585a_1^{[1]} - 0.464a_2^{[1]} + 0.621a_3^{[1]} + 0.035a_4^{[1]} + 1.392a_5^{[1]}\right) = 9.433$$

$$a_3^{[2]} = ReLU\left(0.806 + 1.35a_1^{[1]} - 0.686a_2^{[1]} + 0.189a_3^{[1]} + 0.489a_4^{[1]} - 0.12a_5^{[1]}\right) = 6.233$$

$$a_4^{[2]} = ReLU\left(-0.255 - 0.294a_1^{[1]} - 0.314a_2^{[1]} + 0.232a_3^{[1]} + 0.566a_4^{[1]} - 0.403a_5^{[1]}\right) = 0$$

1-Sample

$$z_0^{[out]} = 0.73 + 0.365a_1^{[3]} - 0.612a_2^{[3]} - 0.906a_3^{[3]} + 0.408a_4^{[3]} = -10.69$$

$$z_1^{[out]} = 0.157 - 1.025a_1^{[3]} + 1.376a_2^{[3]} - 0.577a_3^{[3]} - 0.697a_4^{[3]} = 9.54$$

$$z_2^{[out]} = -0.855 - 0.716a_1^{[3]} + 0.313a_2^{[3]} + 2.061a_3^{[3]} - 0.905a_4^{[3]} = 14.944$$

TAUTOLOGY

1-Sample

$$\hat{\mathbf{y}} = \begin{bmatrix} \dfrac{e^{z_0^{[out]}}}{\sum_{c=0}^{2} e^{z_i^{[out]}}} & \dfrac{e^{z_1^{[out]}}}{\sum_{c=0}^{2} e^{z_i^{[out]}}} & \dfrac{e^{z_2^{[out]}}}{\sum_{c=0}^{2} e^{z_i^{[out]}}} \end{bmatrix} = \begin{array}{ccc} A & B & C \\ \left[0\right. & 0 & \left.1\right] \end{array} \Rightarrow C$$

1-Sample

ดังนั้น เราจะได้ $\hat{y}$ สำหรับข้อมูลชุดนี้คือ

x_1	x_2
0	3

→

$\hat{y}$
C

Prediction

1-Sample

Multi-Sample

Code

Multi-Sample

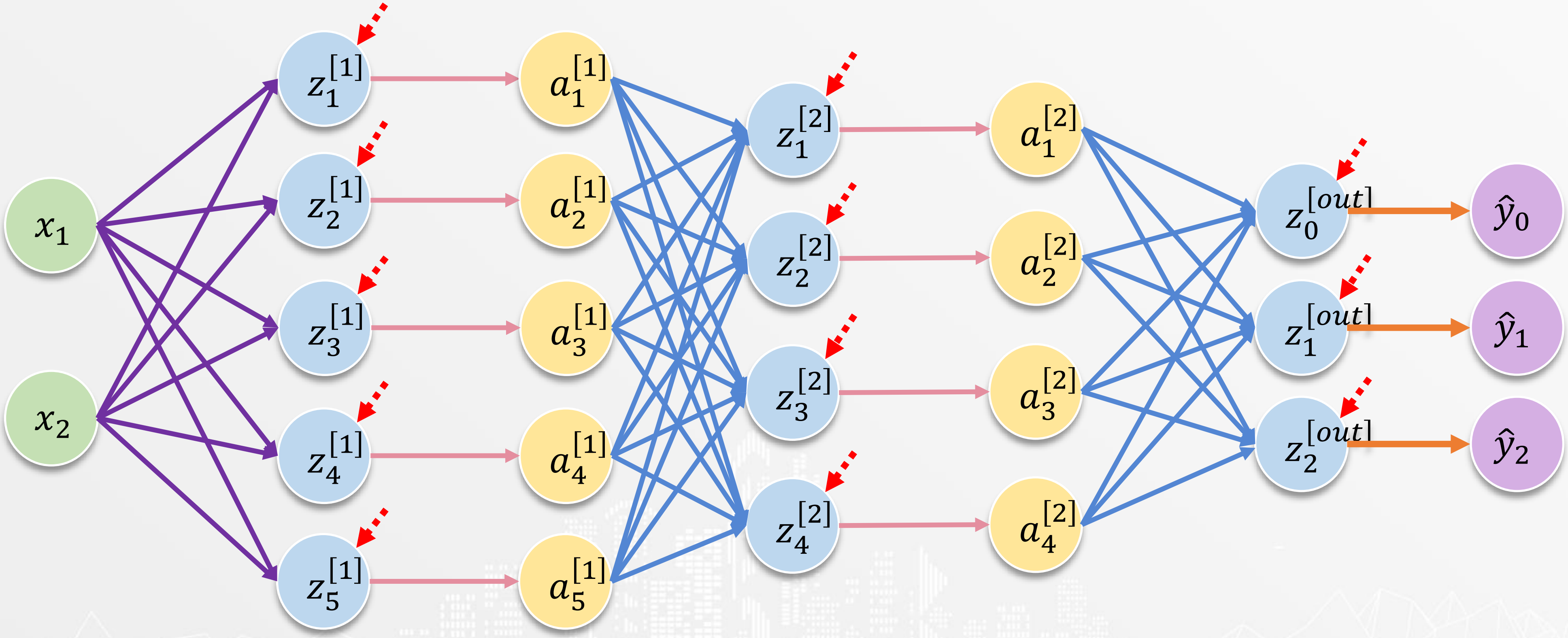
ตัวอย่างการคำนวณ $\hat{y}$

x_1	x_2
2	−2
−2	4
2	1
1	5

→

$\hat{y}$
?
?
?
?

Multi-Sample



Multi-Sample

$$X \rightarrow Z^{[1]} \rightarrow A^{[1]} \rightarrow Z^{[2]} \rightarrow A^{[2]} \rightarrow Z^{[out]} \rightarrow \hat{Y}$$

Multi-Sample

$$Z^{[1]} = XW^{[1]} + \mathbf{b}^{[1]}$$

$$Z^{[1]} = \begin{bmatrix} 2 & -2 \\ -2 & 4 \\ 2 & 1 \\ 1 & 5 \end{bmatrix} \begin{bmatrix} -0.803 & -0.146 & 0.816 & -0.835 & 1.412 \\ -1.7 & 1.283 & -0.367 & 0.832 & -0.348 \end{bmatrix} + \begin{bmatrix} 0.936 & 0.391 & 0.403 & 0.639 & 0.774 \end{bmatrix}$$

$$= \begin{bmatrix} 1.794 & -2.858 & 2.367 & -3.335 & 3.521 \\ -5.194 & 5.424 & -3.102 & 5 & -4.216 \\ -3.306 & 0.991 & 1.265 & -0.838 & 2.477 \\ -9.303 & 6.269 & -1.021 & 3.326 & -0.327 \end{bmatrix} + \begin{bmatrix} 0.936 & 0.391 & 0.403 & 0.639 & 0.774 \\ 0.936 & 0.391 & 0.403 & 0.639 & 0.774 \\ 0.936 & 0.391 & 0.403 & 0.639 & 0.774 \\ 0.936 & 0.391 & 0.403 & 0.639 & 0.774 \end{bmatrix}$$

Multi-Sample

$$Z^{[1]} = XW^{[1]} + \mathbf{b}^{[1]}$$

$$Z^{[1]} = \begin{bmatrix} 2.73 & -2.467 & 2.77 & -2.696 & 4.295 \\ -4.258 & 4.258 & -2.699 & 5.639 & -3.442 \\ -2.37 & 1.382 & 1.668 & -0.199 & 3.251 \\ -8.367 & 6.66 & -0.618 & 3.965 & 0.447 \end{bmatrix}$$

Multi-Sample

$$A^{[1]} = ReLU(Z^{[1]})$$

$$A^{[1]} = ReLU\left(\begin{bmatrix} 2.73 & -2.467 & 2.77 & -2.696 & 4.295 \\ -4.258 & 4.258 & -2.699 & 5.639 & -3.442 \\ -2.37 & 1.382 & 1.668 & -0.199 & 3.251 \\ -8.367 & 6.66 & -0.618 & 3.965 & 0.447 \end{bmatrix}\right)$$

$$= \begin{bmatrix} 2.73 & 0 & 2.77 & 0 & 4.295 \\ 0 & 4.258 & 0 & 5.639 & 0 \\ 0 & 1.382 & 1.668 & 0 & 3.251 \\ 0 & 6.66 & 0 & 3.965 & 0.447 \end{bmatrix}$$

TAUTOLOGY

Multi-Sample

$$Z^{[2]} = A^{[2]}W^{[2]} + \mathbf{b}^{[2]}$$

$$Z^{[2]} = \begin{bmatrix} 2.73 & 0 & 2.77 & 0 & 4.295 \\ 0 & 4.258 & 0 & 5.639 & 0 \\ 0 & 1.382 & 1.668 & 0 & 3.251 \\ 0 & 6.66 & 0 & 3.965 & 0.447 \end{bmatrix} \begin{bmatrix} 0.47 & 0.536 & 1.985 & 0.294 \\ 1.079 & -0.464 & -0.686 & -0.341 \\ -0.224 & 0.621 & 0.189 & 0.232 \\ 1.022 & 0.035 & 0.489 & 0.566 \\ -0.869 & 1.392 & -0.12 & -0.403 \end{bmatrix}$$

$$+ \begin{bmatrix} -0.605 & 0.273 & 0.806 & -0.255 \end{bmatrix}$$

$$= \begin{bmatrix} -3.07 & 9.163 & 5.427 & -0.286 \\ 12.04 & -2.499 & -1.232 & 1.205 \\ -1.708 & 4.921 & -1.024 & -1.395 \\ 10.852 & -2.327 & -2.684 & -0.21 \end{bmatrix} + \begin{bmatrix} -0.605 & 0.273 & 0.806 & -0.255 \\ -0.605 & 0.273 & 0.806 & -0.255 \\ -0.605 & 0.273 & 0.806 & -0.255 \\ -0.605 & 0.273 & 0.806 & -0.255 \end{bmatrix}$$

Multi-Sample

$$Z^{[2]} = A^{[2]}W^{[2]} + \mathbf{b}^{[2]}$$

$$Z^{[2]} = \begin{bmatrix} -3.675 & 9.436 & 6.233 & -0.541 \\ 11.435 & -2.226 & -0.426 & 0.95 \\ -2.313 & 5.194 & -0.218 & -1.65 \\ 10.247 & -2.054 & -1.878 & -0.465 \end{bmatrix}$$

Multi-Sample

$$A^{[2]} = ReLU(Z^{[2]})$$

$$A^{[2]} = ReLU\left(\begin{bmatrix} -3.675 & 9.436 & 6.233 & -0.541 \\ 11.435 & -2.226 & -0.426 & 0.95 \\ -2.313 & 5.194 & -0.218 & -1.65 \\ 10.247 & -2.054 & -1.878 & -0.465 \end{bmatrix}\right)$$

$$= \begin{bmatrix} 0 & 9.436 & 6.233 & 0 \\ 11.435 & 0 & 0 & 0.95 \\ 0 & 5.194 & 0 & 0 \\ 10.247 & 0 & 0 & 0 \end{bmatrix}$$

Multi-Sample

$$Z^{[out]} = A^{[2]}W^{[out]} + \mathbf{b}^{[out]}$$

$$Z^{[out]} = \begin{bmatrix} 0 & 9.436 & 6.233 & 0 \\ 11.435 & 0 & 0 & 0.95 \\ 0 & 5.194 & 0 & 0 \\ 10.247 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0.365 & -1.025 & -0.716 \\ -0.612 & 1.376 & 0.313 \\ -0.906 & -0.577 & 2.061 \\ 0.408 & 0.697 & 0.905 \end{bmatrix} + \begin{bmatrix} 0.73 & 0.157 & -0.855 \end{bmatrix}$$

$$= \begin{bmatrix} -11.418 & 9.394 & 15.802 \\ 4.561 & -11.059 & -7.331 \\ -3.178 & 7.149 & 1.628 \\ 3.74 & -10.503 & -7.339 \end{bmatrix} + \begin{bmatrix} 0.73 & 0.157 & -0.855 \\ 0.73 & 0.157 & -0.855 \\ 0.73 & 0.157 & -0.855 \\ 0.73 & 0.157 & -0.855 \end{bmatrix}$$

Multi-Sample

$$Z^{[out]} = A^{[2]}W^{[out]} + \mathbf{b}^{[out]}$$

$$Z^{[out]} = \begin{bmatrix} -10.688 & 9.551 & 14.947 \\ 5.291 & -10.902 & -8.186 \\ -2.448 & 7.306 & 0.773 \\ 4.47 & -10.346 & -8.194 \end{bmatrix}$$

Multi-Sample

$$\hat{Y} = \begin{bmatrix} \frac{e^{z_{1,1}^{[out]}}}{\sum_{c=0}^{2} e^{z_{1,c}^{[out]}}} & \frac{e^{z_{1,2}^{[out]}}}{\sum_{c=0}^{2} e^{z_{1,c}^{[out]}}} & \frac{e^{z_{1,3}^{[out]}}}{\sum_{c=0}^{2} e^{z_{1,c}^{[out]}}} \\ \frac{e^{z_{2,1}^{[out]}}}{\sum_{c=0}^{2} e^{z_{2,c}^{[out]}}} & \frac{e^{z_{2,2}^{[out]}}}{\sum_{c=0}^{2} e^{z_{2,c}^{[out]}}} & \frac{e^{z_{2,3}^{[out]}}}{\sum_{c=0}^{2} e^{z_{2,c}^{[out]}}} \\ \frac{e^{z_{3,1}^{[out]}}}{\sum_{c=0}^{2} e^{z_{3,c}^{[out]}}} & \frac{e^{z_{3,2}^{[out]}}}{\sum_{c=0}^{2} e^{z_{3,c}^{[out]}}} & \frac{e^{z_{3,3}^{[out]}}}{\sum_{c=0}^{2} e^{z_{3,c}^{[out]}}} \\ \frac{e^{z_{4,1}^{[out]}}}{\sum_{c=0}^{2} e^{z_{4,c}^{[out]}}} & \frac{e^{z_{4,2}^{[out]}}}{\sum_{c=0}^{2} e^{z_{4,c}^{[out]}}} & \frac{e^{z_{4,3}^{[out]}}}{\sum_{c=0}^{2} e^{z_{4,c}^{[out]}}} \end{bmatrix} = \begin{array}{c} \begin{array}{ccc} A & B & C \end{array} \\ \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} \end{array} \Rightarrow \begin{bmatrix} C \\ A \\ B \\ A \end{bmatrix}$$

Multi-Sample

ดังนั้น เราจะได้ $\hat{y}$ สำหรับข้อมูลชุดนี้คือ

$\mathbf{x_1}$	$\mathbf{x_2}$
2	-2
-2	4
2	1
1	5

$\hat{\mathbf{y}}$
C
A
B
A

Prediction

1-Sample

Multi-Sample

Code

Code

```
clf.predict(X)
```

```
array(['C', 'A', 'B', 'A'], dtype='<U1')
```

Code

Code for this section

Open File

Multiclass Classification/ Model Creation.ipynb

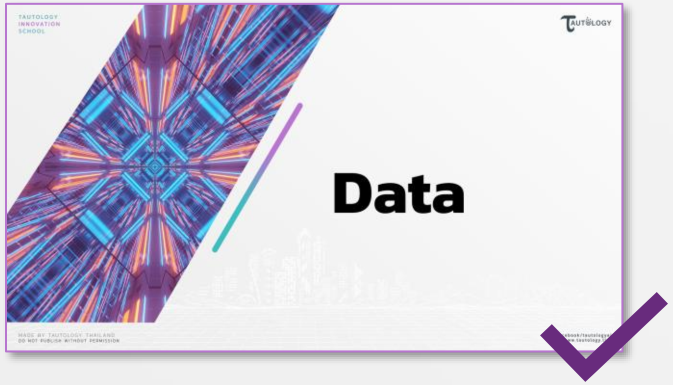
Prediction

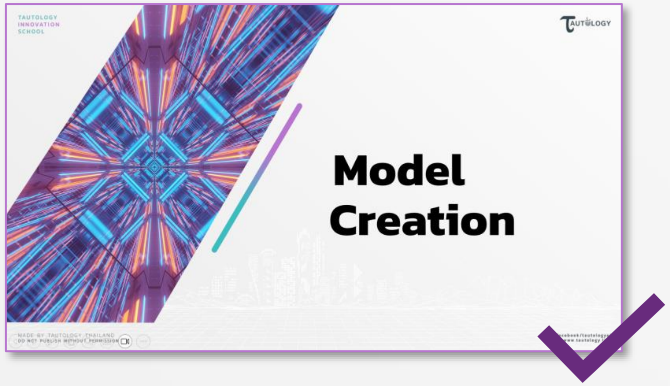
1-Sample

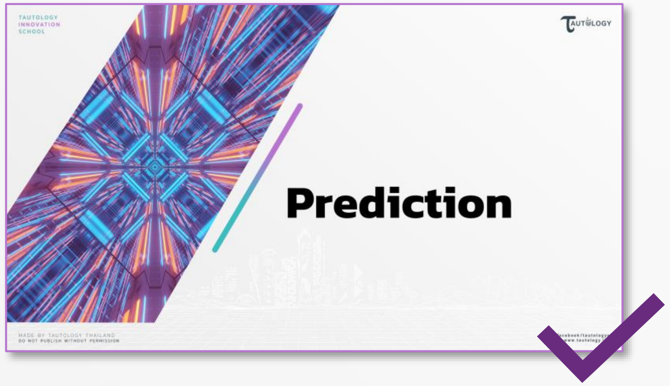
Multi-Sample

Code

Deep Learning for Multi-Class Classification







Deep Learning for Classification

Deep Learning for
Binary Classification

Deep Learning for
Multi-Class Classification

Neural Network & Deep Learning

- Neural Network ✓
- Deep Learning ✓
- Deep Learning for Regression ✓
- Deep Learning for Classification ✓
- Workshop

Workshop

Car Price

Abstract

สร้าง model เพื่อประเมินราคาของรถยนต์มือสอง โดย feature ที่นำมาใช้ คือ ข้อมูลเกี่ยวกับรถยนต์คันนั้น ๆ และรูปแบบการขาย เช่น

- ยี่ห้อรถยนต์
- เลขกิโลของรถยนต์
- ขายด้วยตัวเอง หรือ ขายผ่านนายหน้า

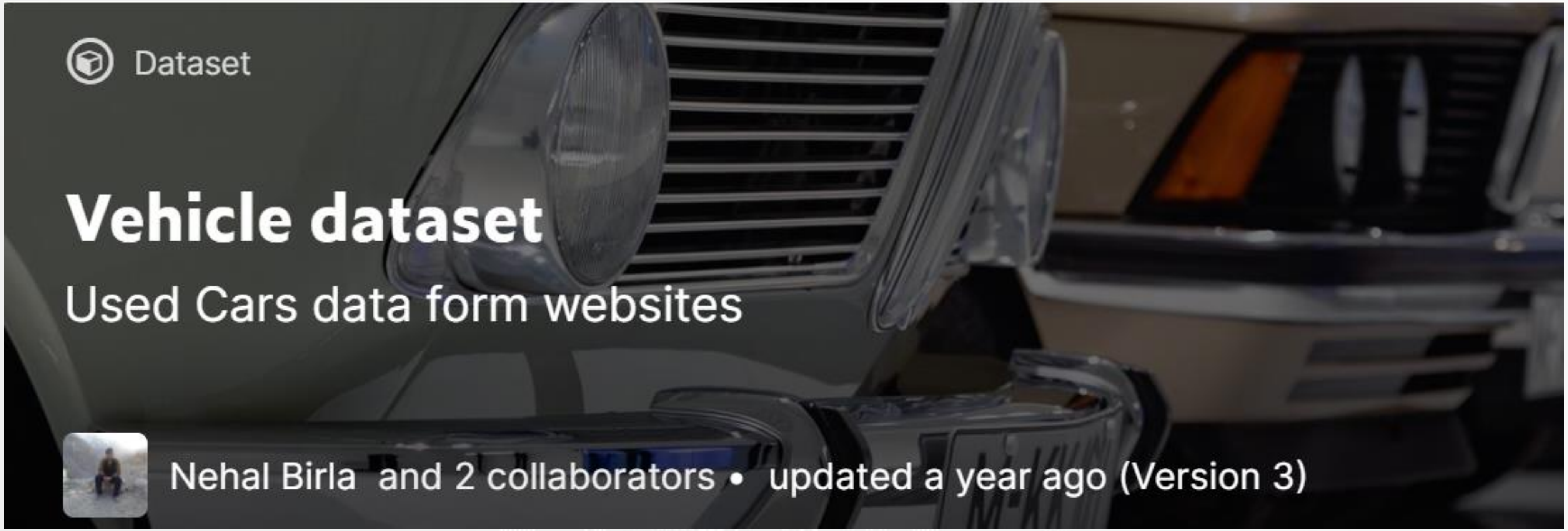
Why this project Important?

- สามารถประเมินราคารถยนต์ได้อย่างสมเหตุสมผลที่สุด
- สามารถนำความรู้ที่ได้จากการสร้าง model ไปประยุกต์ ใช้กับธุรกิจประเภทอื่น ๆ ที่มีลักษณะคล้ายกัน

Who this project is for?

- เจ้าของธุรกิจเต็นท์รถ
- นักประเมินราคารถยนต์
- ผู้เกี่ยวข้องกับธุรกิจที่ต้องประเมินราคา เช่น ธุรกิจโรงรับจำนำ ร้านซื้อ/ขายเครื่องดนตรี ธนาคาร
- นักวิเคราะห์ข้อมูล

Car Price Dataset



https://www.kaggle.com/nehalbirla/vehicle-dataset-from-cardekho

Car Price Dataset

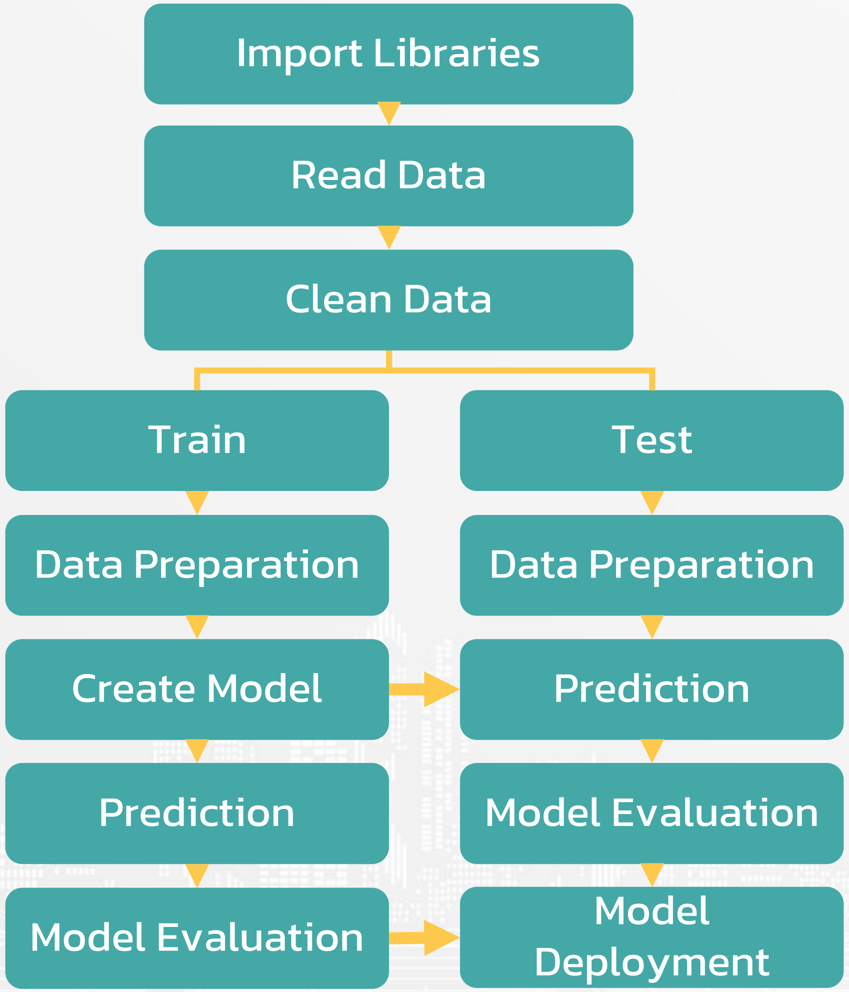
Feature

- name : ยี่ห้อ และรุ่นของรถยนต์
- year : ปีที่รถยนต์ถูกซื้อ
- km_driven : เลขกิโลของรถยนต์
- fuel : ประเภทของน้ำมันที่รถยนต์ใช้
- seller_type : ขายด้วยตัวเอง หรือ ขายผ่านนายหน้า
- transmission : ระบบเกียร์
- owner : เป็นรถยนต์มือหนึ่ง มือสอง หรือ อื่น ๆ

Target

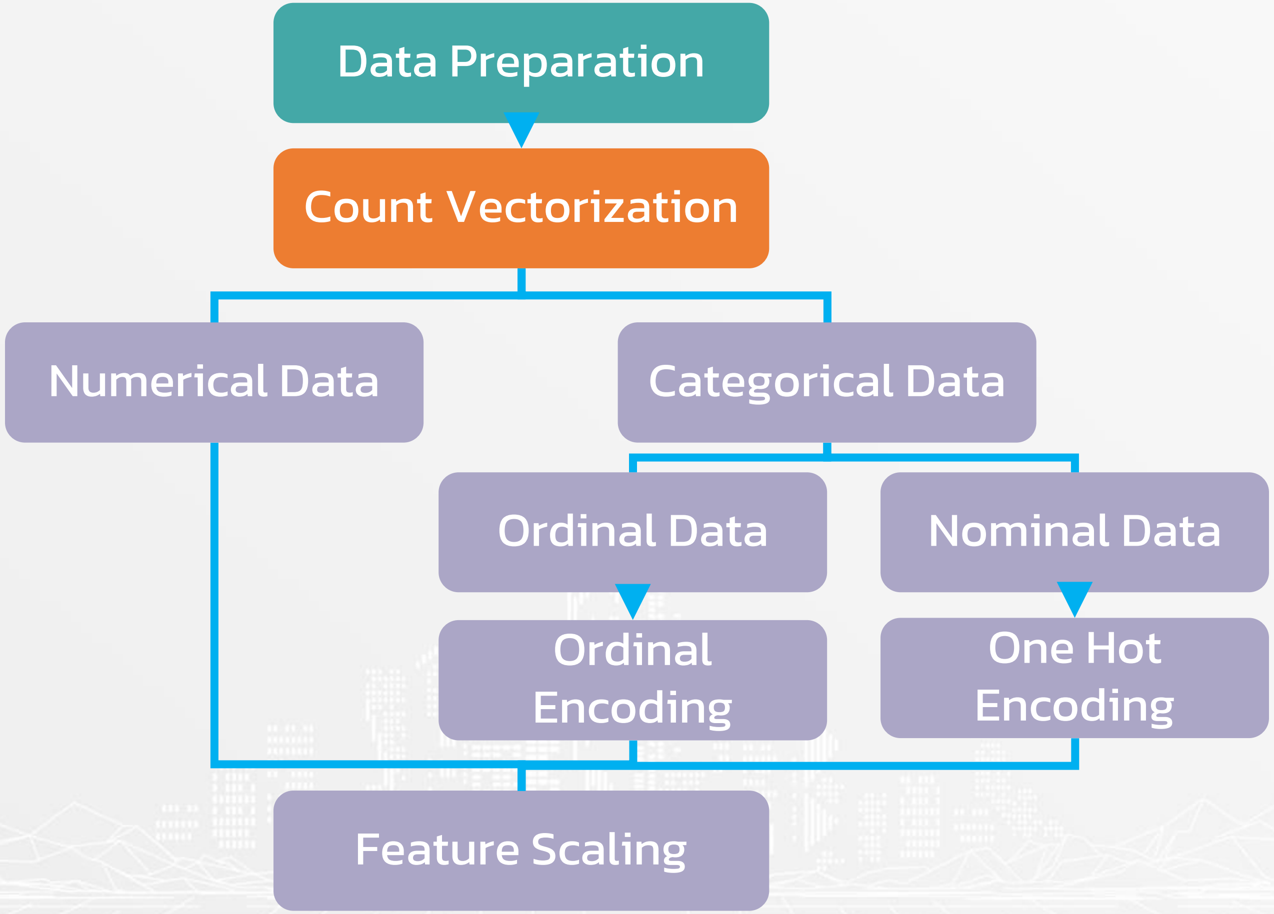
- selling_price : ราคารถยนต์ที่ขายได้

What we learn from this project?

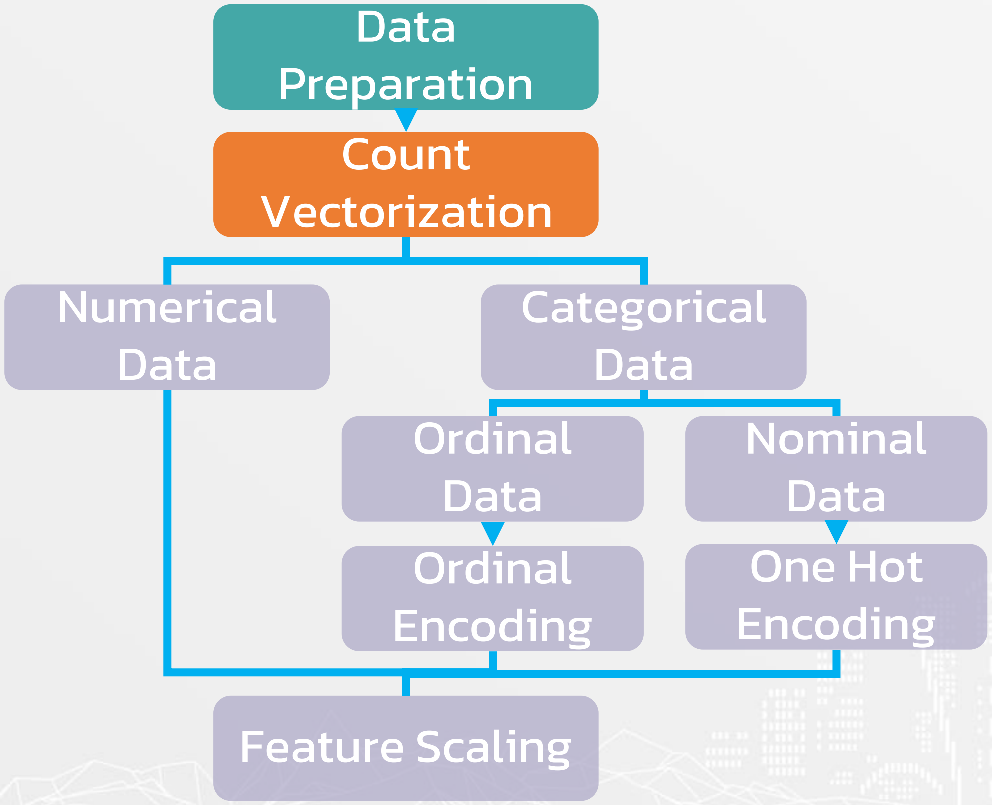


TAUTOLOGY

Data Preparation



What we learn from this project?



Count vectorization

สร้าง feature ใหม่ โดยการหา unique word จากข้อความทั้งหมดใน dataset จากนั้นให้พิจารณาว่าแต่ละข้อความประกอบด้วย unique word อะไรบ้าง และจำนวนกี่ครั้ง

	'apple'	**'green'**	**'is'**	**'kiwi'**	**'orange'**	**'red'**
'Apple is red'	1	0	1	0	0	1
'Kiwi is green'	0	1	1	1	0	0
'Orange is orange'	0	0	1	0	2	0

What we learn from this project?

	con_05	con_0i	con_10	con_100	...	con_xza	con_yaris	...
Mahindra Xylo D4	0	0	0	0	...	0	0	...
Maruti Swift Dzire VDI	0	0	0	0	...	0	0	...
Mahindra KUV 100 mFALCON G80 K8 5str	0	0	0	1	...	0	0	...
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

Code

- Count vectorization for **training set**

```
corpus_train = X_train['name'].tolist()
vectorizer = CountVectorizer()
vectorizer.fit(corpus_train)
cnt_vec_train = vectorizer.transform(corpus_train).toarray()
```

```
cnt_vec_feature_name = ['con_' + feature for feature in vectorizer.get_feature_names()]
```

```
X_train[cnt_vec_feature_name] = cnt_vec_train
X_train.drop('name', axis=1, inplace=True)
```

Code

- Count vectorization for **test set**

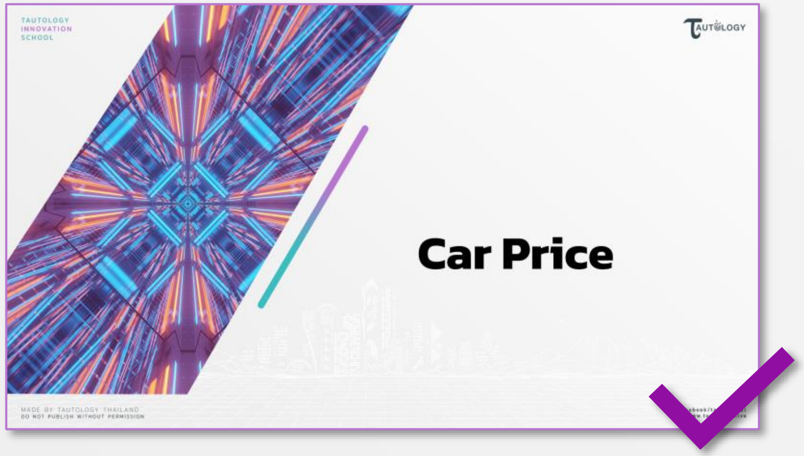
```
corpus_test = X_test['name'].tolist()
cnt_vec_test = vectorizer.transform(corpus_test).toarray()
```

```
X_test[cnt_vec_feature_name] = cnt_vec_test
X_test.drop('name', axis=1, inplace=True)
```

01. CAR PRICE

- carprice_dataset.csv
- carprice_mc.ipynb
- carprice_md.ipynb
- carprice_model.pickle

Workshop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AI in Skin Cancer
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TAUTOLOGY

AI in Skin Cancer

Abstract

สร้างmodelเพื่อวินิฉัยผู้ป่วยโรคมะเร็งผิวหนัง โดยพิจารณาจากภาพถ่ายผิวหนังของผู้ป่วย

Why this project important?

- สามารถสร้างระบบสำหรับตรวจโรคมะเร็งผิวหนังที่ทำงาน ได้ตลอด 24 ชั่วโมง
- สามารถนำไปต่อยอดกับการวินิจฉัยโรคอื่น ๆ
- สามารถใช้เป็นพื้นฐานสำหรับการแพทย์ทางไกล

Who this project is for?

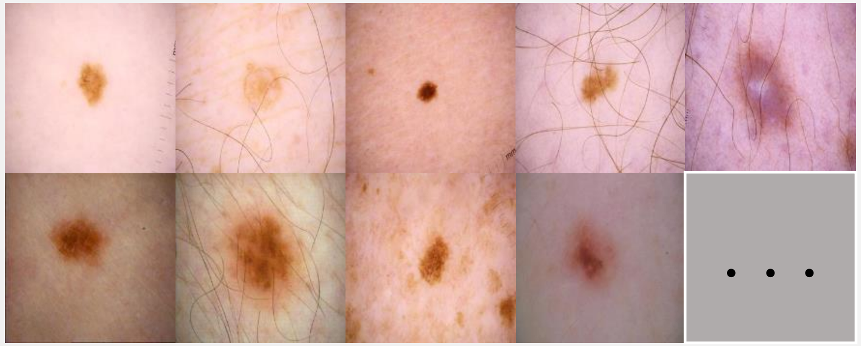
- ผู้บริหารโรงพยาบาล
- บุคลากรทางการแพทย์
- นักวิเคราะห์ข้อมูล

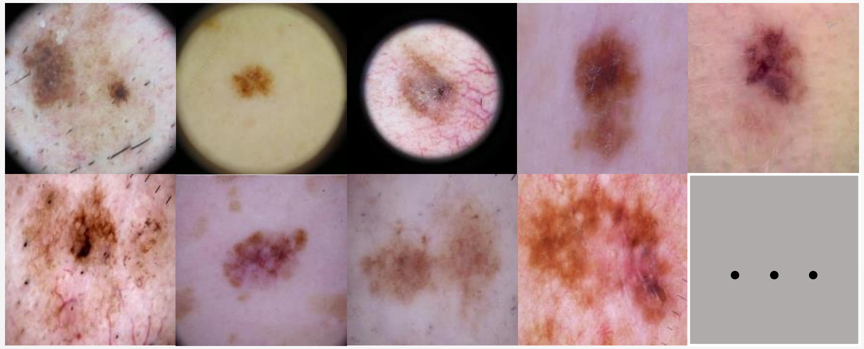
Skin Cancer Dataset

https://www.kaggle.com/datasets/hasnainjaved/melanoma-skin-cancer-dataset-of-10000-images

Skin Cancer Dataset

Feature





Target

- target : การเป็นโรคมะเร็งผิวหนัง (benign, malignant)

What we learn from this project?

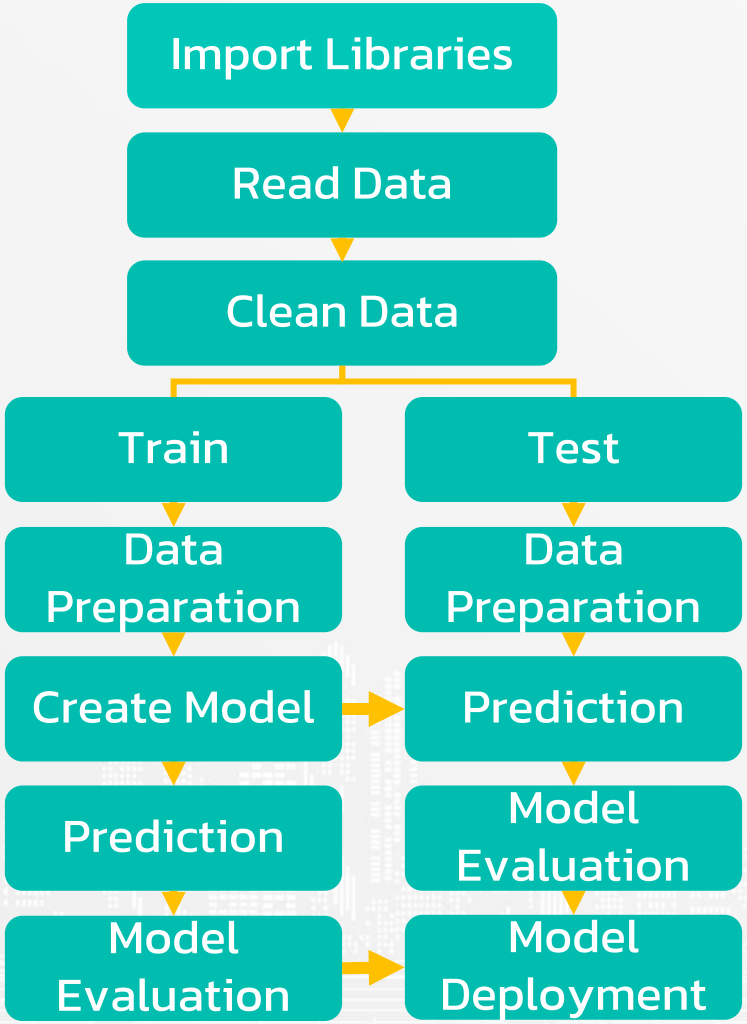


Image to CSV

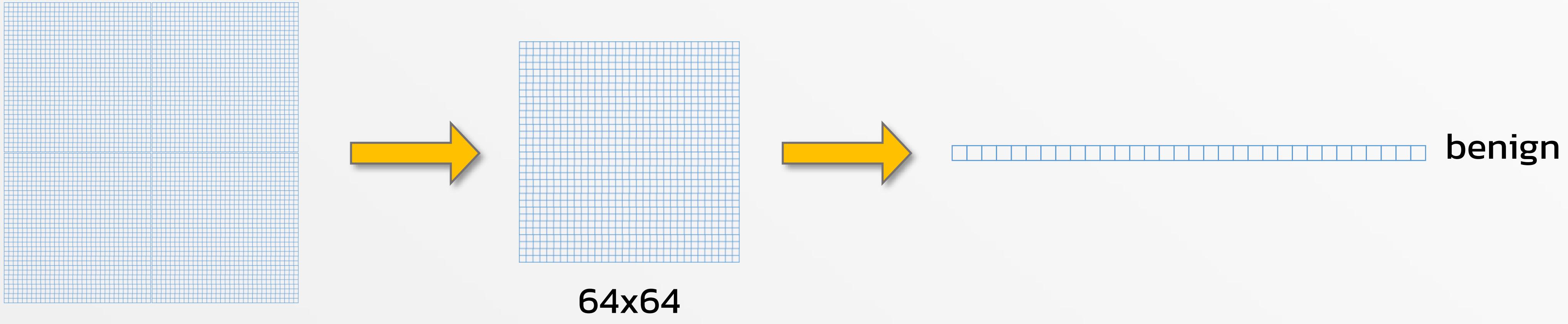
```
classes = ['benign', 'malignant']
```

```
width = 64
height = 64

X = np.empty([0, width*height*3])
y = np.empty([0, 1])

for _class in tqdm(classes):
    img_path = glob('dataset/' + _class + '/*')
    for path in tqdm(img_path):
        img = Image.open(path)
        img = img.resize([width, height])
        img = np.array(img)
        if img.shape[2] == 4:
            img = cv2.cvtColor(img, cv2.COLOR_BGRA2BGR)
        img = img.reshape(1, -1)
        X = np.vstack([X, img])
        y = np.vstack([y, _class])
```

Image to CSV



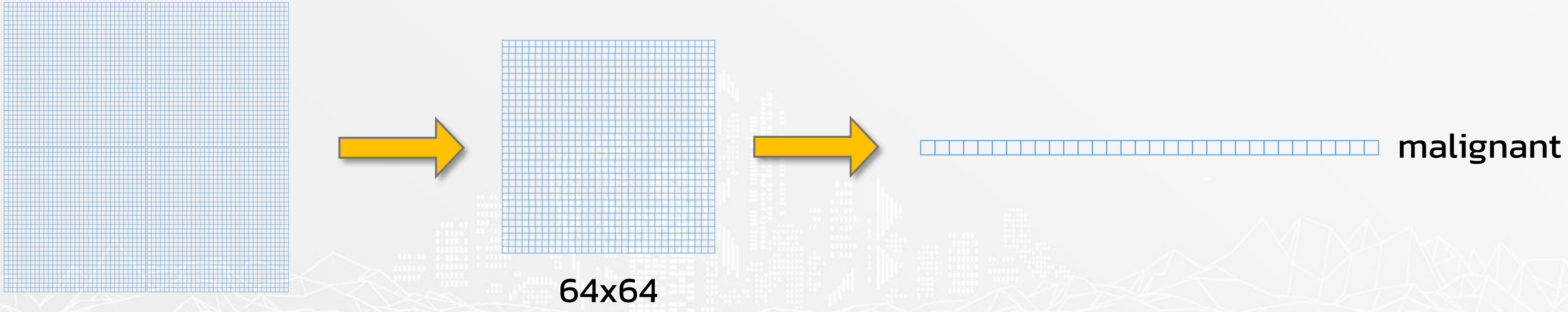


Image to CSV

x_1	x_2	x_3	$\cdots$	x_{12287}
198.0	159.0	160.0	$\cdots$	117.0
121.0	115.0	117.0	$\cdots$	124.0
186.0	136.0	125.0	$\cdots$	110.0
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
44.0	36.0	24.0	$\cdots$	12.0

X

y
benign
benign
benign
$\vdots$
malignant

y

Image to CSV

```
columns = [f'pixel_{i}' for i in range(width*height*3)]

data = pd.DataFrame(X, columns=columns)
data['label'] = y

data.to_csv('skin_cancer_dataset.csv', index=False)
```

Read Data

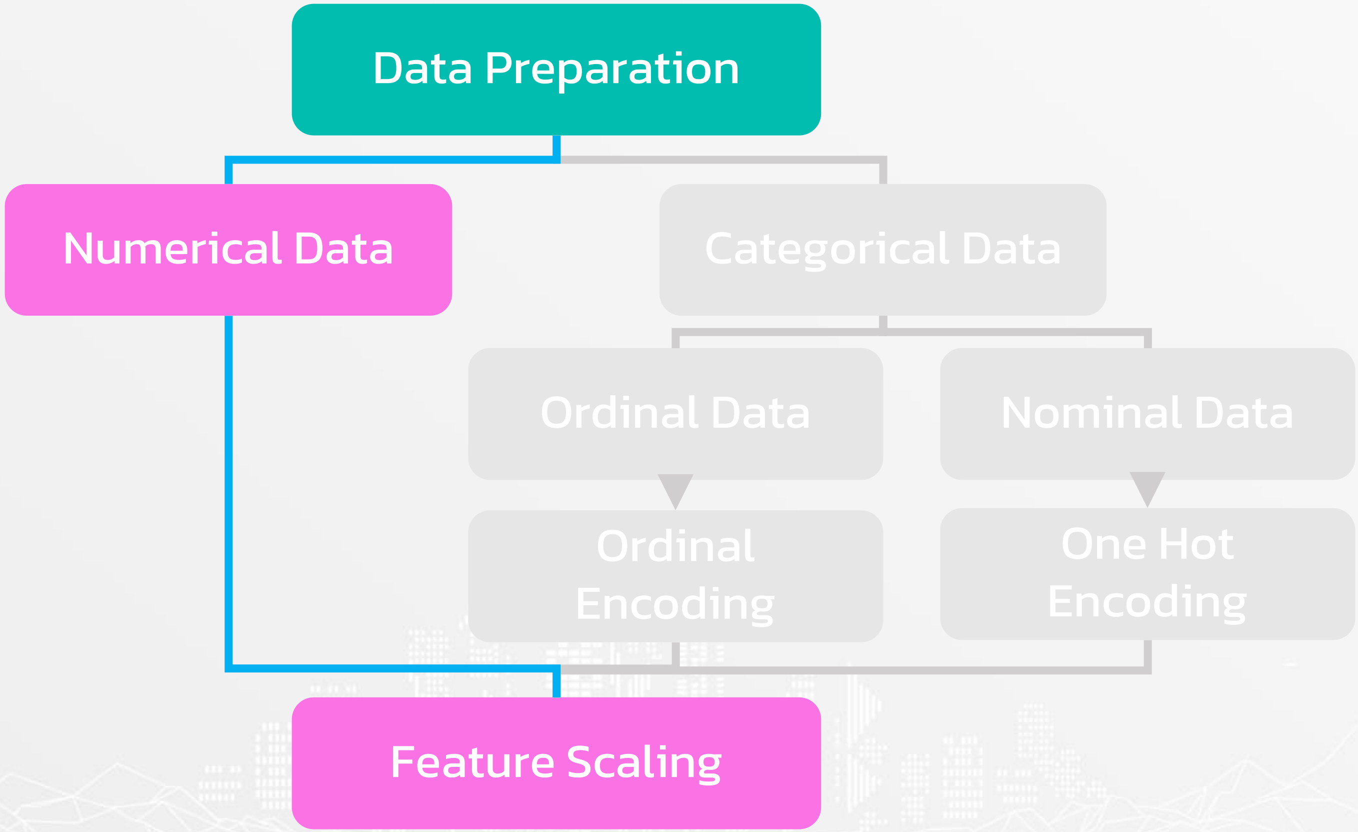
```
data = pd.read_csv('../image_to_csv/skin_cancer_dataset.csv')

data
```

	pixel_0	pixel_1	pixel_2	pixel_3	pixel_4	pixel_5	pixel_6	pixel_7	pixel_8	pixel_9	...	pixel_12286	pixel_12287	label
0	198.0	159.0	160.0	201.0	162.0	163.0	209.0	170.0	171.0	211.0	...	122.0	117.0	benign
1	121.0	115.0	117.0	134.0	128.0	130.0	136.0	131.0	133.0	145.0	...	104.0	124.0	benign
2	186.0	136.0	125.0	186.0	137.0	121.0	189.0	142.0	118.0	194.0	...	116.0	110.0	benign
3	178.0	132.0	136.0	180.0	140.0	137.0	185.0	140.0	131.0	180.0	...	94.0	89.0	benign
4	193.0	156.0	167.0	195.0	155.0	166.0	199.0	156.0	168.0	204.0	...	156.0	167.0	benign
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9600	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	...	0.0	0.0	malignant
9601	171.0	164.0	171.0	174.0	167.0	174.0	178.0	171.0	178.0	178.0	...	170.0	180.0	malignant
9602	148.0	131.0	124.0	149.0	131.0	123.0	146.0	125.0	114.0	153.0	...	57.0	54.0	malignant
9603	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	...	0.0	0.0	malignant
9604	44.0	36.0	24.0	56.0	45.0	33.0	69.0	56.0	42.0	81.0	...	14.0	12.0	malignant

9605 rows × 12289 columns

Data Preparation

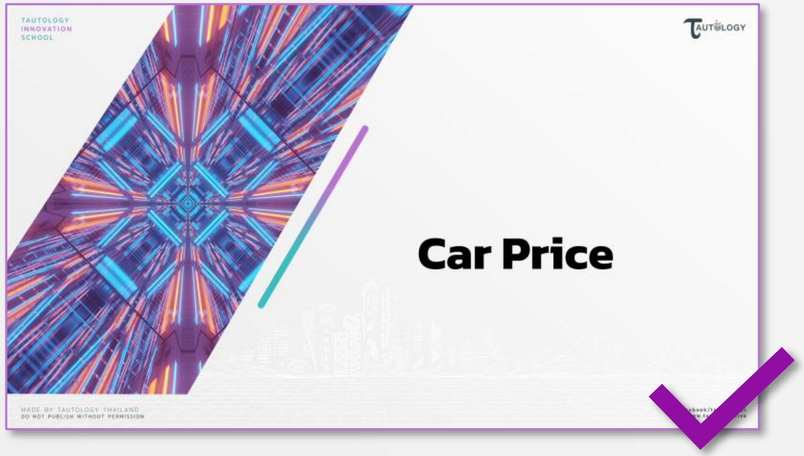


File

03. SKIN CANCER

- skin_cancer_model.pickle
- skin_cancer_mc.ipynb
- skin_cancer_md.ipynb
- Image_to_csv

Workshop



Neural Network & Deep Learning

- Neural Network
- Deep Learning
- Deep Learning for Regression
- Deep Learning for Classification
- Workshop