TAUTOLOGY
INNOVATION
SCHOOL

TAUTOLOGY

BASIC MATH FOR DEEP LEARNING

BY TAUTOLOGY

BASIC MATH FOR DEEP LEARNING

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Basic Math for Deep Learning

- Linear Algebra
- Calculus
- Probability & Statistics

Linear Algebra

Linear Algebra

- Matrix
- Basic Matrix Operation
- Matrix Multiplication
- Hadamard Product
- Types of Matrix
- Inverse of a Matrix

Matrix

Matrix คือ ตัวเลขที่จัดวางในรูปแบบเดียวกันกับตาราง

$$A = \begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,p} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} & a_{n,2} & \cdots & a_{n,p} \end{bmatrix}_{n \times p}$$

- Matrix A เป็น matrix ที่มี n แถว p หลัก
- $a_{n,p}$ คือ สมาชิกในแถวที่ n หลักที่ p

Matrix

<u>ตัวอย่าง</u>

$$A = \begin{bmatrix} 3 & \boxed{1} \\ -1 & 5 \\ \boxed{7} & 2 \end{bmatrix}_{3\times 2}$$

- A คือ matrix ที่มี 3 แถว 2 หลัก
- 1 คือ สมาชิกในแถวที่ 1 หลักที่ 2
- 7 คือ สมาชิกในแถวที่ 3 หลักที่ 1

Linear Algebra

- **Matrix**
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Basic Matrix Operation

1. Addition
2. Subtraction
3. Scalar Multiplication
4. Transposition

Basic Matrix Operation

1. Addition

$$A+B=\begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,p} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} & a_{n,2} & \cdots & a_{n,p} \end{bmatrix}_{n\times p}+\begin{bmatrix} b_{1,1} & b_{1,2} & \cdots & b_{1,p} \\ b_{2,1} & b_{2,2} & \cdots & b_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ b_{n,1} & b_{n,2} & \cdots & b_{n,p} \end{bmatrix}_{n\times p}$$

Basic Matrix Operation

1. Addition

$$A + B = \begin{bmatrix} a_{1,1} + b_{1,1} & a_{1,2} + b_{1,2} & \cdots & a_{1,p} + b_{1,p} \\ a_{2,1} + b_{2,1} & a_{2,2} + b_{2,2} & \cdots & a_{2,p} + b_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} + b_{n,1} & a_{n,2} + b_{n,2} & \cdots & a_{n,p} + b_{n,p} \end{bmatrix}_{n \times p}$$

Basic Matrix Operation

1. Addition

<u>ตัวอย่าง (1)</u>

$$\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}_{2\times 2} + \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix}_{2\times 2} = \begin{bmatrix} 6 & 8 \\ 10 & 12 \end{bmatrix}_{2\times 2}$$

Basic Matrix Operation

1. Addition

ตัวอย่าง (2)

$$\begin{bmatrix} 5 & -4 \\ -2 & 3 \\ 6 & 2 \end{bmatrix}_{3\times 2} + \begin{bmatrix} -1 & 1 \\ 7 & 4 \\ 5 & 3 \end{bmatrix}_{3\times 2} = \begin{bmatrix} 4 & -3 \\ 5 & 7 \\ 11 & 5 \end{bmatrix}_{3\times 2}$$

Basic Matrix Operation

1. Addition

ข้อควรระวัง

$$\begin{bmatrix} 5 & 4 \\ 0 & 3 \\ 1 & 2 \end{bmatrix}_{3\times 2} + \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}_{2\times 2} = \times$$

Basic Matrix Operation

2. Subtraction

$$A - B = \begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,p} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} & a_{n,2} & \cdots & a_{n,p} \end{bmatrix}_{n\times p} - \begin{bmatrix} b_{1,1} & b_{1,2} & \cdots & b_{1,p} \\ b_{2,1} & b_{2,2} & \cdots & b_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ b_{n,1} & b_{n,2} & \cdots & b_{n,p} \end{bmatrix}_{n\times p}$$

Basic Matrix Operation

2. Subtraction

$$A - B = \begin{bmatrix} a_{1,1} - b_{1,1} & a_{1,2} - b_{1,2} & \cdots & a_{1,p} - b_{1,p} \\ a_{2,1} - b_{2,1} & a_{2,2} - b_{2,2} & \cdots & a_{2,p} - b_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} - b_{n,1} & a_{n,2} - b_{n,2} & \cdots & a_{n,p} - b_{n,p} \end{bmatrix}_{n \times p}$$

Basic Matrix Operation

2. Subtraction

ตัวอย่าง (1)

$$\begin{bmatrix} 8 & 7 \\ 6 & 5 \end{bmatrix}_{2\times2} - \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}_{2\times2} = \begin{bmatrix} 7 & 5 \\ 3 & 1 \end{bmatrix}_{2\times2}$$

Basic Matrix Operation

2. Subtraction

ตัวอย่าง (2)

$$\begin{bmatrix} 5 & -4 \\ -2 & 3 \\ 6 & 2 \end{bmatrix}_{3\times 2} - \begin{bmatrix} -1 & 1 \\ 7 & 4 \\ 5 & 3 \end{bmatrix}_{3\times 2} = \begin{bmatrix} 6 & -5 \\ -9 & -1 \\ 1 & -1 \end{bmatrix}_{3\times 2}$$

Basic Matrix Operation

2. Subtraction

ข้อควรระวัง

$$\begin{bmatrix} 5 & 4 \\ 0 & 3 \\ 1 & 2 \end{bmatrix}_{3\times 2} - \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}_{2\times 2} = \times$$

Basic Matrix Operation

3. Scalar Multiplication

$$cA = c\begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,p} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} & a_{n,2} & \cdots & a_{n,p} \end{bmatrix}_{n\times p}$$

Basic Matrix Operation

3. Scalar Multiplication

$$cA = \begin{bmatrix} ca_{1,1} & ca_{1,2} & \cdots & ca_{1,p} \\ ca_{2,1} & ca_{2,2} & \cdots & ca_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ ca_{n,1} & ca_{n,2} & \cdots & ca_{n,p} \end{bmatrix}_{n\times p}$$

Basic Matrix Operation

3. Scalar Multiplication

ตัวอย่าง (1)

$$3 \cdot \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}_{2\times 2} = \begin{bmatrix} 3 & 6 \\ 9 & 12 \end{bmatrix}_{2\times 2}$$

Basic Matrix Operation

3. Scalar Multiplication

ตัวอย่าง (2)

$$-2\cdot\begin{bmatrix}5 & -4\\ -2 & 3\\ 6 & 2\end{bmatrix}_{3\times 2} = \begin{bmatrix}-10 & 8\\ 4 & -6\\ -12 & -4\end{bmatrix}_{3\times 2}$$

Basic Matrix Operation

4. Transposition

$$A^T = \begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,p} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} & a_{n,2} & \cdots & a_{n,p} \end{bmatrix}_{n\times p}^{T}$$

Basic Matrix Operation

4. Transposition

$$A^T = \begin{bmatrix} a_{1,1} & a_{2,1} & \cdots & a_{n,1} \\ a_{1,2} & a_{2,2} & \cdots & a_{n,2} \\ \vdots & \vdots & \ddots & \vdots \\ a_{1,p} & a_{2,p} & \cdots & a_{n,p} \end{bmatrix}_{p \times n}$$

Basic Matrix Operation

4. Transposition

ตัวอย่าง (1)

$$\begin{bmatrix} 1 & 2 \\ 4 & 3 \end{bmatrix}_{2\times 2}^{T} = \begin{bmatrix} 1 & 4 \\ 2 & 3 \end{bmatrix}_{2\times 2}$$

Basic Matrix Operation

4. Transposition

ตัวอย่าง (2)

$$\begin{bmatrix} 5 & -4 \\ -2 & 3 \\ 1 & 2 \end{bmatrix}^T_{3\times 2} = \begin{bmatrix} 5 & -2 & 1 \\ -4 & 3 & 2 \end{bmatrix}_{2\times 3}$$

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Linear Algebra

- **Matrix**
- **Basic Matrix Operation**
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Matrix Multiplication

$$AC = \begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,p} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} & a_{n,2} & \cdots & a_{n,p} \end{bmatrix}_{n\times p} \begin{bmatrix} c_{1,1} & c_{1,2} & \cdots & c_{1,m} \\ c_{2,1} & c_{2,2} & \cdots & c_{2,m} \\ \vdots & \vdots & \ddots & \vdots \\ c_{p,1} & c_{p,2} & \cdots & c_{p,m} \end{bmatrix}_{p\times m}$$

Matrix Multiplication

$$AC = \begin{bmatrix} \sum_{i=1}^{p} a_{1,i}c_{i,1} & \sum_{i=1}^{p} a_{1,i}c_{i,2} & \cdots & \sum_{i=1}^{p} a_{1,i}c_{i,m} \\ \sum_{i=1}^{p} a_{2,i}c_{i,1} & \sum_{i=1}^{p} a_{2,i}c_{i,2} & \cdots & \sum_{i=1}^{p} a_{2,i}c_{i,m} \\ \vdots & \vdots & \ddots & \vdots \\ \sum_{i=1}^{p} a_{n,i}c_{i,1} & \sum_{i=1}^{p} a_{n,i}c_{i,2} & \cdots & \sum_{i=1}^{p} a_{n,i}c_{i,m} \end{bmatrix}_{n\times m}$$

Matrix Multiplication

ตัวอย่าง

$$\begin{bmatrix} 1 & 2 \\ -1 & 3 \\ 5 & -2 \end{bmatrix}_{3\times 2} \times \begin{bmatrix} 3 & 2 & 5 \\ 1 & -1 & 4 \end{bmatrix}_{2\times 3}$$

$$= \begin{bmatrix} (1\times 3)+(2\times 1) & (1\times 2)+(2\times -1) & (1\times 5)+(2\times 4) \\ (-1\times 3)+(3\times 1) & (-1\times 2)+(3\times -1) & (-1\times 5)+(3\times 4) \\ (5\times 3)+(-2\times 1) & (5\times 2)+(-2\times -1) & (5\times 5)+(-2\times 4) \end{bmatrix}_{3\times 3}$$

Matrix Multiplication

ตัวอย่าง

$$\begin{bmatrix} 1 & 2 \\ -1 & 3 \\ 5 & -2 \end{bmatrix}_{3\times 2} \times \begin{bmatrix} 3 & 2 & 5 \\ 1 & -1 & 4 \end{bmatrix}_{2\times 3} = \begin{bmatrix} 5 & 0 & 13 \\ 0 & -5 & 7 \\ 13 & 12 & 17 \end{bmatrix}_{3\times 3}$$

Matrix Multiplication

ข้อควรระวัง

$$\begin{bmatrix} 1 & 5 \\ 3 & 2 \\ 4 & 6 \end{bmatrix}_{3\times 2} \times \begin{bmatrix} 1 & -1 & 2 \\ 5 & 4 & 3 \\ 1 & 3 & 6 \end{bmatrix}_{3\times 3} = \times$$

$$\begin{bmatrix} -1 & 2 \\ 1 & 1 \end{bmatrix}_{2\times 2} \times \begin{bmatrix} 1 & 6 \\ 2 & 3 \\ 4 & 5 \end{bmatrix}_{3\times 2} = \times$$

Linear Algebra

- ✓ **Matrix**
- ✓ **Basic Matrix Operation**
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- Hadamard Product
- Types of Matrix
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Hadamard Product

$$A \circ B = \begin{bmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,p} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} & a_{n,2} & \cdots & a_{n,p} \end{bmatrix}_{3\times 3} \circ \begin{bmatrix} b_{1,1} & b_{1,2} & \cdots & b_{1,p} \\ b_{2,1} & b_{2,2} & \cdots & b_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ b_{n,1} & b_{n,2} & \cdots & b_{n,p} \end{bmatrix}_{3\times 3}$$

Hadamard Product

$$A \circ B = \begin{bmatrix} a_{1,1}b_{1,1} & a_{1,2}b_{1,2} & \cdots & a_{1,p}b_{1,p} \\ a_{2,1}b_{2,1} & a_{2,2}b_{2,2} & \cdots & a_{2,p}b_{2,p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1}b_{n,1} & a_{n,2}b_{n,2} & \cdots & a_{n,p}b_{n,p} \end{bmatrix}_{3\times 3}$$

Hadamard Product

ตัวอย่าง (1)

$$\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}_{2\times 2} \circ \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix}_{2\times 2} = \begin{bmatrix} 5 & 12 \\ 21 & 32 \end{bmatrix}_{2\times 2}$$

Hadamard Product

ตัวอย่าง (2)

$$\begin{bmatrix} 1 & -2 & 3 \\ 4 & 5 & 6 \end{bmatrix}_{2\times 3} \circ \begin{bmatrix} -7 & -1 & 3 \\ 2 & 0 & -4 \end{bmatrix}_{2\times 3} = \begin{bmatrix} -7 & 2 & 9 \\ 8 & 0 & -24 \end{bmatrix}_{2\times 3}$$

Hadamard Product

ข้อควรระวัง

$$\begin{bmatrix} 1 & 5 \\ 3 & 2 \\ 4 & 6 \end{bmatrix}_{3\times 2} \circ \begin{bmatrix} 1 & -1 \\ 5 & 4 \end{bmatrix}_{2\times 2} = \times$$

$$\begin{bmatrix} -1 & 2 \\ 1 & 1 \end{bmatrix}_{2\times 2} \circ \begin{bmatrix} 1 & 6 \\ 2 & 3 \\ 4 & 5 \end{bmatrix}_{3\times 2} = \times$$

Linear Algebra

- ✓ **Matrix**
- ✓ **Basic Matrix Operation**
- ✓ **Matrix Multiplication**
- ✓ **Hadamard Product**
- Types of Matrix
- Inverse of a Matrix

Types of Matrix

1. Square Matrix
2. Identity Matrix (I)
3. Diagonal Matrix
4. Scalar Matrix
5. Symmetric Matrix

Types of Matrix

1. Square Matrix

ตัวอย่าง

$$\begin{bmatrix} 1 & 2 \\ 4 & 3 \end{bmatrix}_{2\times 2}, \quad \begin{bmatrix} 1 & 6 & 5 \\ 7 & 2 & 4 \\ 8 & 9 & 3 \end{bmatrix}_{3\times 3}$$

Types of Matrix

2. Identity Matrix (I)

ตัวอย่าง

$$I = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}_{3\times 3}$$

Types of Matrix

2. Identity Matrix (I)

<u>สมบัติของ identity matrix</u>

$$AI = IA = A$$

Types of Matrix

2. Identity Matrix (I)

สมบัติของ identity matrix

$$\begin{bmatrix} 1 & 2 \\ 4 & 3 \end{bmatrix}_{2\times 2} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}_{2\times 2} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}_{2\times 2} \begin{bmatrix} 1 & 2 \\ 4 & 3 \end{bmatrix}_{2\times 2} = \begin{bmatrix} 1 & 2 \\ 4 & 3 \end{bmatrix}_{2\times 2}$$

Types of Matrix

2. Identity Matrix (I)

สมบัติของ identity matrix

$$\begin{bmatrix}1 & 2 & 3\\4 & 5 & 6\\7 & 8 & 9\end{bmatrix}_{3\times3}\begin{bmatrix}1 & 0 & 0\\0 & 1 & 0\\0 & 0 & 1\end{bmatrix}_{3\times3}=\begin{bmatrix}1 & 0 & 0\\0 & 1 & 0\\0 & 0 & 1\end{bmatrix}_{3\times3}\begin{bmatrix}1 & 2 & 3\\4 & 5 & 6\\7 & 8 & 9\end{bmatrix}_{3\times3}=\begin{bmatrix}1 & 2 & 3\\4 & 5 & 6\\7 & 8 & 9\end{bmatrix}_{3\times3}$$

Types of Matrix

3. Diagonal Matrix

<u>ตัวอย่าง</u>

$$\begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}_{2\times 2}, \quad \begin{bmatrix} -1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 6 \end{bmatrix}_{3\times 3}$$

Types of Matrix

4. Scalar Matrix

<u>ตัวอย่าง</u>

$$\begin{bmatrix} -2 & 0 \\ 0 & -2 \end{bmatrix}_{2\times 2}, \quad \begin{bmatrix} 6 & 0 & 0 \\ 0 & 6 & 0 \\ 0 & 0 & 6 \end{bmatrix}_{3\times 3}$$

Types of Matrix

5. Symmetric Matrix

ตัวอย่าง

$$\begin{bmatrix} 1 & 2 & 5 \\ 2 & -3 & 9 \\ 5 & 9 & 4 \end{bmatrix}_{3\times 3} \quad , \quad \begin{bmatrix} 1 & 3 \\ 3 & 2 \end{bmatrix}_{2\times 2}$$

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Linear Algebra

- ✓ **Matrix**
- ✓ **Basic Matrix Operation**
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- ✓ **Types of Matrix**
- Inverse of a Matrix

Inverse of a Matrix

A^{-1} เป็น inverse ของ A ก็ต่อเมื่อ

$$A \times A^{-1} = A^{-1} \times A = I$$

โดยที่ I คือ identity matrix

ถ้า A สามารถหา inverse ได้ เราจะเรียก A ว่าเป็น **invertible Matrix**

Inverse of a Matrix

ตัวอย่างการใช้งาน ต้องการหา X จากสมการต่อไปนี้

$$XA = B$$

วิธีทำ

$$XAA^{-1} = BA^{-1}$$

$$XI = BA^{-1} \quad (\because AA^{-1} = I)$$

$$X = BA^{-1}$$

Linear Algebra

- ✓ Matrix
- ✓ Basic Matrix Operation
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- ✓ Types of Matrix
- ✓ Inverse of a Matrix

Basic Math for Deep Learning

- ✓ **Basic Linear Algebra**
- Calculus
- Probability & Statistics

Calculus

Calculus

- Basic Derivative
- Chain Rule
- Properties of Differentiation at point a

Basic Derivative

1. $\frac{\partial}{\partial x}(c) = 0\ ;\ c = constant$
2. $\frac{\partial}{\partial x}(x) = 1$
3. $\frac{\partial}{\partial x}(x + v) = \frac{d}{dx}(x) + \frac{d}{dx}(v)$
4. $\frac{\partial}{\partial x}(cx) = c$
5. $\frac{\partial}{\partial x}(x^n) = n \cdot x^{n-1}$

Basic Derivative

6. $\frac{\partial}{\partial x}(a^x) = a^x \log a$
7. $\frac{\partial}{\partial x}(e^x) = e^x$
8. $\frac{\partial}{\partial x}(\log_a x) = \frac{1}{x \log a}$
9. $\frac{\partial}{\partial x}(\log x) = \frac{1}{x}$

Basic Derivative

1. $\frac{\partial}{\partial x}(c) = 0\ ;\ c = constant$

<u>ตัวอย่าง</u>

$$\frac{\partial}{\partial x}(1) = 0$$

$$\frac{\partial}{\partial x}(200) = 0$$

Basic Derivative

2. $\frac{\partial}{\partial x}(x) = 1$

<u>ตัวอย่าง</u>

$$\frac{\partial}{\partial y}(y) = 1$$

$$\frac{\partial}{\partial k}(k) = 1$$

Basic Derivative

3. $\frac{\partial}{\partial x}(x+v) = \frac{d}{dx}(x) + \frac{d}{dx}(v)$

ตัวอย่าง

$$\frac{\partial}{\partial x}(x+1) = \frac{\partial}{\partial x}(x) + \frac{\partial}{\partial x}(1)$$

$$= 1 + 0$$

$$= 1$$

Basic Derivative

4. $$\frac{\partial}{\partial x}(cx) = c$$

<u>ตัวอย่าง</u>

$$\frac{\partial}{\partial x}(2x) = 2$$

$$\frac{\partial}{\partial x}(500x) = 500$$

Basic Derivative

5. $$\frac{\partial}{\partial x}(x^n) = n \cdot x^{n-1}$$

ตัวอย่าง

$$\frac{\partial}{\partial x}(x^3) = 3x^2$$

$$\frac{\partial}{\partial x}(x) = 1x^0 = 1$$

Basic Derivative

5. $\frac{\partial}{\partial x}(x^n) = n \cdot x^{n-1}$

<u>ตัวอย่าง</u>

$$\frac{\partial}{\partial x}(x^{0.5}) = 0.5x^{-0.5}$$

$$\frac{\partial}{\partial x}(x^{-2}) = -2x^{-3}$$

Basic Derivative

6. $\frac{\partial}{\partial x}(a^x) = a^x \log a$

<u>ตัวอย่าง</u>

$$\frac{\partial}{\partial x}(2^x) = 2^x \log 2 = 2^x(0.69)$$

$$\frac{\partial}{\partial x}(3.5^x) = 3.5^x \log 3.5 = 3.5^x(1.25)$$

Basic Derivative

7. $\frac{\partial}{\partial x}(e^{x}) = e^{x}$

<u>ตัวอย่าง</u>

$$\frac{\partial}{\partial(2x)}(e^{2x}) = e^{2x}$$

$$\frac{\partial}{\partial(3x)}(e^{3x}) = e^{3x}$$

Basic Derivative

8. $$\frac{\partial}{\partial x}(\log_a x) = \frac{1}{x \log a}$$

<u>ตัวอย่าง</u>

$$\frac{\partial}{\partial x}(\log_2 x) = \frac{1}{x \log 2} = \frac{1}{x(0.69)}$$

$$\frac{\partial}{\partial x}(\log_{10} x) = \frac{1}{x \log 10} = \frac{1}{x(2.30)}$$

Basic Derivative

9. $\frac{\partial}{\partial x}(\log x) = \frac{1}{x}$

<u>ตัวอย่าง</u>

$$\frac{\partial}{\partial(2x)}(\log 2x) = \frac{1}{2x}$$

$$\frac{\partial}{\partial(5x)}(\log 5x) = \frac{1}{5x}$$

Calculus

- **Basic Derivative**
- Chain Rule
- Properties of Differentiation at point a

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Chain Rule

$$\frac{\partial z}{\partial x} = \frac{\partial z}{\partial y} \cdot \frac{\partial y}{\partial x}$$

$$x$$
$$\downarrow$$
$$y$$
$$\downarrow$$
$$z$$

Chain Rule

<u>ตัวอย่าง (1)</u>

$$y = 2x^3 + 1$$

$$\begin{array}{c} x \\ \downarrow \\ x^3 \\ \downarrow \\ 2x^3 \\ \downarrow \\ 2x^3 + 1 \end{array}$$

Chain Rule

ตัวอย่าง (1)

$$\frac{\partial y}{\partial x} = \frac{\partial(2x^3+1)}{\partial x}$$

$$= \frac{\partial(2x^3+1)}{\partial(2x^3)} \cdot \frac{\partial(2x^3)}{\partial x^3} \cdot \frac{\partial(x^3)}{\partial x}$$

$$= 1 \cdot 2 \cdot 3 \cdot x^2$$

$$= 6x^2$$

$$x$$
$$\downarrow$$
$$x^3$$
$$\downarrow$$
$$2x^3$$
$$\downarrow$$
$$2x^3 + 1$$

Chain Rule

<u>ตัวอย่าง (2)</u>

$$y = (x+1)(x+2)$$

$$x$$

↙ ↘

$$x+1 \quad x+2$$

↘ ↙

$$(x+1)(x+2)$$

Chain Rule

<u>ตัวอย่าง (2)</u>

$$\frac{\partial y}{\partial x} = \frac{\partial(x+1)(x+2)}{\partial x}$$

$$= \frac{\partial(x+1)(x+2)}{\partial(x+1)} \cdot \frac{\partial(x+1)}{\partial x} + \frac{\partial(x+1)(x+2)}{\partial(x+2)} \cdot \frac{\partial(x+2)}{\partial x}$$

$$= (x+2)(1) + (x+1)(1)$$

$$= 2x + 3$$

$$\begin{tikzcd}
& x \arrow[dl] \arrow[dr] & \\
x+1 \arrow[dr] & & x+2 \arrow[dl] \\
& (x+1)(x+2) &
\end{tikzcd}$$

Calculus

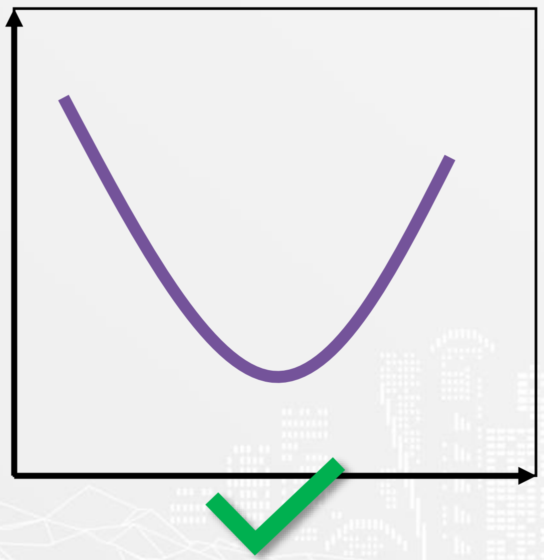
- **Basic Derivative**
- **Chain Rule**
- Properties of Differentiation at point a

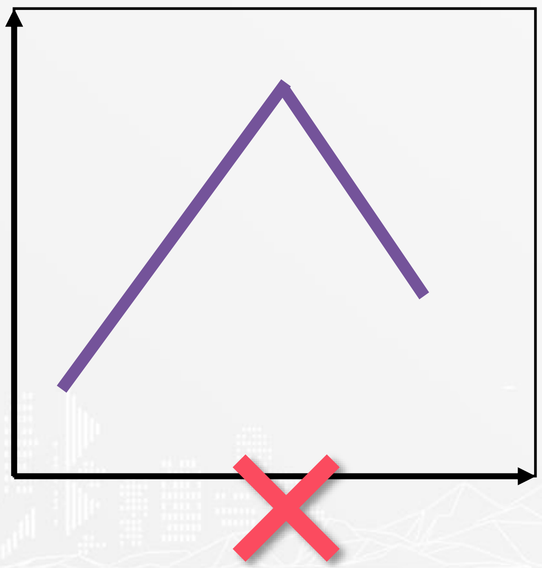
Properties of Differentiable at point a

1. Function is Smooth
2. Function is Continuous at point a

Properties of Differentiable at point a

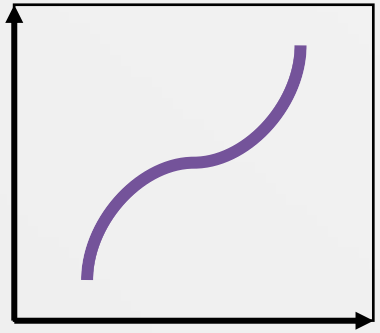
1. Function is Smooth



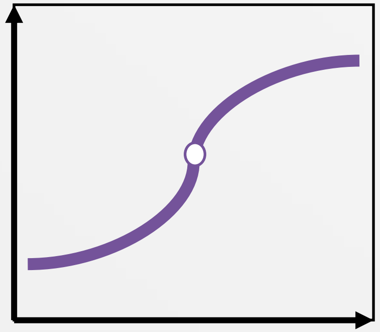


Properties of Differentiable at point a

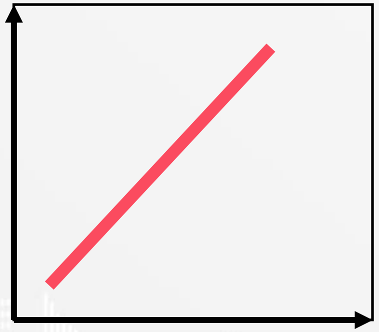
2. Function is Continuous at point a



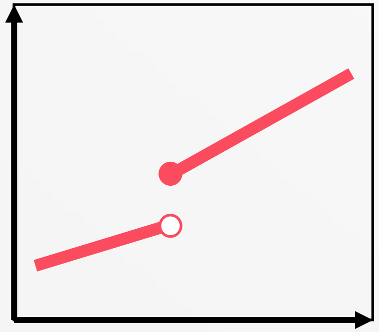
continuous



Not continuous



continuous



Not continuous

Calculus

- ✓ Basic Derivative
- ✓ Chain Rule
- ✓ Properties of Differentiation at point a

Basic Math for Deep Learning

- ✓ **Basic Linear Algebra**
- ✓ **Calculus**
- Probability & Statistics

Probability & Statistics

Probability & Statistics

- Probability
- Mean
- Variance
- Standard Deviation

Probability

Probability คือ ค่าที่บอกถึงโอกาสที่จะเกิดเหตุการณ์นั้น ๆ

<u>ตัวอย่าง</u>

- Probability ของการโยนเหรียญแล้วออกฝั่งหัว = $\frac{1}{2}$
- Probability ของการทอยลูกเต๋าแล้วได้แต้มมากกว่า 4 = $\frac{1}{3}$

Probability

โดยผลรวมค่า probability ของเหตุการณ์ผลลัพธ์ทั้งหมดจะเท่ากับ 1 เสมอ

ตัวอย่าง

เหตุการณ์ผลลัพท์ทั้งหมดของการโยนเหรียญ

- Probability ของการโยนเหรียญแล้วออกฝั่งหัว = $\frac{1}{2}$
- Probability ของการโยนเหรียญแล้วออกฝั่งก้อย = $\frac{1}{2}$

Probability

โดยผลรวมค่า probability ของเหตุการณ์ผลลัพธ์ทั้งหมดจะเท่ากับ 1 เสมอ

ตัวอย่าง

เหตุการณ์ผลลัพท์ทั้งหมดของการทอยลูกเต๋า

- Probability ของการทอยลูกเต๋าแล้วได้แต้ม 1 = $\frac{1}{6}$
- Probability ของการทอยลูกเต๋าแล้วได้แต้ม 2 = $\frac{1}{6}$
- Probability ของการทอยลูกเต๋าแล้วได้แต้ม 3 = $\frac{1}{6}$
- Probability ของการทอยลูกเต๋าแล้วได้แต้ม 4 = $\frac{1}{6}$
- Probability ของการทอยลูกเต๋าแล้วได้แต้ม 5 = $\frac{1}{6}$
- Probability ของการทอยลูกเต๋าแล้วได้แต้ม 6 = $\frac{1}{6}$

Probability & Statistics

- **Probability**
- Mean
- Variance
- Standard Deviation

Mean

Mean คือ ค่าเฉลี่ยของข้อมูล ซึ่งคำนวณได้จาก

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \cdots + x_n}{n}$$

Mean

<u>ตัวอย่าง</u>

ข้อมูลน้ำหนักตัวของนักเรียน 5 คน : $X = \{48, 55, 47, 57, 53\}$

$$\bar{x} = \frac{48+55+47+57+53}{5}$$

$$= \frac{260}{5}$$

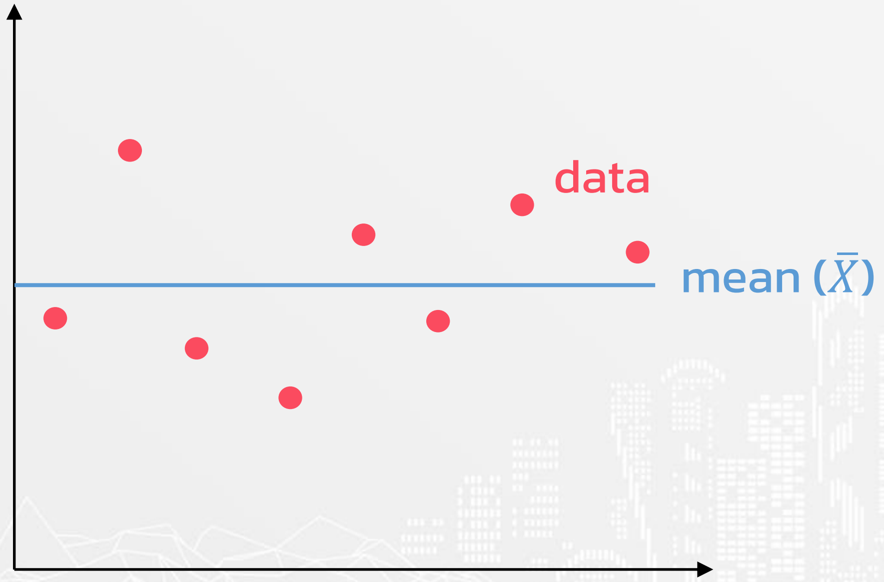
$$= 52$$

Probability & Statistics

- **Probability**
- **Mean**
- Variance
- Standard Deviation

Variance

Variance คือ ค่าความแปรปรวนของข้อมูล โดยจะพิจารณาจากระยะห่างของข้อมูลและ mean กำลังสอง



$$\sigma^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}$$

Variance

ตัวอย่าง

ข้อมูลน้ำหนักตัวของนักเรียน 5 คน : $X = \{48, 55, 47, 57, 53\}$ และ mean = 52

$$\sigma^2 = \frac{\sum_{i=1}^{5}(x_i - 52)^2}{5}$$

$$= \frac{(48-52)^2+(55-52)^2+(47-52)^2+(57-52)^2+(53-52)^2}{5}$$

$$= \frac{(-4)^2+3^2+(-5)^2+5^2+1}{5}$$

$$= \frac{16+9+25+25+1}{5}$$

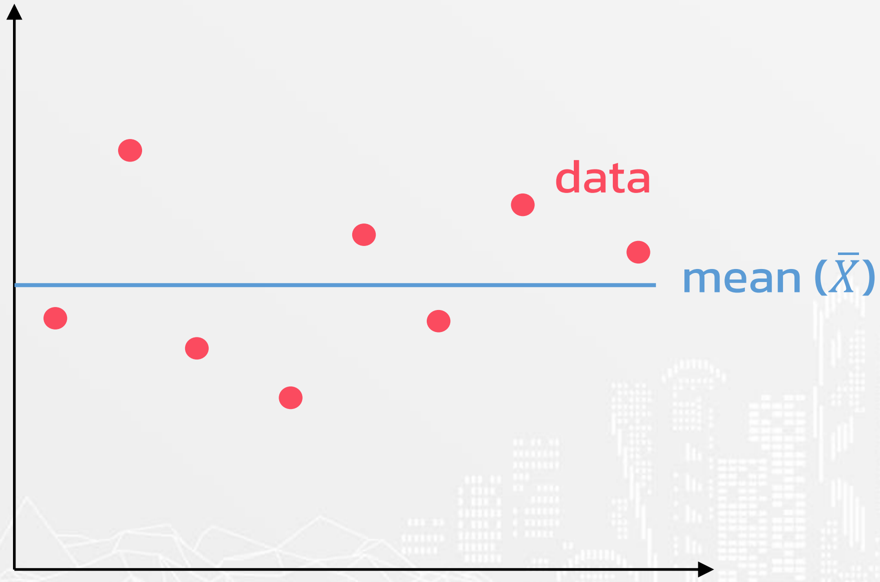
$$= \frac{76}{5} = 15.2$$

Probability & Statistics

- ✓ **Probability**
- ✓ **Mean**
- ✓ **Variance**
- Standard Deviation

Standard Deviation

Standard Deviation คือ ค่าเบี่ยงเบนมาตรฐาน ที่ใช้วัดการกระจายตัวของข้อมูล โดยจะพิจารณาจาก square root ของ variance เพื่อให้ค่าที่มี unit เดียวกับข้อมูล



$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}}$$

Standard Deviation

<u>ตัวอย่าง</u>

ข้อมูลน้ำหนักตัวของนักเรียน 5 คน : $X = \{48, 55, 47, 57, 53\}$ และ mean = 52

$$\sigma = \sqrt{\frac{\sum_{i=1}^{5}(x_i - 52)^2}{5}}$$

$$= \sqrt{15.2}$$

$$= 3.90$$

TAUTOLOGY

Probability & Statistics

- Probability
- Mean
- Variance
- Standard Deviation

Basic Math for Deep Learning

- ✓ Basic Linear Algebra
- ✓ Calculus
- ✓ Probability & Statistics