Linear Regression

Gradient Descent

- □□**Model**□$y=w\cdot x + b$

  - Model□□□□□□□□□□□□□□□□□□□
    - **□□□Model□training data□□□□□□□□□testing data□□□□□Overfitting**

- **Loss**□$L(w,b) = \sum_{i=1}^{n}(y-(w \cdot x + b))^2$

- □□□□□□□□□□

  - $w_1 = w_0 - \alpha\frac{\partial L}{\partial w}|_{w=w_0}$
  - $b_1 = b_0 - \alpha\frac{\partial L}{\partial b}|_{b=b_0}$
  - α□□**Learning rate**□□□□□□□□□□

Regularization

- □□□□**Loss function**
  - $L(w,b) = \sum_{i=1}^{n}(y-(w \cdot x + b))^2 + \lambda\sum(w_i)^2$
  - □□λ□□□□□w□**Loss function**□□□
    - λ□□□□□□□□□□□□□□□□w□□□□ 0□□□□□□□□□□□□□
    - λ□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□

Classification

- ### 1. □□□□□□

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  - □□□□□□□□□□□□□□□□□□$ P(y=k|x)$□□□□□□□□□□□□□□□□□□□

  - □□□□□□□□□□□□□□

    $P(y=k|x)=\frac{P(x | y = k) P(y = k)}{P(x)}$

    □□□

    - $P(y=k|x)$□□□□□□□□□□□ x□□□□□ k □□□□□
    - $P(x|y=k)$□□□□□□□□ k □□□□ x □□□□
    - $P(y=k)$□□□□□□□□□ k □□□□□□□□□
    - $P(x)$□□□□□□□□□□□□□□□ 1□□□□□□□□□□

  ### 2. □□□□□□□□□

  - **□□□□ $P(y=k|x)$ □□□□ $P(x|y=k)$ □ $P(y=k)$ □□□□□□□**
  - □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
  - □□□□□□□□□□□□□□□□□□□

  ### 3. □□□□□

  1. **□□□□□□ $P(y=k)$**□□□□□□□□□□□□□□□□□□□□□□□
  2. **□□□□ $P(x|y=k)$**□
     - □□□□□□□x□□□□□□□□□□□□□□□□□□□□□□□

3. **□□□□□□ $P(y=k|x)$**□□□□□□□□□□□□□□□□□□

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4. □□□□□□□

- □□□□□□□**MLE**□□□□□□□□□□□μ □□□□□□ Σ□□□□□□□□□□□□□□□□
  - □□$L(\mu,\Sigma) = f_{\mu,\Sigma}(x^1)f_{\mu,\Sigma}(x^2)f_{\mu,\Sigma}(x^3)f_{\mu,\Sigma}(x^4)\dots f_{\mu,\Sigma}(x^{79})$
  - □□□□$L(\mu,\Sigma)$□□□μ,Σ
  - □□□□□□□ $μ1,μ2,Σ\mu^1, \mu^2, \Sigmaμ1,μ2,Σ $□□□□□□□□□□□□□□
- □□□□□□□□□□□□ x□□□ $P(y=1|x)$ □ $P(y=2|x)$□□□□□□□□□□

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5. □□□□

- $\large P(C_1|x) = \frac{P(x|C_1)P(C_1)}{P(x|C_1)P(C_1)+P(x|C_2)P(C_2)} = \frac{1}{1+\frac{P(x|C_2)P(C_2)}{P(x|C_1)P(C_1)}} = \frac{1}{1+e^{-z}} = \sigma(z)$
  - **$\sigma(z)$□sigmoid**□□□□□□□[0,1]□□□□□□□□□
- □□□z□□$z = wx + b$
  - □□$z = \large ln\frac{P(x|C_1)P(C_1)}{P(x|C_2)P(C_2)}$□□□□□□□□□
    - $w^T = (\mu^1 - \mu^2)\Sigma^{-1}$
    - $b = -\frac{1}{2}(\mu^1)^T(\Sigma^1)^{-1}\mu^1+\frac{1}{2}(\mu^2)^T(\Sigma^2)^{-1}\mu^2+ln\frac{N_1}{N_2}$
      - □□$\mu^1□\mu^2□\Sigma^1□\Sigma^2□N_1□N_2$□□□□□□□□□□□□□□□□□□□□□□□□□□□$\Sigma^1 = \Sigma^2 = \Sigma$

Logistic Regression

Loss function

□□□□□□**$f_{w,b}(X) = P_{w,b}(C_1|x)$**□□□□□□

- □□□□□
□□□□	**x^1**	**x^2**	**x^3**	**$\cdots$**
□□	C_1	C_1	C_2	$\cdots$
□□	$\hat{y} = 1$	$\hat{y} = 1$	$\hat{y} = 0$	$\cdots$

- □□□□□□□$\large f(w,b) = f_{w,b}(x^1)f_{w,b}(x^2)(1-f_{w,b}(x^3))\dots f_{w,b}(x^N)$
- □□□ $f_{w,b}(x)$ □□□□□□□□□ x□□□□□□□□□□□□ C_1 □□□□□□

  $\large f_{w,b}(x) = P_{w,b}(C_1 | x)$

  □□□□□□□□□□□□ C_1 □ C_2□□□□□□ C_2 □□□□□□

  $\large P_{w,b}(C_2 | x) = 1 - P_{w,b}(C_1 | x) = 1 - f_{w,b}(x)$

  - □□□**□□w,b□□□□□□□□□□□*$$w^,b^* = argmaxL(w,b) = argmin (- lnL(w,b))$$
  - $$-lnL(w,b) = lnf_{w,b}(x^1)+lnf_{w,b}(x^2)+ln(1-f_{w,b}(x^3)) = \sum_{n}-[\hat{y}^nlnf_{w,b}(x^n)+(1-\hat{y}^n)ln(1-f_{w,b}(x^n))]$$

    - □□**Cross entropy**□$ C(f(x^n),\hat{y}^n) = \sum_{n}-[\hat{y}^nlnf_{w,b}(x^n)+(1-\hat{y}^n)ln(1-f_{w,b}(x^n))]$□□□□□□□□□

□□Gradient Descent□□□□□□

□**Cross entropy**□$C(f(x^n),\hat{y}^n) = \sum_{n}-[\hat{y}^nlnf_{w,b}(x^n)+(1-\hat{y}^n)ln(1-f_{w,b}(x^n))]$□□**Gradient Descent**□

- $\Large\frac{\partial{ln(1-f_{w,b}(x))}}{\partial{w_i}} = \frac{\partial{ln(1-f_{w,b}(x))}}{\partial{z}}\frac{\partial{z}}{\partial{w_i}} = -\sigma(z)x_i$
    - $\large \frac{\partial{ln(1-\sigma(z))}}{\partial{z}} = -\frac{1}{1-\sigma(z)}\sigma(z)(1-\sigma(z))$
    - $\large\frac{\partial{z}}{\partial{w_i}} = x_i$
- □□□$\Large\frac{\partial{lnf_{w,b}(x)}}{\partial{w_i}} = \frac{\partial{lnf_{w,b}(x)}}{\partial{z}}\frac{\partial{z}}{\partial{w_i}} = (1-\sigma(z))x_i$
- □□□$\Large \frac{\partial{(-ln(w,b))}}{w_i} = \sum_n -(\hat{y}^n - f_{w,b}(x^n))x_i^n$
    - □□□□□□□□□□□□□□□

□□Square Error□□□

- □**Loss function**□□$L(f) = \frac{1}{2}\sum_n(f_{w,b}(x^n)- \hat{y}^n)^2$
- $\large\frac{\partial{(f_{w,b}(x)-\hat{y}^n)^2}}{\partial w_i} = \normalsize 2(f_{w,b}(x) - \hat{y})f_{w,b}(x)(1-f_{w,b}(x))x_i$
    - □$\hat{y}^n = 0$□□□□□□□$f_{w,b}(x) = 1$□□□□□□0□□□□□□□□□□□□□□□□□□□□□□□□□□
    - □$\hat{y}^n = 1$□□□□□□□$f_{w,b}(x) = 0$□□□□□□0□□□□□□□□□□□□□□□□□□□□□□□□□□

Multi-class Classification

□□□□□□□□□□□weight□bias

- $C_1:w^1,b_1$ $z_1 = w^1 \cdot x+ b_1$
- $C_2:w^2,b_2$ $z_2 = w^2 \cdot x+ b_2$
- $C_3:w^3,b_3$ $z_3 = w^3 \cdot x+ b_3$

1. □□ `softmax` □□□□□□

- $f(z) = \large \frac{e^z}{\sum_{i=1}^n e^i}$
- $f(z)$□□□□[0,1]□□□□□□□□□□1

2. □□ `Cross entropy` □□□□□□□□□□□□□□

- $\large -\sum_{i=1}^n \hat{y_i}lny_i$

Limitation of Logistic Regression

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- □□□□□$\sigma(z) = 0.5$□□$w \cdot x + b = 0$

□□□□□□□Feature transformation□□□□□□□□□□□□□□□

Discriminative and Generative

Discriminative□□□□□□□

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- □□□□□□□□□□□□□**x**□□□□□□
- □□□□□$P(y|x)$□□
- □□□□□□□□□□□□□□□□□□□□□□□□□□

Generative□□□□□

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- □□□□$P(x|y)$□□□□□□□□□□□□
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Deep Learning

Three steps for Deep Learning

1. Define a set of funtion

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- □□□□□□□□ Sigmoid□□□□□ ReLU□ReLU □□□□□

  ### Sigmoid □□□

  - **□□□□ (0, 1)**□□□□
    - □□□□□□□□□□□□□□□□□ 0□□□□□□□
  - □□□□□□□□□□□□□□□□□

  ### ReLU □□□

  - **□□□ [0, ∞)**□□□□□□□□□□□ 0
  - □□□□□□□□□□ sigmoid □□□□□□□□□□
  - □□□□□□□□□□

  ### □ ReLU □□□□

  - **ReLU** □□□□□□□□□□□ 0□□□□□□□□□□□□□□□□□□

2. Goodness of function

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3. Pick the best function

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Gradient Descent

- Learning Rate□□□□□
    - □□□□□□□
    - □□□□□□□□

□□□□□□□□**Taylor Series**□□□□□□□

Adagrad□□□

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Stochastic Gradient Descent

□□□□□$L=\sum_n(\hat{y^n}-(b + \sum(w_ix_i^n)))^2$

- **Gradient Descent**□$\theta^i = \theta^{i-1} - \eta \nabla L(\theta^{i-1})$□□□□□□□□□□
- **Stochastic Gradient Descent**□□□□□□□□□□**example**□□□□□□□□□□□
    - □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□

Feature Scaling

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- $\large x_i^r \leftarrow \frac{x_i^r - m_i}{\sigma _i}$
    - □□□□□i□□□□**m_i□□□σ_i**
    - □□□□□□□□□**0□□□1**

Backpropagation

- **□Forward pass□Backword pass□□**
    - □□□□□□□□□□□□□□□□□□□□□□□□
        - □□□□□□□□□□□□□□□□
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image-20250416233353334

Forward pass[illegible]

Backword pass[illegible]

BERT

[illegible]

Unsupervised Learning

Self-supervised Learning

Word Embedding[illegible]

[illegible]

[illegible]

1. [illegible]

- [illegible]**(one-hot encoding)**illegible
- [illegible](illegible50-300[illegible])

2. [illegible]

- [illegible]
- [illegible]

Predication-based

Prediction-based[illegible] [illegible]

[illegible]

[illegible]

1. [illegible]one-hot encoding[illegible]

    - [illegible]"[illegible]"[illegible]"[illegible]"[illegible]"[illegible]"[illegible]"[illegible]"[illegible]

2. [illegible]

    - "[illegible]"[illegible] × [illegible] → "[illegible]"[illegible]

- "[illegible]"[illegible] × [illegible] → "[illegible]"[illegible]
    - [illegible]
    - [illegible]
    - [illegible]

4. [illegible]

    - [illegible]

    - [illegible]

5. [illegible]
    - [illegible]
    - [illegible]

[illegible]

1. [illegible]
    - [illegible]
    - [illegible]
2. [illegible]
    - [illegible]
    - [illegible]

Seq2Seq

Sequence to Sequence Model[illegible]

[illegible]

Seq2Seq[illegible]

1. [illegible]Encoder[illegible]
2. [illegible]Decoder[illegible]

AT[illegible]Auto-regressive[illegible]VS NAT[illegible]Non-Autoregressive Transformer[illegible]

[illegible]**AR/AT**[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]GPT[illegible]**Transformer**[illegible]

[illegible]**NAT**[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]