

# Functions of Linear Regression

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Given a data set  $X = \{X_j^i | X_j^i \in \mathbb{R}^{n \times (m-1)}\}$  and a label set  $Y = \{Y^i | Y^i \in \mathbb{R}^{n \times 1}\}$ , where  $1 \leq i \leq n$  and  $2 \leq j \leq m$ . For all  $X^i$ , insert  $X_1^i = 1$  so that  $X_j^i \in \mathbb{R}^{n \times m}$ . Initialize weight matrix  $W = \{W_j | W_j \in \mathbb{R}^{1 \times m}\}$ .

Hypothesis function is defined in Equation (1).

$$H(X^i) = \sum_{j=1}^m W_j X_j^i \quad (1)$$

Loss function is defined in Equation (2).

$$C(X^i) = H(X^i) - Y^i \quad (2)$$

Cost function is defined in Equation (3).

$$\begin{aligned} J(W) &= \frac{1}{2n} \sum_{i=1}^n C^2(X^i) \\ &= \frac{1}{2n} \sum_{i=1}^n \left( \sum_{j=1}^m W_j X_j^i - Y^i \right)^2 \end{aligned} \quad (3)$$

The partial derivative of  $J(W)$  with respect to  $W_j$  is given as follows:

$$\begin{aligned} \frac{\partial J(W)}{\partial W_j} &= \frac{1}{2n} \sum_{i=1}^n \frac{\partial C^2(X^i)}{\partial W_j} \\ &= \frac{1}{2n} \sum_{i=1}^n \frac{\partial C^2(X^i)}{\partial C(X^i)} \cdot \frac{\partial C(X^i)}{\partial H(X^i)} \cdot \frac{\partial H(X^i)}{\partial W_j} \\ &= \frac{1}{2n} \sum_{i=1}^n 2C(X^i) \cdot 1 \cdot X_j^i \\ &= \frac{1}{n} \sum_{i=1}^n (H(X^i) - Y^i) X_j^i \end{aligned}$$

Thus, for all  $W_j$ , the update function is given as follows:

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