Closed Form Solution for Linear Regression Ident. Act. With Regularization:

$$\boxed{W = (D^T D + \lambda I)^{-1} D^T Y}, \quad \text{where: } W_{(d+1)\times 1},\ D_{N\times(d+1)},\ Y_{N\times 1}$$

1D Eample: Polynomial Curve Fitting (Identity Activation fn.) (Regression)

$$y(x,w) = w_0 + w_1 x + w_2 x^2 + \cdots + w_M x^M = \sum_{j=0}^{M} w_j x^j \begin{cases} \text{Gradient Descent Method (Mean Square Loss fn.)} \\ \text{In Closed Form Solution} \rightarrow D_{N\times(M+1)} W_{(M+1)\times 1} = Y_{N\times 1} \rightarrow \boxed{W = (D^T D)^{-1} D^T Y} \end{cases}$$

$$\text{Precision: } \boxed{\frac{TP}{TP+FP}}, \quad \text{Accuracy: } \boxed{\frac{TP+TN}{TP+TN+FP+FN}}$$

Batch Normalization

$$\begin{array}{lcl} \text{Input} & \rightarrow & x : (N \times D) \\ \text{Intermediates} & \rightarrow & \mu, \sigma : D,\ \hat{x} : (N \times D) \\ \text{Output} & \rightarrow & y : (N \times D) \end{array}, \quad \boxed{\mu_i = \frac{1}{N}\sum_{i=1}^{N} x_{ij}} \quad \boxed{\sigma_j^2 = \frac{1}{N}\sum_{i=1}^{N}(x_{ij} - \mu_j)^2}$$

$$\boxed{\hat{x}_{ij} = \frac{x_{ij} - \mu_j}{\sqrt{\sigma_j^2 + \varepsilon}}} \quad \boxed{y_{ij} = \gamma_j \hat{x}_{ij} + \beta_j}$$

Backpropagation (Vectorization Rule):

Backward

$$\boxed{\frac{\partial L}{\partial W3} = \frac{\partial L}{\partial A3} * \frac{\partial A3}{\partial Z3} \cdot \left(\frac{\partial Z3}{\partial W3}\right)^T} \quad \boxed{\frac{\partial L}{\partial b_3} = \frac{\partial L}{\partial A3} * \frac{\partial A3}{\partial Z3} = \theta}$$

$$\boxed{\frac{\partial L}{\partial W2} = \left(\frac{\partial Z3}{\partial A2}\right)^T \cdot \theta * \frac{\partial A2}{\partial Z2} \cdot \left(\frac{\partial Z2}{\partial W2}\right)^T} \quad \boxed{\frac{\partial L}{\partial b_2} = \left(\frac{\partial Z3}{\partial A2}\right)^T \cdot \theta * \frac{\partial A2}{\partial Z2} = \delta}$$

$$\boxed{\frac{\partial L}{\partial W1} = \left(\frac{\partial Z2}{\partial A1}\right)^T \cdot \delta * \frac{\partial A1}{\partial Z1} \cdot \left(\frac{\partial Z1}{\partial W1}\right)^T} \quad \boxed{\frac{\partial L}{\partial b_1} = \left(\frac{\partial Z2}{\partial A1}\right)^T \cdot \delta * \frac{\partial A1}{\partial Z1} = \lambda}$$

Forward

$$\boxed{Z_1 = W_1 \cdot X + b_1} \quad \boxed{A_1 = f_1(Z_1)}$$

$$\boxed{Z_2 = W_2 \cdot A_1 + b_2} \quad \boxed{A_2 = f_2(Z_2)}$$

$$\boxed{Z_3 = W_3 \cdot A_2 + b_3} \quad \boxed{A_3 = f_3(Z_3)}$$

$$\text{CNN: } \boxed{W_{n+1} = \frac{W_n - F + 2P}{S} + 1}\ ;\ \boxed{H_{n+1} = \frac{H_n - F + 2P}{S} + 1},\ \boxed{D_{n+1} = K}, \quad \text{Centroid: } \boxed{z = \frac{\sum_{i=1}^{N} x_i \cdot A_i}{\sum_{i=1}^{N} A_i}}$$

Basic requirements:

	Boundary	Monotonicity	Commutativity	Associativity:
Fuzzy Intersection: ($T-norm$)	$T(0,0) = 0$ $T(a,1) = T(1,a) = a$	$T(a,b) \le T(c,d)$ $if\ a \le c \,\&\, b \le d$	$T(a,b) = T(b,a)$	$T(a,T(b,c)) = T(T(a,b),c)$
Fuzzy Union: ($S-norm$) or ($S-Conorm$)	$S(1,1) = 1$ $S(a,0) = S(0,a) = a$	$S(a,b) \le S(c,d)$ $if\ a \le c \,\&\, b \le d$	$S(a,b) = S(b,a)$	$S(a,S(b,c)) = S(S(a,b),c)$

Concentration: $\boxed{CON(A) = A^2}$ (very)

Dilation: $\boxed{DIL(A) = A^{0.5}}$ (more or less ≈ Approximately)

Criterion for Comparison (Objective Function == Error) ------→

$$\begin{cases} IAE = \int_0^\infty |e(t)|\,dt \\ ITAE = \int_0^\infty t|e(t)|\,dt \\ ISE = \int_0^\infty e(t)^2\,dt \\ ITSE = \int_0^\infty te(t)^2\,dt \end{cases}$$

$$\text{Genetic: } \boxed{Step = \frac{range}{d_{max}}}, \quad \boxed{d = \frac{r - r_{min}}{range} d_{max}}$$

Particle Swarm Optimization:

$$\boxed{\mathbf{v}_i^{t+1} = \underbrace{\mathbf{v}_i^t}_{\text{Diversification}} + \underbrace{c_1 \mathbf{U}_1^t(\mathbf{pb}_i^t - \mathbf{p}_i^t) + c_2 \mathbf{U}_2^t(\mathbf{gb}^t - \mathbf{p}_i^t)}_{\text{Intensification}}} \quad \boxed{\mathbf{p}_i^{t+1} = \mathbf{p}_i^t + \mathbf{v}_i^{t+1}}$$