

Neural Networks Assignment 4

44251017 *HuangJiahui*

Q1. Summarize the key idea of the BP algorithm briefly.

Ans: The Backpropagation (BP) algorithm is a supervised learning method used to train neural networks. It computes the gradient of the loss function with respect to all the weights in the network using the chain rule of calculus. The training process includes two phases: forward pass (computing outputs) and backward pass (computing gradients and updating weights). BP helps minimize the error between predicted and target outputs through iterative gradient descent.

Q2.

① (1) Derive the backpropagation (BP) training algorithm and describe your derivation process.

Ans:

Given:

- $x(t)$: input
- $d(t)$: target output
- $W_1 \in \mathbb{R}^{M \times 1}, b_1 \in \mathbb{R}^M$
- $W_2 \in \mathbb{R}^{1 \times M}, b_2 \in \mathbb{R}$
- Hidden output: $Z = f_1(W_1 x(t) + b_1)$
- Network output: $y(t) = f_2(W_2 Z + b_2)$
- Loss: $E = \frac{1}{2}(d(t) - y(t))^2$

Backward propagation:

Output error:

$$\delta_2 = (y(t) - d(t)) \cdot f_2'(W_2 Z + b_2)$$

Hidden error:

$$\delta_1 = f_1'(W_1 x + b_1) \odot (W_2^\top \delta_2)$$

Gradients:

$$\Delta W_2 = -\mu \delta_2 Z^\top, \Delta b_2 = -\mu \delta_2$$

$$\Delta W_1 = -\mu \delta_1 x(t), \Delta b_1 = -\mu \delta_1$$

① (2) How many δ 's are there in this MLP?

Ans:

There are:

M δ values in the hidden layer (δ_1)

1 δ value in the output layer (δ_2)

Thus:

Total: $(M + 1) \delta$

② Refer to and fill out the following table.

t	W_1/b_1	W_2/b_2	Z	$y(1)$	δ_1	δ_2	$\Delta W_1/\Delta b_1$	$\Delta W_2/\Delta b_2$
0	[[0.3 -0.3]]/[0.0 0.0]	[[-0.1] [0.1]]/[0.0]	[0.21 0]	[-0.021]	[-0.07 0.0]	[0.701]	[[-0.01 0.0]]/[-0.014 0.0]	[[0.029] [0.0]]/[0.14]
1	[[0.29 -0.3]]/[-0.014 0.0]	[[-0.071] [0.1]]/[0.14]	[0.189 0.000]	[0.12686]	[0.04 -0.00]	[-0.553]	[0.005464015277130524 -0.0] /[0.007805736110186464 -0.0]	[-0.020921005654136793 -0.0]/[-0.11063]
2	[0.28472198472286947 -0.3] /[-0.021825736110186466 0.0]	[-0.04963699434586322 0.1]/0.251	[0.177 0.000]	[0.24202]	[0.02 -0.00]	[-0.438]	[0.0030436078268129027 -0.0]/[0.00434801118116129 -0.0]	[-0.015546539968699284 -0.0]/[-0.0876]
3	[0.28167837689605657 -0.3] /[-0.026173747291347756 0.0]	[-0.03409045437716393 0.1]/0.338	[0.171 0.000]	[0.33260]	[0.01 -0.00]	[-0.347]	[0.0016580456582325352 -0.0]/ [0.0023686366546179075 -0.0]	[-0.011881317512705972 -0.0]/[-0.06948]