

# 第二次期末大作业

本次作业是期末第二次大作业，该作业包含两道大题，请大家运用所学的知识独立完成。提交作业的时候需要提交一份报告（PDF 格式）和代码，禁止抄袭。

## 题目

Several exercises will make use of the following three-dimensional data sampled from three categories, denoted  $\omega_i$ .

sample	$\omega_1$			$\omega_2$			$\omega_3$		
	$x_1$	$x_2$	$x_3$	$x_1$	$x_2$	$x_3$	$x_1$	$x_2$	$x_3$
1	0.28	1.31	-6.2	0.011	1.03	-0.21	1.36	2.17	0.14
2	0.07	0.58	-0.78	1.27	1.28	0.08	1.41	1.45	-0.38
3	1.54	2.01	-1.63	0.13	3.12	0.16	1.22	0.99	0.69
4	-0.44	1.18	-4.32	-0.21	1.23	-0.11	2.46	2.19	1.31
5	-0.81	0.21	5.73	-2.18	1.39	-0.19	0.68	0.79	0.87
6	1.52	3.16	2.77	0.34	1.96	-0.16	2.51	3.22	1.35
7	2.20	2.42	-0.19	-1.38	0.94	0.45	0.60	2.44	0.92
8	0.91	1.94	6.21	-0.12	0.82	0.17	0.64	0.13	0.97
9	0.65	1.93	4.38	-1.44	2.31	0.14	0.85	0.58	0.99
10	-0.26	0.82	-0.96	0.26	1.94	0.08	0.66	0.51	0.88

1. Consider a 2-2-1 network with bias, where the activation function at the hidden units and the output unit is a sigmoid  $y_j = a \tanh(b \text{net}_j)$  for  $a = 1.716$  and  $b = 2/3$ .

(a) Suppose the matrices describing the input-to-hidden weights ( $w_{ji}$  for  $j = 1, 2$  and  $i = 0, 1, 2$ ) and the hidden-to-output weights ( $w_{kj}$  for  $k = 1$  and  $j = 0, 1, 2$ ) are, respectively,

$$\begin{pmatrix} 0.5 & -0.5 \\ 0.3 & -0.4 \\ -0.1 & 1.0 \end{pmatrix} \text{ and } \begin{pmatrix} 1.0 \\ -2.0 \\ 0.5 \end{pmatrix}.$$

The network is to be used to place patterns into one of two categories, based on the sign of the output unit signal. Shade a two-dimensional  $x_1 x_2$  input space ( $-5 \leq x_1, x_2 \leq +5$ ) black or white according to the category given by the network.

(b) Repeat part(a) with the following weight matrices:

$$\begin{pmatrix} -1.0 & 1.0 \\ -0.5 & 1.5 \\ 1.5 & -0.5 \end{pmatrix} \quad \text{and} \quad \begin{pmatrix} 0.5 \\ -1.0 \\ 1.0 \end{pmatrix}.$$

2. Create a 3-1-1 sigmoidal network with bias to be trained to classify patterns from  $\omega_1$  and  $\omega_2$  in the table above. Use stochastic backpropagation to (Algorithm 1) with learning rate  $\eta = 0.1$  and sigmoid as described in Eq. 1.

(a) Initialize all weights randomly in the range  $-1 \leq w \leq +1$ . Plot a learning curve — the training error as a function of epoch.

(b) Now repeat (a) but with weights initialized to be the *same* throughout each level. In particular, let all input-to-hidden weights be initialized with  $w_{ji} = 0.5$  and all hidden-to-output weights with  $w_{kj} = -0.5$ .

(c) Explain the source of the differences between your learning curves.

$$f(net) = a \cdot \tanh(b \cdot net) = a \cdot \left[ \frac{1 - e^{b \cdot net}}{1 + e^{b \cdot net}} \right] = \frac{2a}{1 + e^{-b \cdot net}} - a \quad \text{Eq. 1}$$

$a = 1.716$  and  $b = 2/3$

#### Algorithm 1 (Stochastic backpropagation)

1. **begin initialize** network topology(# hidden units),  $\mathbf{w}$ , criterion  $\theta$ ,  $\eta$ ,  $m \leftarrow 0$
2.     **do**  $m \leftarrow m + 1$
3.          $\mathbf{x}^m \leftarrow$  randomly chosen pattern
4.          $w_{ij} \leftarrow w_{ij} + \eta \delta_j x_i$ ;     $w_{jk} \leftarrow w_{jk} + \eta \delta_k y_j$
5.     **until**  $\nabla J(\mathbf{w}) < \theta$
6.     **return**  $\mathbf{w}$
7. **end**

## 作业要求

- 1) 编程语言不限。
- 2) 作业包含一份报告（PDF 格式）和代码，并打包到.zip，其中 zip 文件的命名格式为学号\_姓名。
- 3) 禁止使用深度学习与梯度下降相关的库。
- 4) 禁止抄袭。