# Artificial Neural Networks Homework #1 MLP with BP

## Breast Cancer classification

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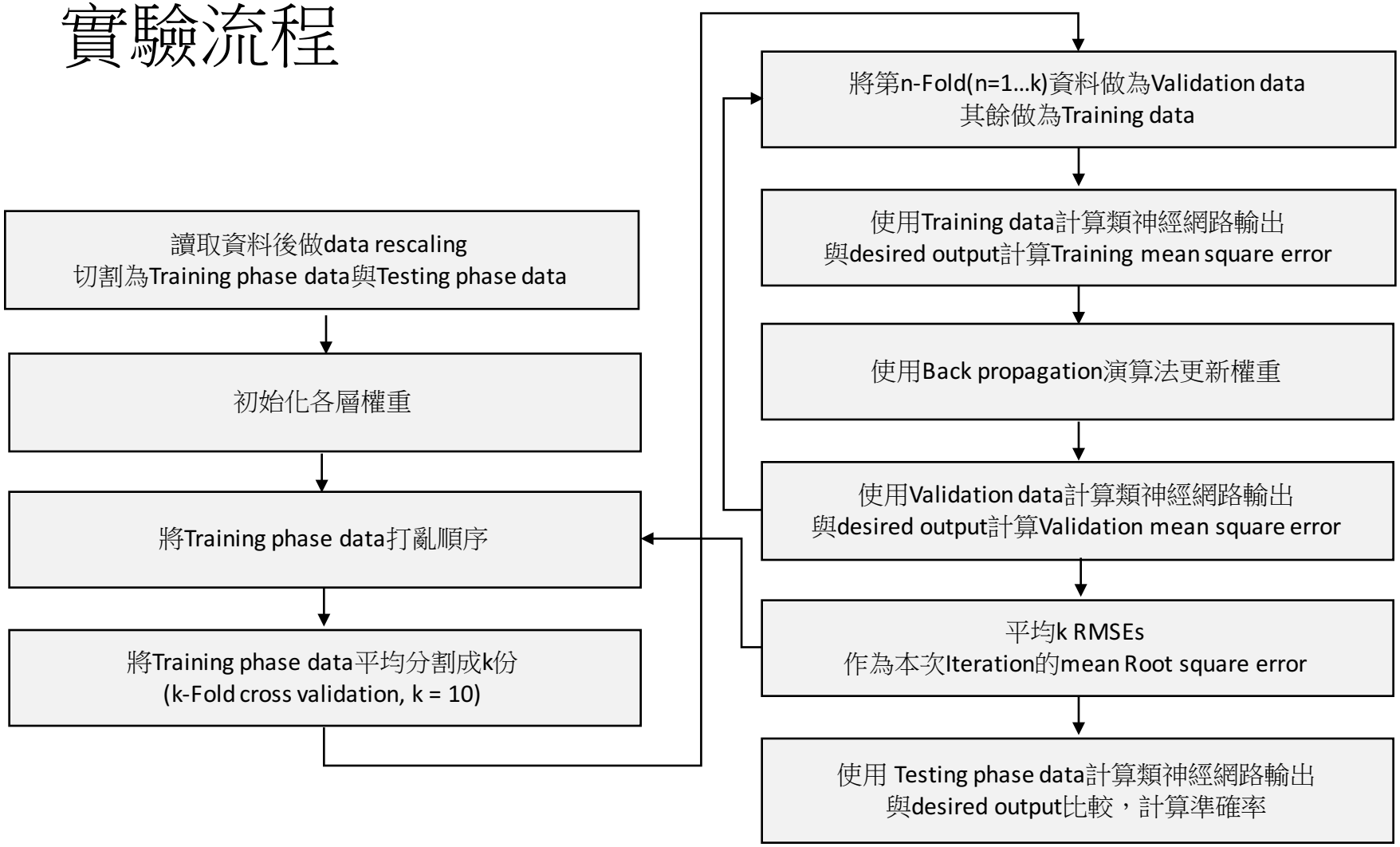
# 實驗目的

- 設計 Three-layer Neuron Network 搭配 Back-Propagation 演算法修正權重，對乳癌資料庫做學習，根據Clump Thickness, Uniformity of Cell Size, Uniformity of Cell Shape, Marginal Adhesion, Single Epithelial Cell Size, Bare Nuclei, Bland Chromatin, Normal Nucleoli 與 Mitoses 九個參數，判斷患者罹患良性或惡性腫瘤。

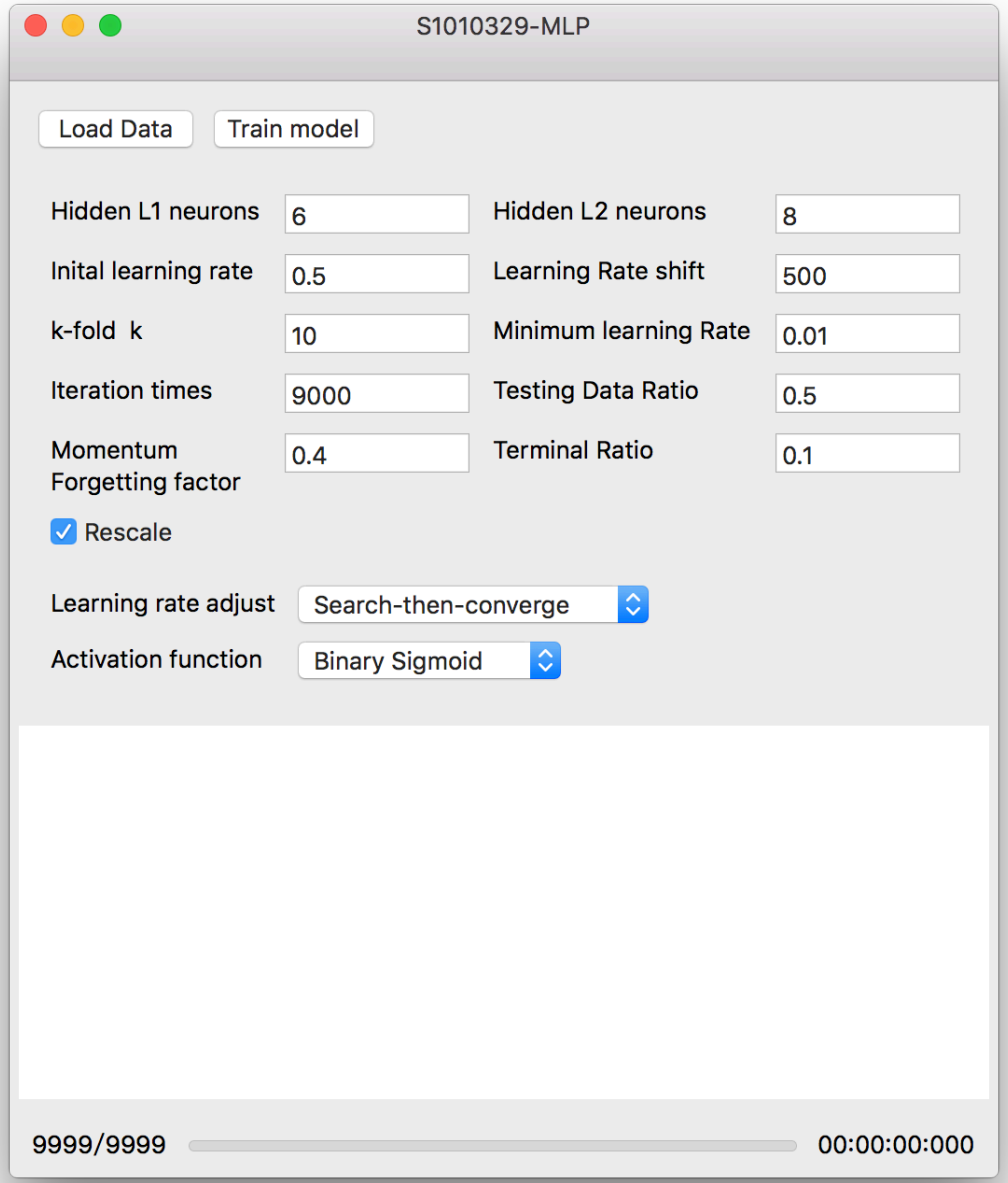
# 實驗方法

1. 讀入資料
2. 將九項輸入參數Rescale 到0.01~0.99之間，輸出參數為二維，各表示良性腫瘤與惡性腫瘤
3. 將所有資料分割成Training phase data與Testing phase data
4. 初始化權重(0.1~0.4 uniform)
5. 將Training phase data平均分割成k份 (k-Fold cross validation, k = 10)
6. 更新權重
7. 計算Training Square Error
8. 根據Error使用Back-Propagation演算法更新權重
9. 計算Validation Square Error
10. 計算RMSE
11. 使用Testing phase data計算神經網路準確率

# 實驗流程


讀取資料後做data rescaling
切割為Training phase data與Testing phase data
初始化各層權重
將Training phase data打亂順序
將Training phase data平均分割成k份
(k-Fold cross validation, k = 10)
將第n-Fold(n=1…k)資料做為Validation data
其餘做為Training data
使用Training data計算類神經網路輸出
與desired output計算Training mean square error
使用Back propagation演算法更新權重
使用Validation data計算類神經網路輸出
與desired output計算Validation mean square error
平均k RMSEs
作為本次Iteration的mean Root square error
使用 Testing phase data計算類神經網路輸出
與desired output比較，計算準確率

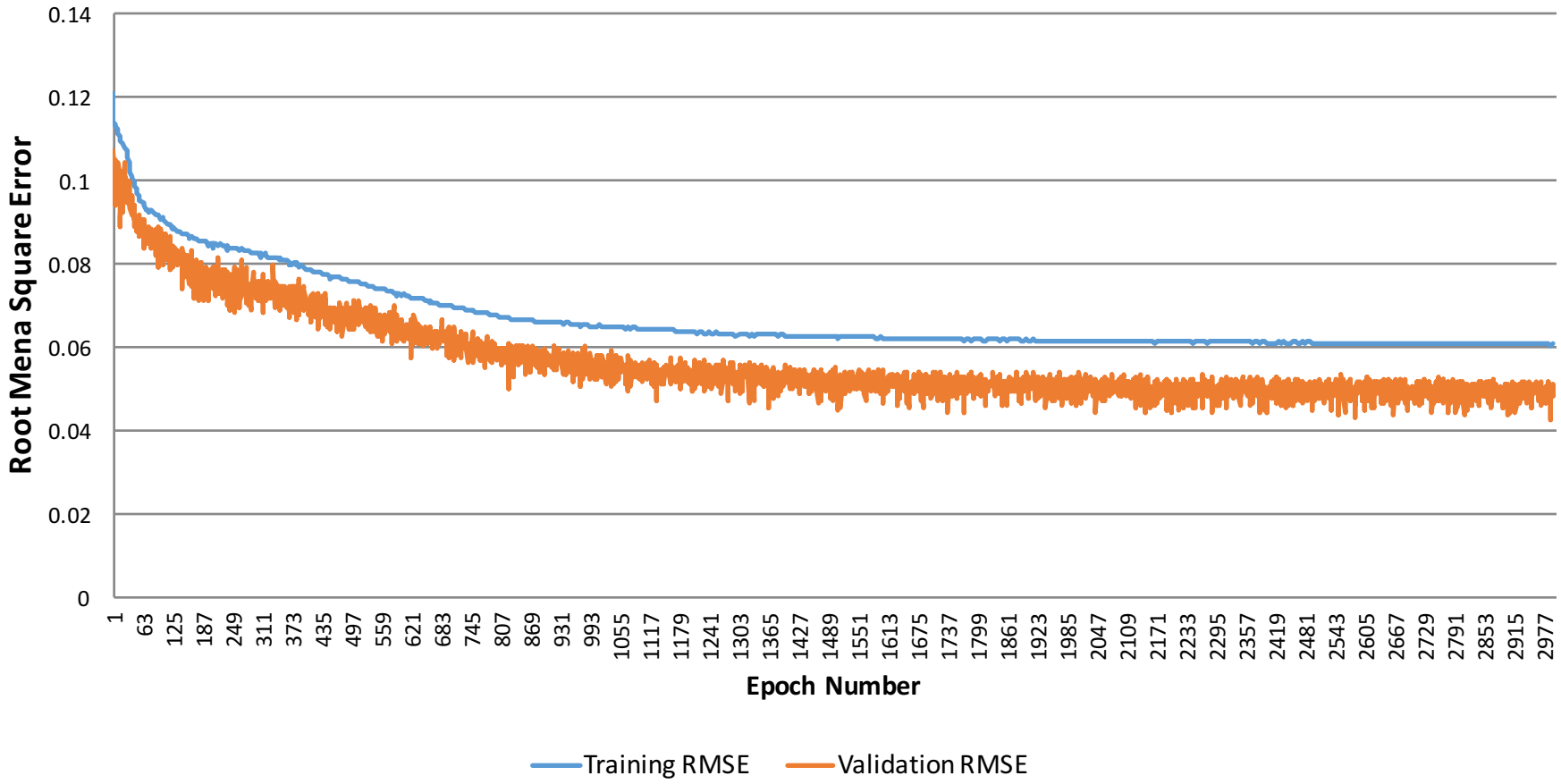
# 程式操作介面


S1010329-MLP
Load Data
Train model
Hidden L1 neurons
6
Hidden L2 neurons
8
Inital learning rate
0.5
Learning Rate shift
500
k-fold k
10
Minimum learning Rate
0.01
Iteration times
9000
Testing Data Ratio
0.5
Momentum
Forgetting factor
0.4
Terminal Ratio
0.1
Rescale
Learning rate adjust
Search-then-converge
Activation function
Binary Sigmoid
9999/9999
00:00:00:000

# 實驗參數

- Neuron Network
  - Three-Layer :
    - Number of neurons：
      - Hidden layer 1 :6
      - Hidden layer 2 :8
      - Output layer :2
- Activation Function
  - Binary Sigmoid, slope = 0.5
- Learning rate adjusting
  - Search then converge , slope = 0.5
- cross validation
  - K-fold, k = 10
- Momentum
  - Forgetting factor = 0.4

# 實驗結果


0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Root Mena Square Error
1
63
125
187
249
311
373
435
497
559
621
683
745
807
869
931
993
1055
1117
1179
1241
1303
1365
1427
1489
1551
1613
1675
1737
1799
1861
1923
1985
2047
2109
2171
2233
2295
2357
2419
2481
2543
2605
2667
2729
2791
2853
2915
2977
Epoch Number
Training RMSE
Validation RMSE

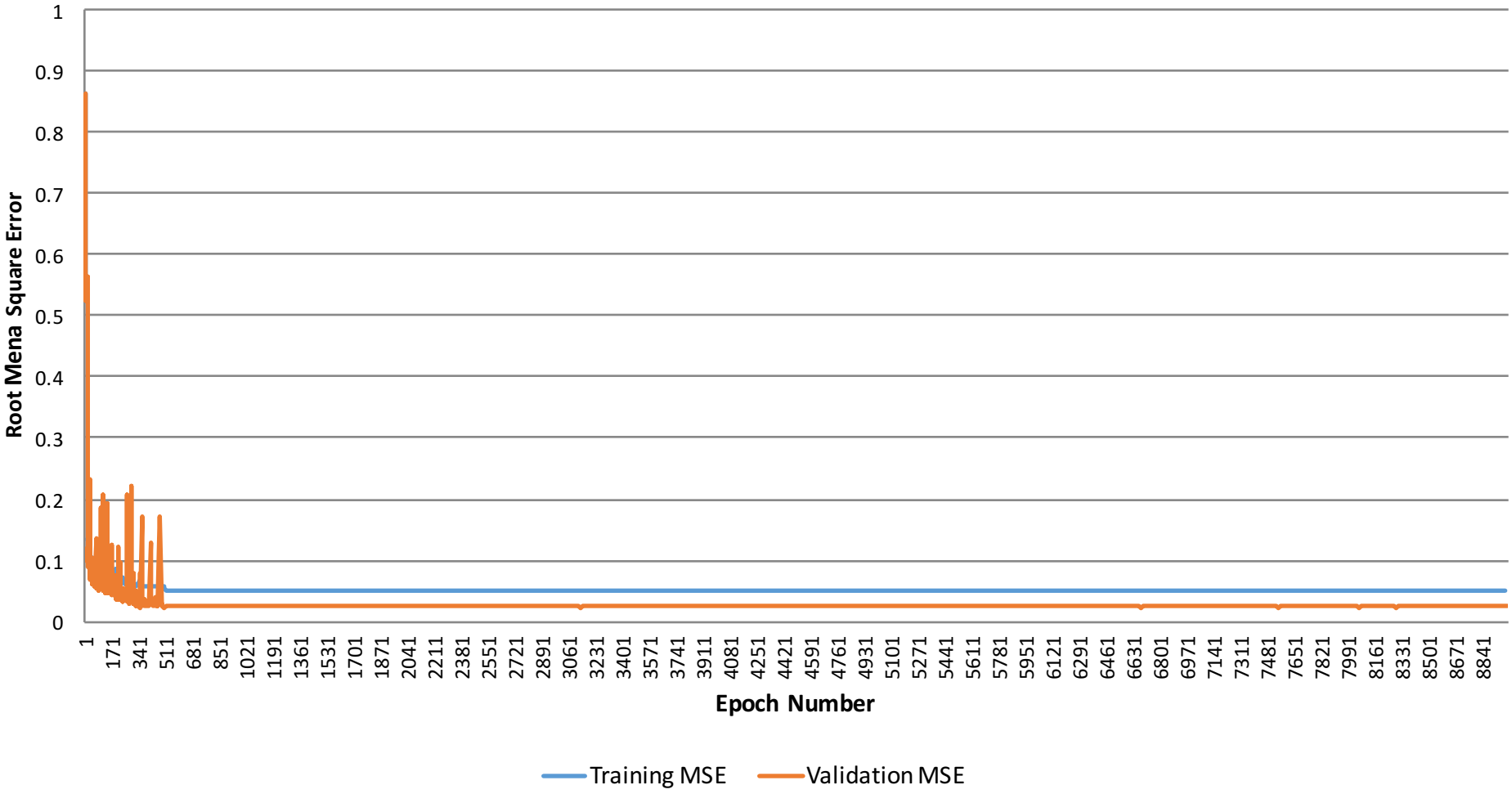
# 實驗結果 (準確率:97.654%)

| Epoch | Training MSE | Validation MSE |
|---|---|---|
| 1 | 0.120542 | 0.101057 |
| 300 | 0.082235 | 0.075398 |
| 600 | 0.072357 | 0.065119 |
| 900 | 0.066045 | 0.059805 |
| 1200 | 0.063655 | 0.052102 |
| 1500 | 0.062317 | 0.046954 |
| 1800 | 0.061705 | 0.049519 |
| 2100 | 0.061318 | 0.050235 |
| 2400 | 0.060878 | 0.047251 |
| 2700 | 0.060878 | 0.048456 |
| 3000 | 0.060719 | 0.048781 |

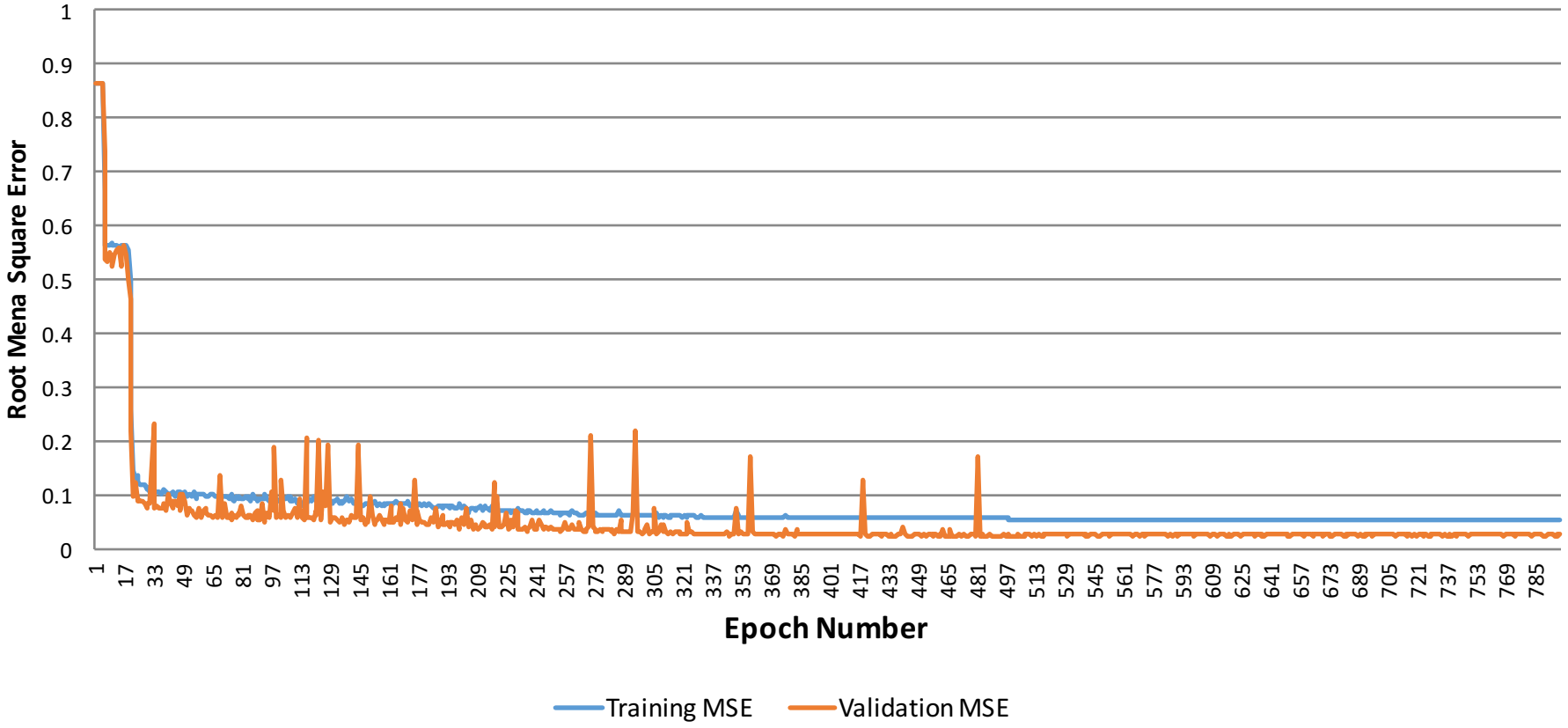
# 實驗參數

- Three-Layer：
  - Number of neurons：
    - Hidden layer 1 :99
    - Hidden layer 2 :99
    - Output layer :2
- Activation Function
  - Binary Sigmoid, slope = 0.5
- Learning rate adjusting
  - Binary Sigmoid, slope = 0.5, shift = 500
- cross validation
  - K-fold, k = 10
- Momentum
  - Forgetting factor = 0.4

# 實驗結果 (Epoch 1~9000)



# 實驗結果 (Epoch 1~800)



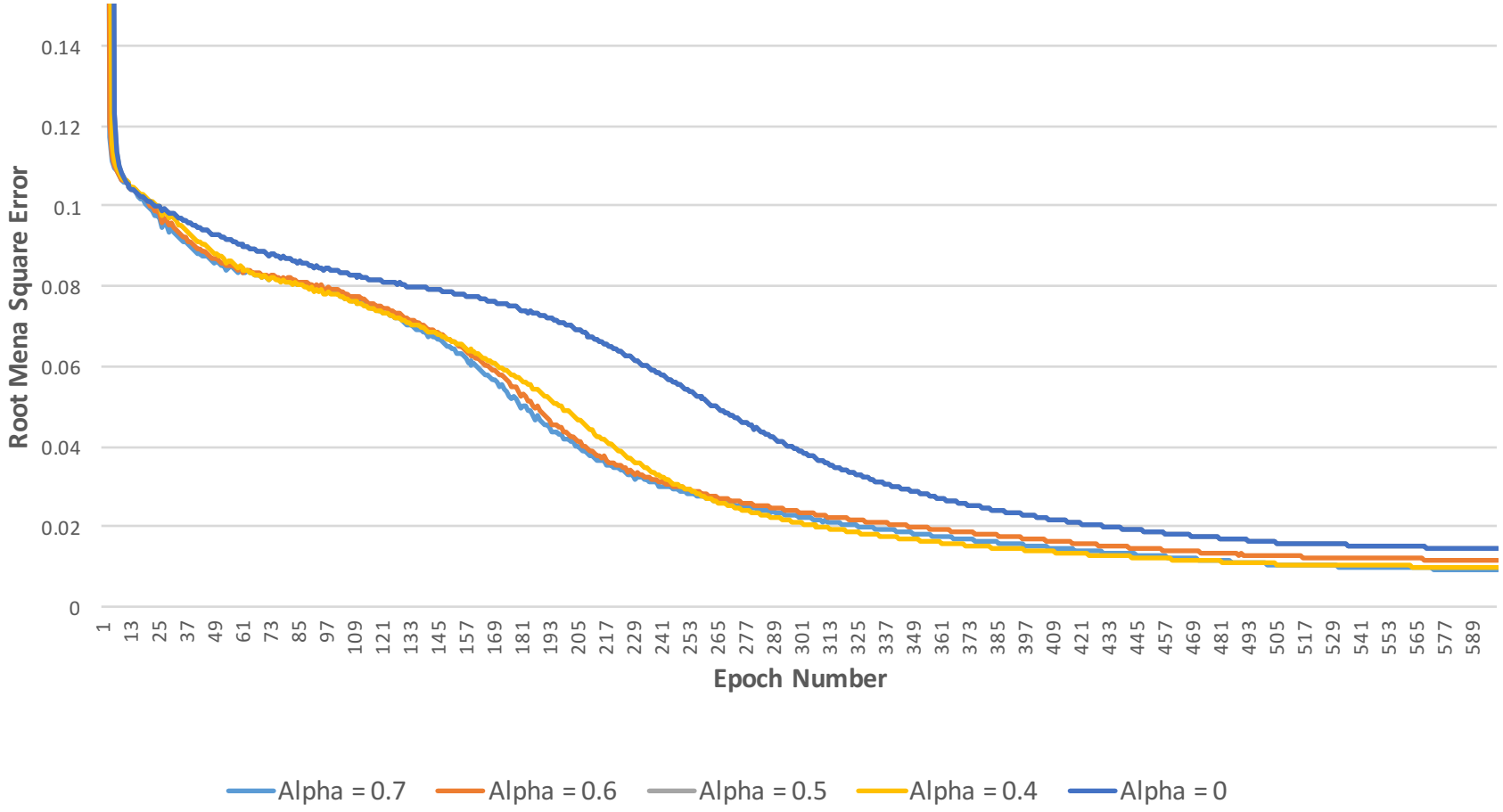
# 實驗結果 (準確率:96.187%)

| Epoch | Training MSE | Validation MSE |
|---|---|---|
| 1 | 0.863128 | 0.863128 |
| 1000 | 0.051896 | 0.026077 |
| 2000 | 0.051872 | 0.024871 |
| 3000 | 0.051834 | 0.025112 |
| 4000 | 0.051733 | 0.023816 |
| 5000 | 0.051728 | 0.024109 |
| 6000 | 0.051726 | 0.024511 |
| 7000 | 0.051680 | 0.025230 |
| 8000 | 0.051649 | 0.024131 |
| 9000 | 0.051616 | 0.023899 |

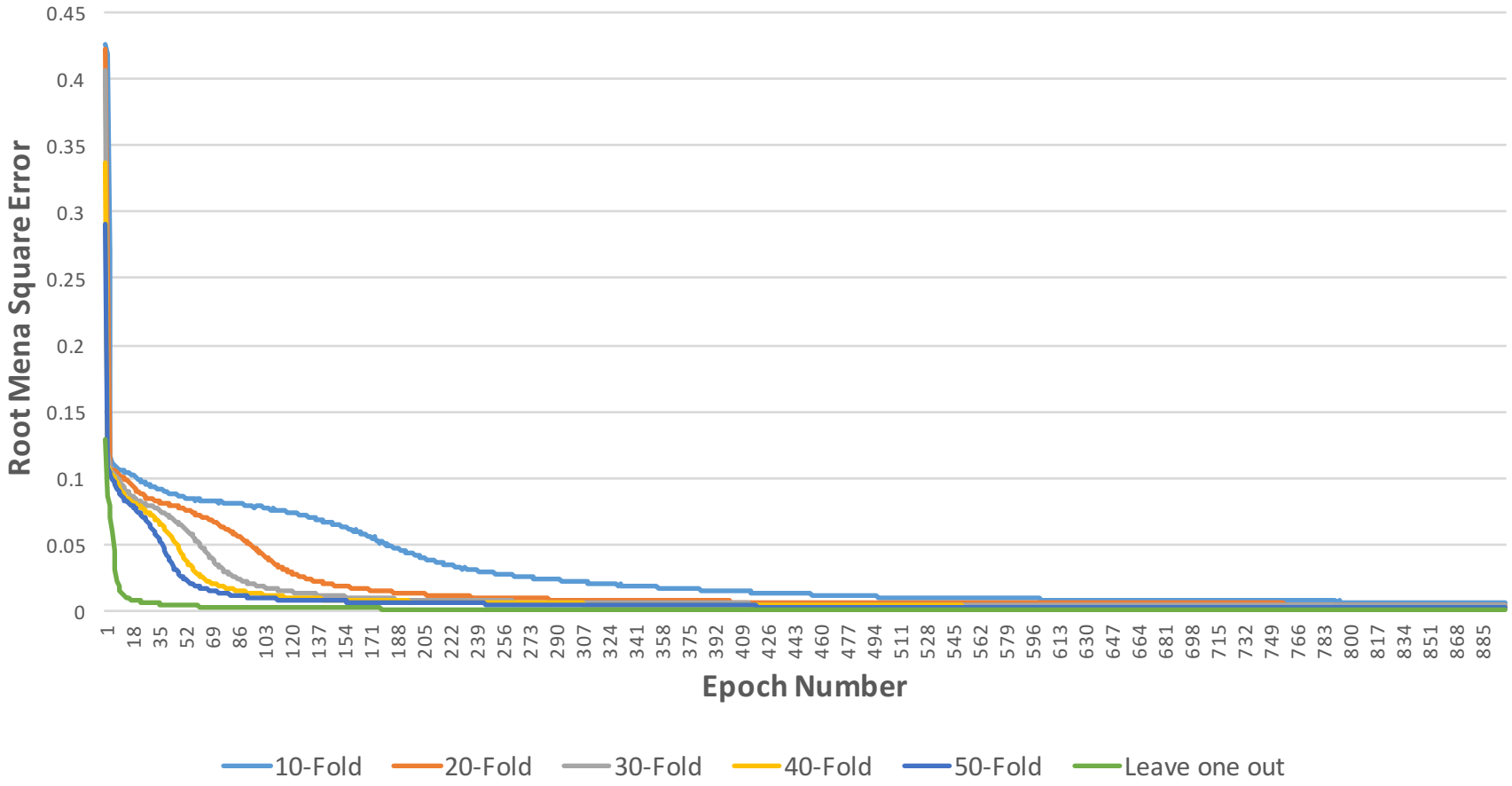
# 類神經網路參數比較

- 以下所有比較皆基於此參數設定做更動:
- Hidden Layer 1 Neurons: 6
- Hidden Layer 2 Neurons: 8
- Iteration times: 9000
- Cross validation: 10-Fold
- Learning rate adjust: Search then converge
- Activation function: Binary Sigmoid

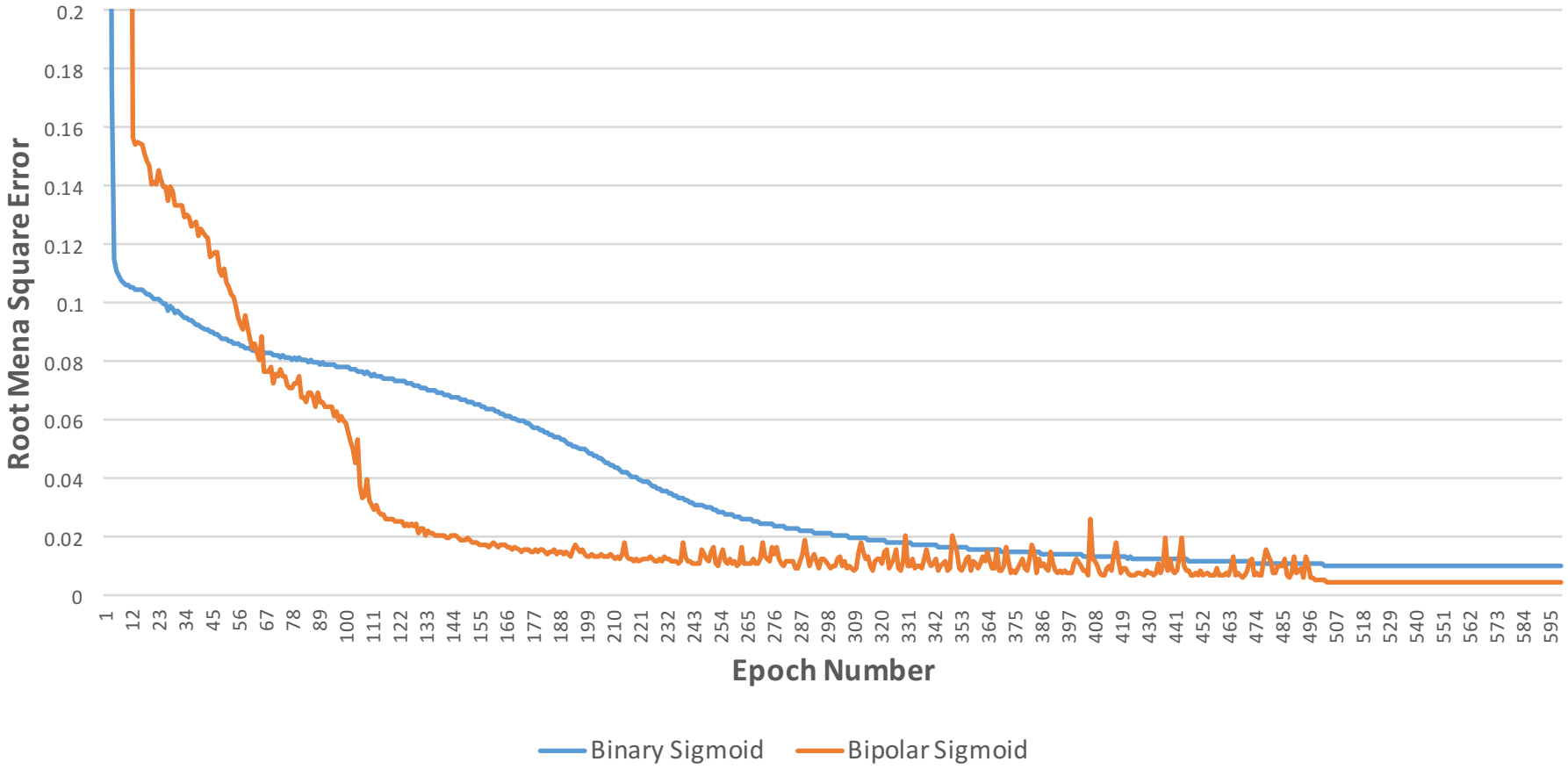
# Compare Momentum Forgetting factor



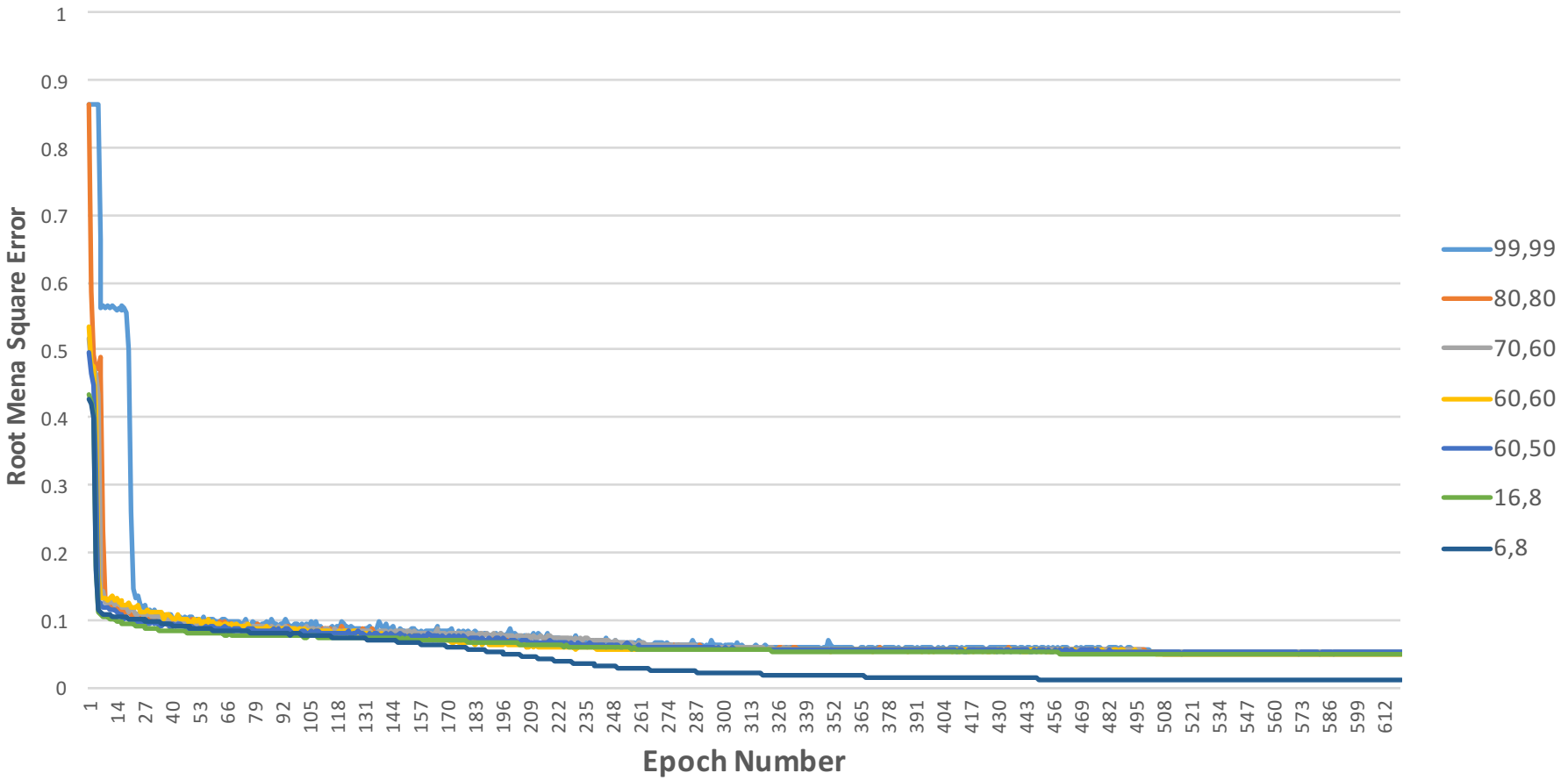
# Compare k-fold cross validation



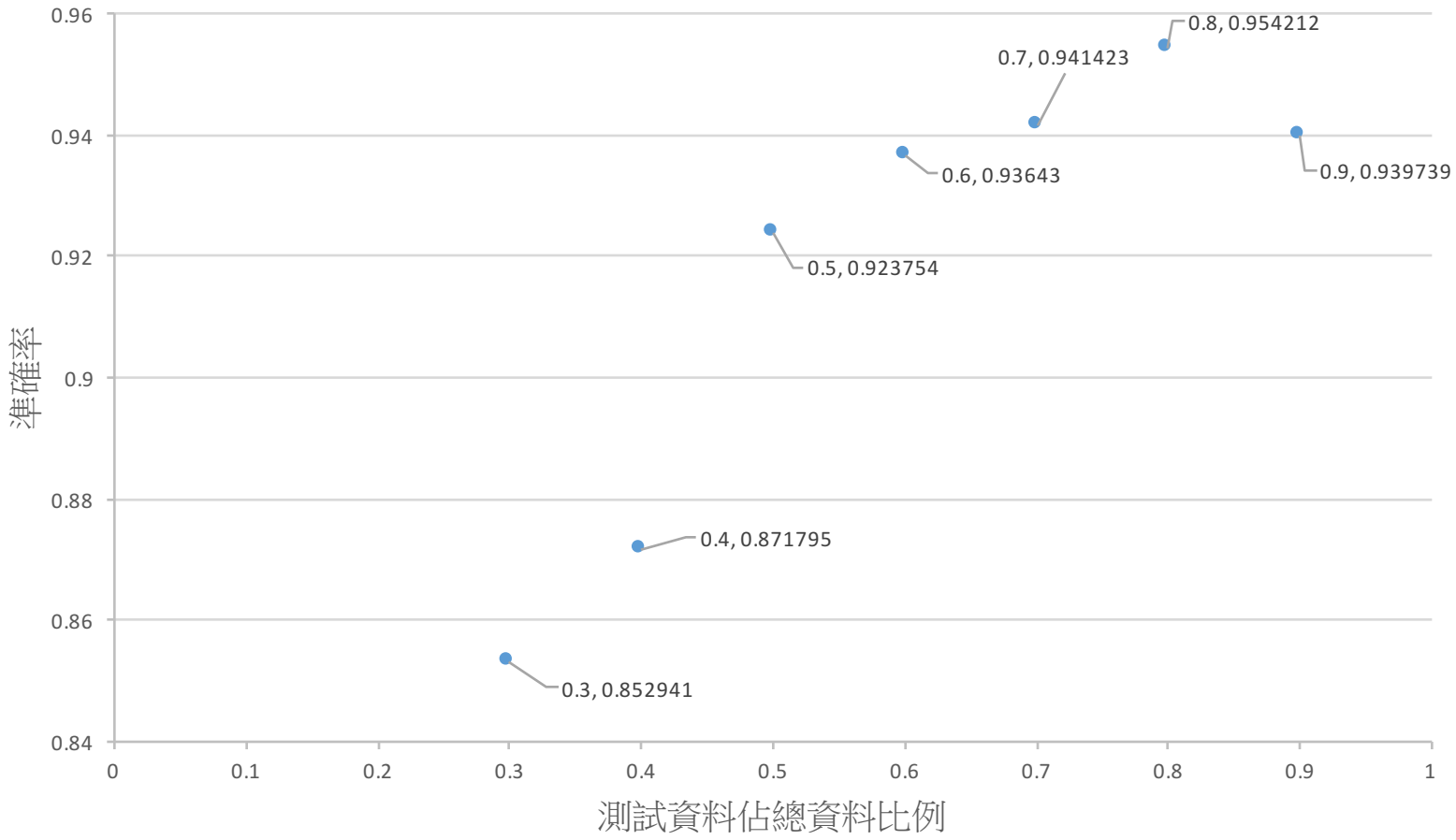
# Compare Activation function



# 比較神經元數目 (epoch = 9000)



# 測試資料數量與準確率之關係



# 程式碼