**EE7207 Neural & Fuzzy Systems**

Student Name: Wei Zhifeng

Student ID: G2002825F

# RBF network

1. Train an RBF neural network classifier, assuming Gaussian basis function is used. The structure of a RBF is shown below:

图示




**Figure 1.1** RBF Structure

We have 330 data as training sample, each data has 33 dimensions. These data are divided into 2 group, each group are labeled as 1 or -1.

表格

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**Figure 1.2** Data Structure

We use PCA algorithm to perform dimension reduction and visualize the data. As is shown in Figure 1.3

图表, 散点图

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**Figure 1.3** Data Distribution

The left figure is the data distribution of training data, and the right figure is training data combined with test data. The black \* is test data. From figure 1.3 we could observe roughly the distribution of data

In this assignment, we first use SOM algorithm to choose the center neurons, the structure of SOM is shown below.

图示

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**Figure 1.4** SOM Structure

The parameter setting in SOM network:

Self-organizing phase:

Iter means the iteration number, it is less than 1000.

Convergence phase:

图表, 散点图

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**Figure 1.4** SOM Center Distribution

As figure 1.4 shown, the green \* is the SOM center we calculated (we choose 16 neurons). From the figure, we could observe that the som center can roughly represent the distribution of the training data.

Then, we used 1,4,16,49,100,225 neurons chosen by SOM respectively as the hidden neurons of RBF network, and use **10-fold** cross validation to evaluate the performance the RBF network, the result is shown as the table below:

**Table 1.1 validation Result**

|  |  |  |
| --- | --- | --- |
| Neurons | Average accuracy | Best accuracy |
| 1 | 0.64848 | 0.81818 |
| 4 | 0.85455 | 0.9697 |
| 16 | 0.88182 | 0.9697 |
| 49 | 0.87273 | 1 |
| 100 | 0.85455 | 0.90909 |
| 225 | 0.74242 | 0.87879 |

From table 1.1, we can find out that the network with 16 hidden neurons has the best average accuracy. Therefore, we use this model to perform prediction.

The MATLAB code is shown in appendix.

# Kernel SVM

1. Train a kernel SVM classifier, assuming Gaussian kernel function is used.

We use the training data to train a kernel SVM, use Gaussian kernel function to map the data to high dimension and then perform classification. We also use 10-fold cross validation to evaluate the performance of SVM classifier. The evaluation result in training data is shown below:

**Table 2.1 SVM validation Result**

|  |  |
| --- | --- |
| Average Accuracy | Best Accuracy |
| 0.94545 | 1 |

From the table, we can find out that the performance of SVM is slightly better than RBF in these training data.

The MATLAB code is shown in appendix.

# Comparison

1. Compare and discuss the performance of the two classifiers on the training data.

In our experiment，we use **10-fold cross validation** to evaluate the accuracy of our model. We divided the training data into 10 groups, each time we use 1 group as validation data and train the model using the other 9 groups.

From our experiment, we can see that the average accuracy of RBF is nearly **0.88** (using 16 hidden neurons) while the SVM is **0.94**. Therefore, the SVM’s performance might better than RBF in this dataset. However, the best accuracy of these two model during 10-fold validation is both 1, which means that these 2 models both have excellent performance in classify these data.

In practice, accuracy is sometimes not the best criteria of the performance of the model, so we introduced f1 score as the evaluation criteria to evaluate the model.

**Table 3.1 model comparison**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Model | Acc | precise | Recall | F1-score |
| RBF | 0.969697 | 0.972028 | 0.969697 | 0.969933 |
| SVM | 0.969697 | 0.971014 | 0.969697 | 0.969312 |

We choose 1 fold which RBF and SVM have the same accuracy, and calculate their f1 score. From the table, we could find out that RBF might slightly better than SVM.

In conclusion, both classifiers have good performance in classification task, SVM perform better than RBF, but when the data are near the decision boundary, svm is slightly prone to misclassification.

# Prediction

1. Predict class labels for testing data using the two classifiers

We use 4 models to predict the test data:

RBF\_all is the model trained by all training data, with 16 hidden neurons.

RBF\_best is the model using the best weight matrix that obtain during the 10-fold validation. We keep the weight that has the highest validation accuracy and use it to predict the result. The model also has 16 hidden neurons.

SVM\_all is the SVM model that trained by all training data.

SVM\_best is the SVM using the best parameter that obtain during the 10-fold validation. We keep the parameter that has the highest validation accuracy and use it to predict the result.

**Table 4.1 Predict Result**

|  |  |
| --- | --- |
| Model | Predict Result |
| RBF\_best | 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, 1, -1, 1, -1, 1 |
| RBF\_all | 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, 1, 1, 1, 1, 1, 1, -1, 1, -1, 1 |
| SVM\_best | 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, -1,1, -1, 1 |
| SVM\_all | 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, -1,1, -1, 1 |

In general, these models have similar prediction result. And there are 3 different prediction result in the test data, these 3 data might be in the decision boundary:

12: [1,1,-0.5421,1,-1,1,-1,1,0.36217,1,-0.41119, 1,1,1,-1,1,-0.29354,1,-0.93599,1,1,1,1,1,-0.40888,1,-0.62745,1,-1,1,-1,1,-1]

14: [1,1,-0.867,1,0.2228,0.85492,-0.39896,1,-0.1209,1,0.35147,1,0.07772,1,-0.14767,1,-1,1,-1,0.61831,0.158030,1,0.62349,1 -0.17012,1,0.35924,1,-0.66494,1,0.88428,1,-0.18826]

16: [1,1,-0.867,1,0.2228,0.85492,-0.39896,1,-0.1209,1,0.35147,1,0.07772,1,-0.14767,1,-1,1,-1,0.61831,0.158030,1,0.62349,1 -0.17012,1,0.35924,1,-0.66494,1,0.88428,1,-0.18826]

**Appendix**

**SOM:**

**图形用户界面, 文本, 应用程序

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**RBF:**

**图形用户界面, 应用程序

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**应用程序, 表格

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**SVM:**

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