CSI 5387 Data Mining and Concept Learning Assignment 2

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In this assignment, I used Python to handle it.

GitHub Source Code: https://github.com/RichardChangCA/CSI-5387-Data-Mining-and-Concept-Learning/tree/master/Assignment_2

1 A. Data Preprocessing

1.1 1.

About the missing value, I used sklearn.inpute.SimpleImputer to impute the missing value. For the strategy attribute, I chose the most frequent value, which means the mode value for each attributes, to impute.

Central measure of tendency used in handling missing data: mode value

1.2 2.

Neural network can perform well when the input data are scaled in the same range because some attribute values will be dominant without scaling.

In this assignment, I used sklearn.preprocessing.MinMaxScalar to scale the input data.

Method of re-scaling the data with a normalizing: min-max normalization

2 B. Model Development

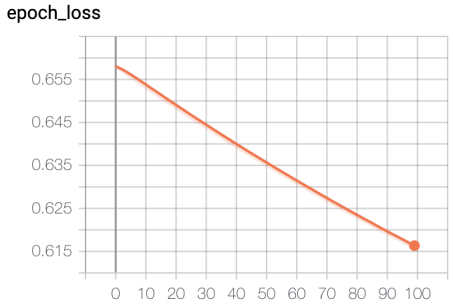
2.1 Single Layer

2.1.1 1.

In this section, I used TensorFlow version 2.0 deep learning framework combined with Keras to build up neural network models. Dense layers in Keras represent fully-connected layers.

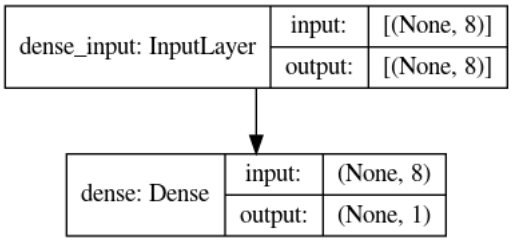
In the single node model, there are 1 unit in the dense layer,which output dimension is 1 value and input dimension is 8, because it is a binary classification task and meaningful attributes have 8 columns.

There are several hyper-parameters I set:
bias usage: True
activation function: Sigmoid
Optimizer: SGD(Stochastic gradient descent)
learning rate: 0.01
Loss function: binary cross-entropy
Training epoch: 100
The loss plot is shown below, and decreasing loss value means the model is learning.



2.1.2 2.

The neural network plot is shown below.



There are 9 parameters in total, where 8 parameters are weights and 1 parameter is the bias.

2.1.3 3. Model Performance

accuracy: 0.59375
some predictions:
1. X=[[0.11764706 0.39354839 0.6557377 0.41304348 0.22576832 0.31697342 0.27028181 0.13333333]], prediction=[[0]], actual=1
2. X=[[0.29411765 0.41935484 0.50819672 0.36956522 0.15248227 0.3599182 0.18616567 0.06666667]], prediction=[[0]], actual=1
3. X=[[0.23529412 0.70967742 0.59016393 0.23913043 0.14893617 0.26789366 0.11101623 0.26666667]], prediction=[[0]], actual=0
4. X=[[0.35294118 0.39354839 0.57377049 0.27173913 0.08037825 0.25766871 0.01878736 0.26666667]], prediction=[[0]], actual=0

5. X=[[0.70588235 0.36129032 0.68852459 0.2826087 0.12411348 0.24130879 0.17506405 0.41666667]], prediction=[[0]], actual=0

2.1.4 4. Confusion Matrix

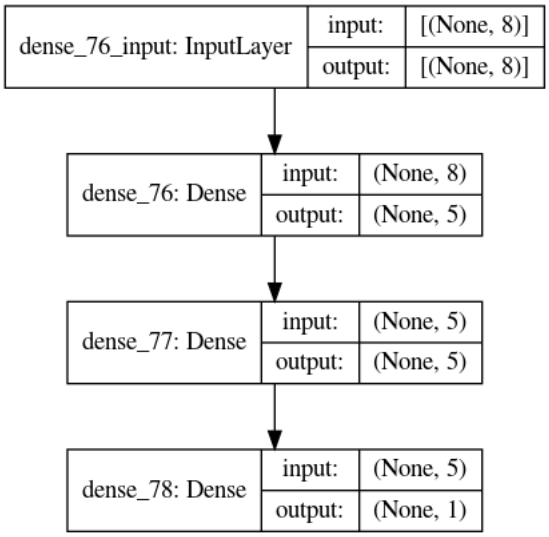
		Prediction outcome p	Prediction outcome n	total
Actual value	p′	0	78	78
	n′	0	114	114
	total	0	192	

sensitivity:0.0
specificity:1.0

2.2 Multi-Layer

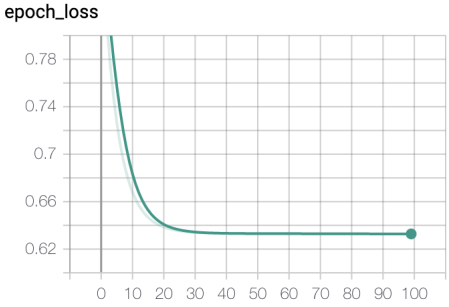
2.2.1 1.

The image below is the structure of multi-layer perceptron, which has 5 hidden nodes and 2 hidden layers. In this case, I maintained the same hyper-parameter as the single node perceptron.



The accuracy is also 0.59375 because the model predicts all tuples are negative. Both single node perceptron and multi-layer perceptron fail to perform well without fine-tuning.

The loss plot is shown below.



2.2.2 2.

Activation function, learning rate, training epochs and bias existence are hyper-parameter we can fine-tune.

In this assignment, I chose several values for these hyper-parameters and get various results.

Activation function: sigmoid, relu, tanh

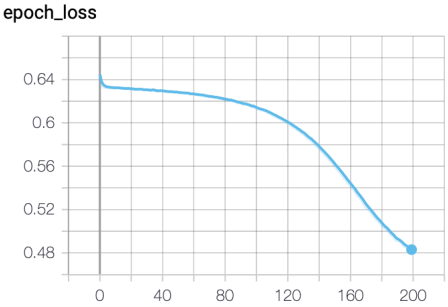
Learning rate: 0.1, 0.01, 0.001

Training epochs: 50, 100, 200

Bias existence: True, False

The results are shown in the appendix.

The loss plot of the multi-layer perceptron with the highest accuracy in shown in below.



The hyper-parameters of the highest accuracy multi-layer perceptron are:

Activation function: sigmoid

Learning rate: 0.1

Training epochs: 200

Bias existence: True

2.3 C. Model Comparison

SVM results are shown below:
accuracy:0.7552083333333334
TP:35
TN:110
FP:4
FN:43
sensitivity:0.44871794871794873
specificity:0.9649122807017544

2.4 D. Model Evaluation

2.4.1 1.

Multi-layer perceptron:
accuracy:0.59375
sensitivity:0.0
specificity:1.0

Multi-layer perceptron with fine-tuning:
accuracy:0.7552083333333334
sensitivity:0.47435897435897434
specificity:0.9473684210526315

SVM:
accuracy:0.7552083333333334
sensitivity:0.44871794871794873
specificity:0.9649122807017544

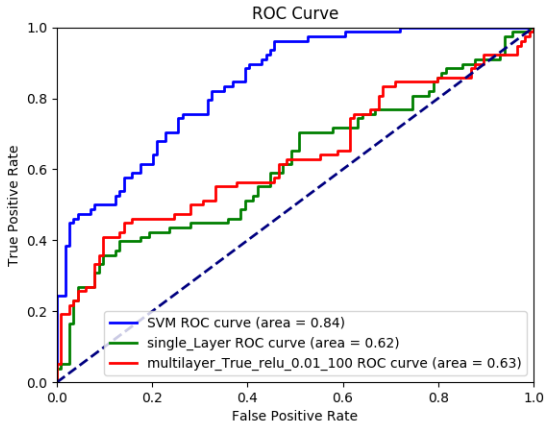
2.4.2 2.

1.In the case of multi-layer perceptron without fine-tuning:
SVM performs best and multi-layer perceptron performs worst in criteria of accuracy and sensitivity.
Multi-layer perceptron performs best and SVM performs worst in criteria of specificity.

2.In the case of multi-layer perceptron with fine-tuning:
SVM performs same as multi-layer perceptron in criteria of accuracy
SVM performs best and multi-layer perceptron performs worst in criteria of specificity.
Multi-layer perceptron performs best and SVM performs worst in criteria of sensitivity.
In conclusion, various hyper-parameter combinations in multi-layer perceptron performs different.

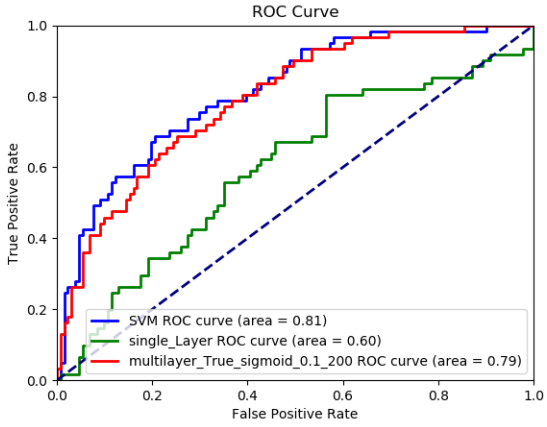
2.4.3 3.

ROC curve is shown in below.



SVM performs better than single node and multi-layer perceptron because AUC of SVM is greater than others.

ROC curve of fine-tuned multi-layer perceptron and SVM is shown in below and SVM is also the best model.



2.5 Appendix

2.6 bias: False, activation: tanh, lr: 0.001, epochs: 50

TP:2
TN:114
FP:0
FN:76
accuracy:0.6041666666666666

sensitivity:0.02564102564102564
specificity:1.0

2.7 bias: True, activation: sigmoid, lr: 0.0001, epochs: 50

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.8 bias: False, activation: relu, lr: 0.01, epochs: 50

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.9 bias: True, activation: relu, lr: 0.0001, epochs: 50

TP:2
TN:113
FP:1
FN:76
accuracy:0.5989583333333334
sensitivity:0.02564102564102564
specificity:0.9912280701754386

2.10 bias: False, activation: relu, lr: 0.0001, epochs: 100

TP:21
TN:105
FP:9
FN:57
accuracy:0.65625
sensitivity:0.2692307692307692
specificity:0.9210526315789473

2.11 bias: False, activation: tanh, lr: 0.0001, epochs: 100

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.12 bias: True, activation: tanh, lr: 0.01, epochs: 200

TP:40
TN:100
FP:14
FN:38
accuracy:0.7291666666666666
sensitivity:0.5128205128205128
specificity:0.8771929824561403

2.13 bias: True, activation: tanh, lr: 0.001, epochs: 50

TP:14
TN:111
FP:3
FN:64
accuracy:0.6510416666666666
sensitivity:0.1794871794871795
specificity:0.9736842105263158

2.14 bias: True, activation: relu, lr: 0.0001, epochs: 200

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.15 bias: True, activation: relu, lr: 0.001, epochs: 100

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375

sensitivity:0.0
specificity:1.0

2.16 bias: False, activation: relu, lr: 0.001, epochs: 200

TP:21
TN:111
FP:3
FN:57
accuracy:0.6875
sensitivity:0.2692307692307692
specificity:0.9736842105263158

2.17 bias: False, activation: sigmoid, lr: 0.0001, epochs: 200

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.18 bias: False, activation: tanh, lr: 0.01, epochs: 200

TP:42
TN:102
FP:12
FN:36
accuracy:0.75
sensitivity:0.5384615384615384
specificity:0.8947368421052632

2.19 bias: False, activation: sigmoid, lr: 0.001, epochs: 200

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.20 bias: False, activation: sigmoid, lr: 0.0001, epochs: 50

TP:78
TN:0
FP:114
FN:0
accuracy:0.40625
sensitivity:1.0
specificity:0.0

2.21 bias: True, activation: sigmoid, lr: 0.001, epochs: 100

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.22 bias: False, activation: tanh, lr: 0.01, epochs: 50

TP:38
TN:106
FP:8
FN:40
accuracy:0.75
sensitivity:0.48717948717948717
specificity:0.9298245614035088

2.23 bias: True, activation: sigmoid, lr: 0.001, epochs: 200

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.24 bias: False, activation: tanh, lr: 0.01, epochs: 100

TP:38
TN:104
FP:10
FN:40
accuracy:0.7395833333333334
sensitivity:0.48717948717948717
specificity:0.9122807017543859

2.25 bias: False, activation: tanh, lr: 0.001, epochs: 200

TP:33
TN:107
FP:7
FN:45
accuracy:0.7291666666666666
sensitivity:0.4230769230769231
specificity:0.9385964912280702

2.26 bias: False, activation: tanh, lr: 0.0001, epochs: 200

TP:1
TN:113
FP:1
FN:77
accuracy:0.59375
sensitivity:0.01282051282051282
specificity:0.9912280701754386

2.27 bias: True, activation: sigmoid, lr: 0.0001, epochs: 200

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.28 bias: True, activation: sigmoid, lr: 0.01, epochs: 50

TP:0
TN:114
FP:0

FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.29 bias: False, activation: relu, lr: 0.001, epochs: 50

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.30 bias: False, activation: relu, lr: 0.0001, epochs: 200

TP:5
TN:110
FP:4
FN:73
accuracy:0.5989583333333334
sensitivity:0.0641025641025641
specificity:0.9649122807017544

2.31 bias: True, activation: tanh, lr: 0.001, epochs: 200

TP:41
TN:103
FP:11
FN:37
accuracy:0.75
sensitivity:0.5256410256410257
specificity:0.9035087719298246

2.32 bias: True, activation: tanh, lr: 0.0001, epochs: 100

TP:4
TN:112
FP:2
FN:74
accuracy:0.6041666666666666
sensitivity:0.05128205128205128
specificity:0.9824561403508771

2.33 bias: False, activation: sigmoid, lr: 0.001, epochs: 100

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.34 bias: True, activation: relu, lr: 0.0001, epochs: 100

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.35 bias: False, activation: tanh, lr: 0.0001, epochs: 50

TP:0
TN:113
FP:1
FN:78
accuracy:0.5885416666666666
sensitivity:0.0
specificity:0.9912280701754386

2.36 bias: False, activation: tanh, lr: 0.001, epochs: 100

TP:7
TN:114
FP:0
FN:71
accuracy:0.6302083333333334
sensitivity:0.08974358974358974
specificity:1.0

2.37 bias: False, activation: sigmoid, lr: 0.01, epochs: 50

TP:0
TN:114
FP:0

FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.38 bias: False, activation: sigmoid, lr: 0.001, epochs: 50

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.39 bias: True, activation: relu, lr: 0.001, epochs: 200

TP:35
TN:109
FP:5
FN:43
accuracy:0.75
sensitivity:0.44871794871794873
specificity:0.956140350877193

2.40 bias: True, activation: tanh, lr: 0.0001, epochs: 50

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.41 bias: False, activation: relu, lr: 0.0001, epochs: 50

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.42 bias: True, activation: relu, lr: 0.001, epochs: 50

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.43 bias: False, activation: relu, lr: 0.01, epochs: 100

TP:59
TN:82
FP:32
FN:19
accuracy:0.734375
sensitivity:0.7564102564102564
specificity:0.7192982456140351

2.44 bias: True, activation: tanh, lr: 0.0001, epochs: 200

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.45 bias: True, activation: relu, lr: 0.01, epochs: 200

TP:45
TN:99
FP:15
FN:33
accuracy:0.75
sensitivity:0.5769230769230769
specificity:0.868421052631579

2.46 bias: False, activation: sigmoid, lr: 0.0001, epochs: 100

TP:0
TN:114
FP:0

FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.47 bias: False, activation: sigmoid, lr: 0.01, epochs: 100

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.48 bias: False, activation: sigmoid, lr: 0.01, epochs: 200

TP:20
TN:113
FP:1
FN:58
accuracy:0.6927083333333334
sensitivity:0.2564102564102564
specificity:0.9912280701754386

2.49 bias: True, activation: tanh, lr: 0.01, epochs: 50

TP:38
TN:103
FP:11
FN:40
accuracy:0.734375
sensitivity:0.48717948717948717
specificity:0.9035087719298246

2.50 bias: True, activation: relu, lr: 0.01, epochs: 100

TP:34
TN:106
FP:8
FN:44
accuracy:0.7291666666666666
sensitivity:0.4358974358974359
specificity:0.9298245614035088

2.51 bias: True, activation: relu, lr: 0.01, epochs: 50

TP:39
TN:101
FP:13
FN:39
accuracy:0.7291666666666666
sensitivity:0.5
specificity:0.8859649122807017

2.52 bias: True, activation: sigmoid, lr: 0.001, epochs: 50

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.53 bias: True, activation: tanh, lr: 0.001, epochs: 100

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.54 bias: True, activation: sigmoid, lr: 0.01, epochs: 100

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.55 bias: True, activation: sigmoid, lr: 0.01, epochs: 200

TP:37
TN:108
FP:6
FN:41
accuracy:0.7552083333333334

sensitivity:0.47435897435897434
specificity:0.9473684210526315

2.56 bias: True, activation: tanh, lr: 0.01, epochs: 100

TP:39
TN:100
FP:14
FN:39
accuracy:0.7239583333333334
sensitivity:0.5
specificity:0.8771929824561403

2.57 bias: False, activation: relu, lr: 0.001, epochs: 100

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.58 bias: True, activation: sigmoid, lr: 0.0001, epochs: 100

TP:0
TN:114
FP:0
FN:78
accuracy:0.59375
sensitivity:0.0
specificity:1.0

2.59 bias: False, activation: relu, lr: 0.01, epochs: 200

TP:37
TN:103
FP:11
FN:41
accuracy:0.7291666666666666
sensitivity:0.47435897435897434
specificity:0.9035087719298246