

▼ IT 402

Assignment 3 - Multi Layer Perceptron

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```
1 import math
2 import numpy as np
3 import pandas as pd
4 import seaborn as sn
5 from csv import reader
6 from random import seed
7 from random import randrange
8 import matplotlib.pyplot as plt
9 from sklearn import preprocessing, datasets
10 from sklearn.preprocessing import OneHotEncoder
11 from sklearn.model_selection import KFold
12 from sklearn.metrics import confusion_matrix
13 from sklearn.metrics import precision_score, recall_score, f1_score, accuracy_score
14 import warnings
15
16 warnings.filterwarnings("ignore")
17 np.random.seed(0)
18
```

```
1 !rm -rf SPECT.train
2 !wget https://archive.ics.uci.edu/ml/machine-learning-databases/spect/SPECT.train
```

```
--2022-09-10 18:56:32-- https://archive.ics.uci.edu/ml/machine-learning-databases/spect/SPECT.train
Resolving archive.ics.uci.edu (archive.ics.uci.edu)... 128.195.10.252
```

```
Connecting to archive.ics.uci.edu (archive.ics.uci.edu)|128.195.10.252|:443... connected.  
HTTP request sent, awaiting response... 200 OK  
Length: 3758 (3.7K) [application/x-httpd-php]  
Saving to: 'SPECT.train'
```

```
SPECT.train          100%[=====>]    3.67K  --.-KB/s    in 0s
```

```
2022-09-10 18:56:34 (33.2 MB/s) - 'SPECT.train' saved [3758/3758]
```

```
1 def sigmoid(z):  
2     return 1 / (1 + np.exp(-z))  
3  
4  
5 def loss(y, y_hat):  
6     minval = 0.000000000001  
7     m = y.shape[0]  
8     loss = -1 / m * np.sum(y * np.log(y_hat.clip(min=minval)))  
9     return loss  
10  
11  
12 def sigmoid_derivative(z):  
13     return z * (1 - z)  
14  
15  
16 def loss_derivative(y, y_hat):  
17     return y_hat - y  
18  
19  
20 def tanh_derivative(x):  
21     return 1 - np.power(x, 2)  
22  
23  
24 def calc_accuracy(model, x, y):  
25     m = y.shape[0]  
26     pred = predict(model, x)  
27     pred = pred.reshape(y.shape)  
28     error = np.sum(np.abs(pred - y))
```

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29     return (m - error) / m * 100
30
```

```
1 def forward_prop(model, a0):
2     W1, b1, W2, b2, W3, b3, W4, b4 = (
3         model["W1"],
4         model["b1"],
5         model["W2"],
6         model["b2"],
7         model["W3"],
8         model["b3"],
9         model["W4"],
10        model["b4"],
11    )
12    z1 = a0.dot(W1) + b1
13    a1 = np.tanh(z1)
14    z2 = a1.dot(W2) + b2
15    a2 = np.tanh(z2)
16    z3 = a2.dot(W3) + b3
17    a3 = np.tanh(z3)
18    z4 = a3.dot(W4) + b4
19    a4 = sigmoid(z4)
20    cache = {
21        "a0": a0,
22        "z1": z1,
23        "a1": a1,
24        "z2": z2,
25        "a2": a2,
26        "a3": a3,
27        "z3": z3,
28        "a4": a4,
29        "z4": z4,
30    }
31    return cache
32
```

```

33
34 def backward_prop(model, cache, y):
35     W1, b1, W2, b2, W3, b3, W4, b4 = (
36         model["W1"],
37         model["b1"],
38         model["W2"],
39         model["b2"],
40         model["W3"],
41         model["b3"],
42         model["W4"],
43         model["b4"],
44     )
45     a0, a1, a2, a3, a4 = cache["a0"], cache["a1"], cache["a2"], cache["a3"], cache["a4"]
46     m = y.shape[0]
47     dz4 = np.multiply(loss_derivative(y=y, y_hat=a4), sigmoid_derivative(a4))
48     dW4 = 1 / m * (a3.T).dot(dz4)
49     db4 = 1 / m * np.sum(dz4, axis=0)
50     dz3 = np.multiply(dz4.dot(W4.T), tanh_derivative(a3))
51     dW3 = 1 / m * np.dot(a2.T, dz3)
52     db3 = 1 / m * np.sum(dz3, axis=0)
53     dz2 = np.multiply(dz3.dot(W3.T), tanh_derivative(a2))
54     dW2 = 1 / m * np.dot(a1.T, dz2)
55     db2 = 1 / m * np.sum(dz2, axis=0)
56     dz1 = np.multiply(dz2.dot(W2.T), tanh_derivative(a1))
57     dW1 = 1 / m * np.dot(a0.T, dz1)
58     db1 = 1 / m * np.sum(dz1, axis=0)
59     grads = {
60         "dW4": dW4,
61         "db4": db4,
62         "dW3": dW3,
63         "db3": db3,
64         "dW2": dW2,
65         "db2": db2,
66         "dW1": dW1,
67         "db1": db1,
68     }
69     return grads

```

```

70
71
72 def update_parameters(model, grads, learning_rate):
73     W1, b1, W2, b2, W3, b3, W4, b4 = (
74         model["W1"],
75         model["b1"],
76         model["W2"],
77         model["b2"],
78         model["W3"],
79         model["b3"],
80         model["W4"],
81         model["b4"],
82     )
83     W1 -= learning_rate * grads["dW1"]
84     b1 -= learning_rate * grads["db1"]
85     W2 -= learning_rate * grads["dW2"]
86     b2 -= learning_rate * grads["db2"]
87     W3 -= learning_rate * grads["dW3"]
88     b3 -= learning_rate * grads["db3"]
89     W4 -= learning_rate * grads["dW4"]
90     b4 -= learning_rate * grads["db4"]
91     model = {
92         "W1": W1,
93         "b1": b1,
94         "W2": W2,
95         "b2": b2,
96         "W3": W3,
97         "b3": b3,
98         "W4": W4,
99         "b4": b4,
100     }
101     return model
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```

```

1 def initialize_parameters(nn_input_dim, nn_hdim, nn_output_dim):
2     W1 = np.random.randn(nn_input_dim, nn_hdim[0])
3     b1 = np.zeros((1, nn_hdim[0]))

```

```

4     W2 = np.random.randn(nn_hdim[0], nn_hdim[1])
5     b2 = np.zeros((1, nn_hdim[1]))
6     W3 = np.random.randn(nn_hdim[1], nn_hdim[2])
7     b3 = np.zeros((1, nn_hdim[2]))
8     W4 = np.random.randn(nn_hdim[2], nn_output_dim)
9     b4 = np.zeros((1, nn_output_dim))
10    model = {
11        "W1": W1,
12        "b1": b1,
13        "W2": W2,
14        "b2": b2,
15        "W3": W3,
16        "b3": b3,
17        "W4": W4,
18        "b4": b4,
19    }
20    return model
21

```

```

1 def predict(model, x):
2     c = forward_prop(model, x)
3     y_hat = np.argmax(c["a4"], axis=1)
4     return y_hat
5
6
7 def train(model, X_, y_, learning_rate, epochs=1000, print_loss=False):
8     for i in range(0, epochs):
9         cache = forward_prop(model, X_)
10        grads = backward_prop(model, cache, y_)
11        model = update_parameters(model=model, grads=grads, learning_rate=learning_rate)
12    return model
13
14
15 def evaluate_algorithm(dataset, n_folds, l_rate, in_dim, hid_dim, out_dim):
16     kf = KFold(n_splits=n_folds, random_state=None, shuffle=True)
17     scores = list()
18     f = 1

```

```

19     for train_index, test_index in kf.split(dataset):
20         print("\nFold {}".format(f))
21         f += 1
22         df_train, df_test = dataset[train_index], dataset[test_index]
23         df_train = pd.DataFrame(df_train)
24         df_test = pd.DataFrame(df_test)
25         train_Y = pd.get_dummies(df_train.iloc[:, -1]).values
26         train_X = df_train.iloc[:, :-1].values
27         test_Y = pd.get_dummies(df_test.iloc[:, -1]).values
28         test_X = df_test.iloc[:, :-1].values
29         model = initialize_parameters(
30             nn_input_dim=in_dim, nn_hdim=hid_dim, nn_output_dim=out_dim
31         )
32         model = train(
33             model, train_X, train_Y, learning_rate=l_rate, epochs=4500, print_loss=True
34         )
35         y_hat = predict(model, test_X)
36         y_true = test_Y.argmax(axis=1)
37         accuracy = accuracy_score(y_pred=y_hat, y_true=y_true) * 100
38         print("Accuracy = {}".format(accuracy))
39         scores.append(accuracy)
40     return scores
41

```

▼ SPECTF Dataset

```

1 data = pd.read_csv("SPECT.train", header=None)
2 data.head()
3

```

	0	1	2	3	4	5	6	7	8	9	...	13	14	15	16	17	18	19	20	21	22
0	1	0	0	0	1	0	0	0	1	1	...	1	1	0	0	0	0	0	0	0	0
1	1	0	0	1	1	0	0	0	1	1	...	1	1	0	0	0	0	0	0	0	1
2	1	1	0	1	0	1	0	0	1	0	...	1	0	0	0	0	0	0	0	0	0

```

1 print("Learning Rate = {}".format(0.01))
2 scores = evaluate_algorithm(
3     data.values, n_folds=5, l_rate=0.01, in_dim=22, hid_dim=[15, 10, 5], out_dim=2
4 )
5

```

Learning Rate = 0.01

Fold 1

Accuracy = 68.75

Fold 2

Accuracy = 43.75

Fold 3

Accuracy = 62.5

Fold 4

Accuracy = 50.0

Fold 5

Accuracy = 50.0

```

1 print("Learning Rate = {}".format(0.001))
2 scores = evaluate_algorithm(
3     data.values, n_folds=5, l_rate=0.001, in_dim=22, hid_dim=[15, 10, 5], out_dim=2
4 )
5

```

Learning Rate = 0.001

Fold 1
Accuracy = 56.25

Fold 2
Accuracy = 62.5

Fold 3
Accuracy = 75.0

Fold 4
Accuracy = 62.5

Fold 5
Accuracy = 68.75

```
1 print("Learning Rate = {}".format(0.0001))
2 scores = evaluate_algorithm(
3     data.values, n_folds=5, l_rate=0.0001, in_dim=22, hid_dim=[15, 10, 5], out_dim=2
4 )
5
```

Learning Rate = 0.0001

Fold 1
Accuracy = 62.5

Fold 2
Accuracy = 43.75

Fold 3
Accuracy = 50.0

Fold 4
Accuracy = 37.5

Fold 5
Accuracy = 50.0

▼ Iris Dataset

```
1 iris_data = datasets.load_iris()
2 df = pd.DataFrame(data=iris_data.data, columns=iris_data.feature_names)
3 df["class"] = iris_data.target
4 df.head()
5
```

	sepal length (cm)	sepal width (cm)	petal length (cm)	petal width (cm)	class
0	5.1	3.5	1.4	0.2	0
1	4.9	3.0	1.4	0.2	0
2	4.7	3.2	1.3	0.2	0
3	4.6	3.1	1.5	0.2	0
4	5.0	3.6	1.4	0.2	0

```
1 print("Learning Rate = {}".format(0.01))
2 scores = evaluate_algorithm(
3     df.values, n_folds=5, l_rate=0.01, in_dim=4, hid_dim=[4, 4, 3], out_dim=3
4 )
5
```

Learning Rate = 0.01

Fold 1

Accuracy = 90.0

Fold 2

Accuracy = 30.0

Fold 3

Accuracy = 20.0

Fold 4
Accuracy = 23.333333333333332

Fold 5
Accuracy = 26.666666666666668

```
1 print("Learning Rate = {}".format(0.001))
2 scores = evaluate_algorithm(
3     df.values, n_folds=5, l_rate=0.001, in_dim=4, hid_dim=[4, 4, 3], out_dim=3
4 )
5
```

Learning Rate = 0.001

Fold 1
Accuracy = 63.33333333333333

Fold 2
Accuracy = 33.33333333333333

Fold 3
Accuracy = 33.33333333333333

Fold 4
Accuracy = 33.33333333333333

Fold 5
Accuracy = 40.0

```
1 print("Learning Rate = {}".format(0.0001))
2 scores = evaluate_algorithm(
3     df.values, n_folds=5, l_rate=0.0001, in_dim=4, hid_dim=[4, 4, 3], out_dim=3
4 )
5
```

Learning Rate = 0.0001

Fold 1
Accuracy = 43.333333333333336

Fold 2
Accuracy = 30.0

Fold 3
Accuracy = 43.333333333333336

Fold 4
Accuracy = 43.333333333333336

Fold 5
Accuracy = 33.33333333333333