

assignment6_q2_2

September 20, 2019

```
In [1]: from sklearn.datasets import fetch_openml, load_iris
        from sklearn.model_selection import train_test_split
        from sklearn.preprocessing import OneHotEncoder
        from sklearn.metrics import log_loss
        from sklearn.metrics import confusion_matrix, classification_report
        from sklearn.utils import shuffle
        import seaborn as sn
        import numpy as np
        import matplotlib.pyplot as plt
        import matplotlib
        import pandas as pd
```

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In [2]: def sigmoid(z):
        s = 1 / (1 + np.exp(-z))
        return s
```

```
In [3]: def compute_multiclass_loss(Y, Y_hat):

        L_sum = np.sum(np.multiply(Y, np.log(Y_hat)))
        m = Y.shape[0]
        L = -(1/m) * L_sum

        return L
```

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In [4]: iris = load_iris()
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        X = iris.data
        y = iris.target
```

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In [5]: X,y = shuffle(X,y)
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In [6]: digits = 3
        examples = y.shape[0]

        y = y.reshape(1, examples)

        Y_new = np.eye(digits)[y.astype('int32')]
        Y_new = Y_new.T.reshape(digits, examples)
```

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In [7]: m = 120
        m_test = X.shape[0] - m

        X_train, X_test = X[:m].T, X[m:].T
        Y_train, Y_test = Y_new[:, :m], Y_new[:, m:]

        shuffle_index = np.random.permutation(m)
        X_train, Y_train = X_train[:, shuffle_index], Y_train[:, shuffle_index]

In [8]: def train(learning_rate = 0.1, epochs = 2000):

        n_x = X_train.shape[0]
        n_h = 64

        W1 = np.random.randn(n_h, n_x)
        b1 = np.zeros((n_h, 1))
        W2 = np.random.randn(digits, n_h)
        b2 = np.zeros((digits, 1))

        X = X_train
        Y = Y_train

        for i in range(epochs):

            Z1 = np.matmul(W1, X) + b1
            A1 = sigmoid(Z1)
            Z2 = np.matmul(W2, A1) + b2
            A2 = np.exp(Z2) / np.sum(np.exp(Z2), axis=0)

            cost = compute_multiclass_loss(Y, A2)

            dZ2 = A2 - Y
            dW2 = (1./m) * np.matmul(dZ2, A1.T)
            db2 = (1./m) * np.sum(dZ2, axis=1, keepdims=True)

            dA1 = np.matmul(W2.T, dZ2)
            dZ1 = dA1 * sigmoid(Z1) * (1 - sigmoid(Z1))
            dW1 = (1./m) * np.matmul(dZ1, X.T)
            db1 = (1./m) * np.sum(dZ1, axis=1, keepdims=True)

            W2 = W2 - learning_rate * dW2
            b2 = b2 - learning_rate * db2
            W1 = W1 - learning_rate * dW1
            b1 = b1 - learning_rate * db1

            if (i % 100 == 0):
                print("Epoch", i, "cost: ", cost)

```

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print("Final cost:", cost)

Z1 = np.matmul(W1, X_test) + b1
A1 = sigmoid(Z1)
Z2 = np.matmul(W2, A1) + b2
A2 = np.exp(Z2) / np.sum(np.exp(Z2), axis=0)

predictions = np.argmax(A2, axis=0)
labels = np.argmax(Y_test, axis=0)

cf_matrix = confusion_matrix(predictions, labels)

%matplotlib inline
plt.rcParams['figure.figsize'] = [10,5]
label = list(iris.target_names)
df_cm = pd.DataFrame(cf_matrix, label, label)
sn.set(font_scale=1)
sn.heatmap(df_cm, annot=True, annot_kws={"size":16})
plt.show()

print(classification_report(predictions, labels))

return cost

```

```

In [9]: cost = []
        lr = []
        for x in range(10):
            temp = train(learning_rate = (x+1)/10)
            cost.append(temp)
            lr.append((x+1)/10)

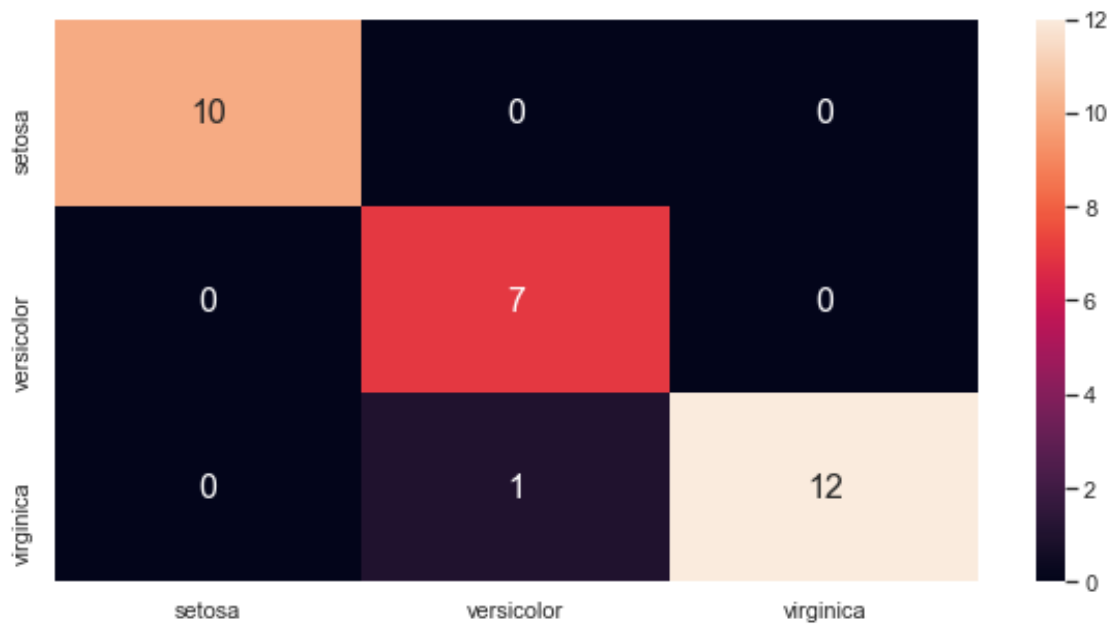
```

```

Epoch 0 cost: 179.46415903245276
Epoch 100 cost: 7.841611155766224
Epoch 200 cost: 6.517747903883593
Epoch 300 cost: 5.829459262813259
Epoch 400 cost: 5.319122993488872
Epoch 500 cost: 4.8694214913741405
Epoch 600 cost: 4.532778071649286
Epoch 700 cost: 4.278678785686965
Epoch 800 cost: 4.065151454299583
Epoch 900 cost: 3.880676933075973
Epoch 1000 cost: 3.719493537365884
Epoch 1100 cost: 3.577618754903425
Epoch 1200 cost: 3.452015232593288
Epoch 1300 cost: 3.340272609002172
Epoch 1400 cost: 3.240434918503163
Epoch 1500 cost: 3.150889042999696
Epoch 1600 cost: 3.0702859770517628

```

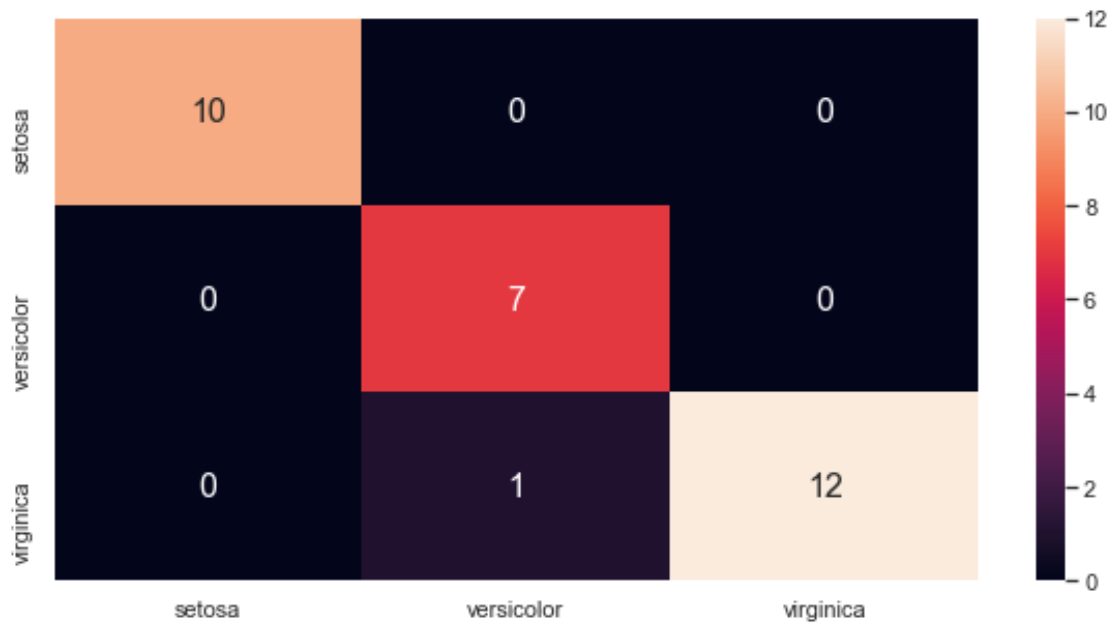
Epoch 1700 cost: 2.9974835042250083
 Epoch 1800 cost: 2.931504590486853
 Epoch 1900 cost: 2.871507303922307
 Final cost: 2.817286240746922



	precision	recall	f1-score	support
0	1.00	1.00	1.00	10
1	0.88	1.00	0.93	7
2	1.00	0.92	0.96	13
accuracy			0.97	30
macro avg	0.96	0.97	0.96	30
weighted avg	0.97	0.97	0.97	30

Epoch 0 cost: 208.90327820145995
 Epoch 100 cost: 7.430679906323455
 Epoch 200 cost: 4.138717705351518
 Epoch 300 cost: 3.5393676562451084
 Epoch 400 cost: 3.178674929675627
 Epoch 500 cost: 2.9497966203228807
 Epoch 600 cost: 2.7872361086883677
 Epoch 700 cost: 2.665330911012063
 Epoch 800 cost: 2.570196777196827
 Epoch 900 cost: 2.493526048324006
 Epoch 1000 cost: 2.430035832577451

Epoch 1100 cost: 2.3762231069983617
 Epoch 1200 cost: 2.329682647109837
 Epoch 1300 cost: 2.2887101216615897
 Epoch 1400 cost: 2.2520721446237806
 Epoch 1500 cost: 2.2188908754828773
 Epoch 1600 cost: 2.188617840514441
 Epoch 1700 cost: 2.1610354745052414
 Epoch 1800 cost: 2.1361287036090286
 Epoch 1900 cost: 2.113783407370674
 Final cost: 2.0938370300767644



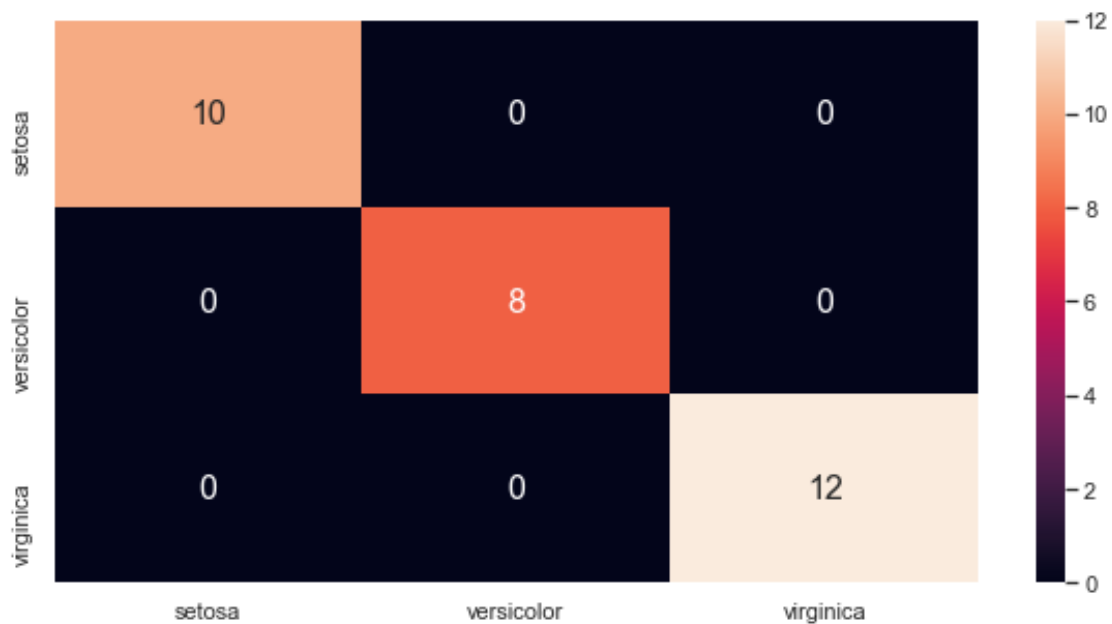
	precision	recall	f1-score	support
0	1.00	1.00	1.00	10
1	0.88	1.00	0.93	7
2	1.00	0.92	0.96	13
accuracy			0.97	30
macro avg	0.96	0.97	0.96	30
weighted avg	0.97	0.97	0.97	30

Epoch 0 cost: 170.11673427115056
 Epoch 100 cost: 21.41528212360359
 Epoch 200 cost: 3.870085467639603
 Epoch 300 cost: 3.3452860611657123
 Epoch 400 cost: 3.3445147563100583

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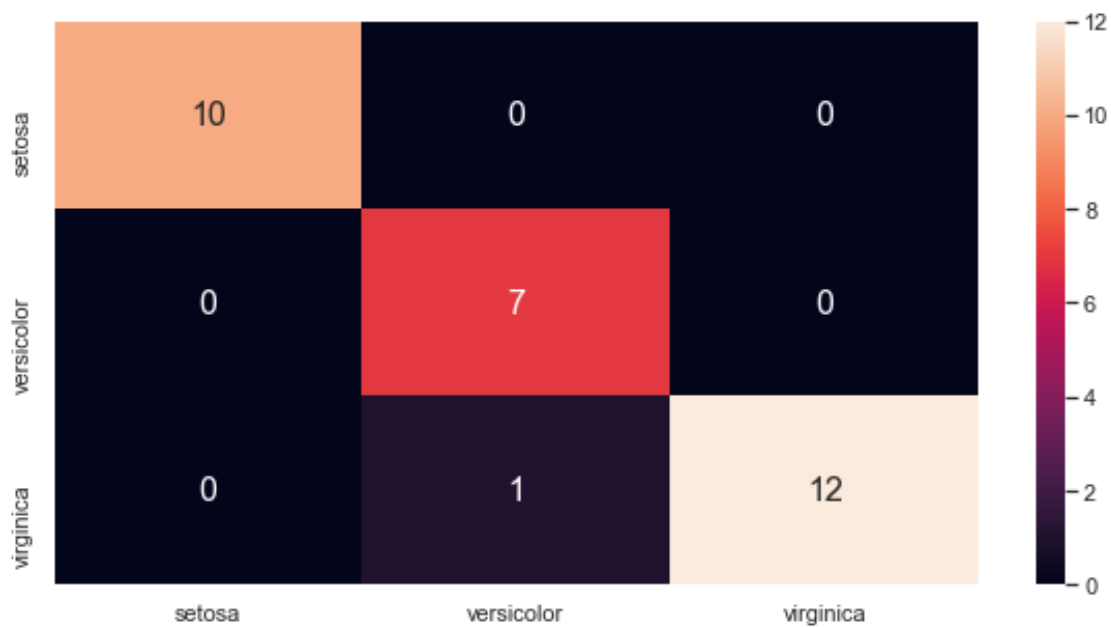
Epoch 500 cost: 2.8723223107573315
Epoch 600 cost: 2.72489905905316
Epoch 700 cost: 2.638197285131485
Epoch 800 cost: 2.6383109261982494
Epoch 900 cost: 2.508421304818477
Epoch 1000 cost: 2.454088491715502
Epoch 1100 cost: 2.4158962968483917
Epoch 1200 cost: 2.374094015796502
Epoch 1300 cost: 2.3512376360281046
Epoch 1400 cost: 2.329205101096199
Epoch 1500 cost: 2.301591079601314
Epoch 1600 cost: 2.278342313773745
Epoch 1700 cost: 2.2545408376112004
Epoch 1800 cost: 2.2331699994244922
Epoch 1900 cost: 2.2126035687704935
Final cost: 2.19868708745848

```



	precision	recall	f1-score	support
0	1.00	1.00	1.00	10
1	1.00	1.00	1.00	8
2	1.00	1.00	1.00	12
accuracy			1.00	30
macro avg	1.00	1.00	1.00	30
weighted avg	1.00	1.00	1.00	30

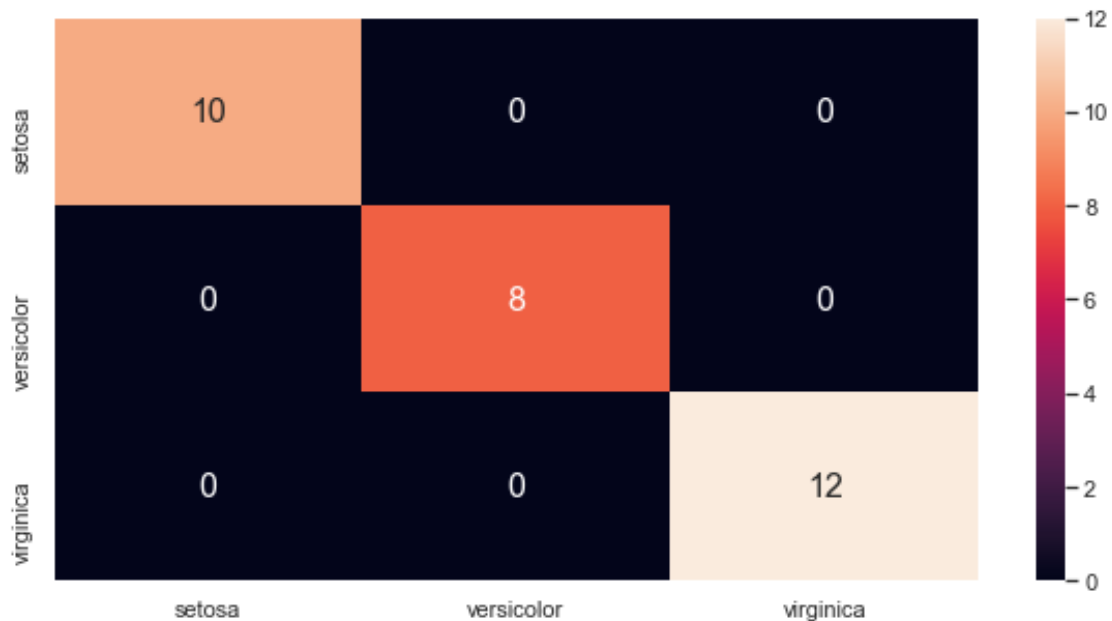
Epoch 0 cost: 215.65554998215012
Epoch 100 cost: 37.446874985894254
Epoch 200 cost: 32.185511474530664
Epoch 300 cost: 7.407036490250239
Epoch 400 cost: 2.765142175193884
Epoch 500 cost: 2.600294872973171
Epoch 600 cost: 2.496732060931272
Epoch 700 cost: 2.4184910660586274
Epoch 800 cost: 2.3543101766164547
Epoch 900 cost: 2.2925895768915083
Epoch 1000 cost: 2.203332936555232
Epoch 1100 cost: 2.158326976134484
Epoch 1200 cost: 2.1271567484074994
Epoch 1300 cost: 2.099986993429427
Epoch 1400 cost: 2.0755420828866695
Epoch 1500 cost: 2.053215003592465
Epoch 1600 cost: 2.0326968558220586
Epoch 1700 cost: 2.0154056743917055
Epoch 1800 cost: 2.0638856109995913
Epoch 1900 cost: 2.0757774515840226
Final cost: 2.031675752175906



	precision	recall	f1-score	support
0	1.00	1.00	1.00	10

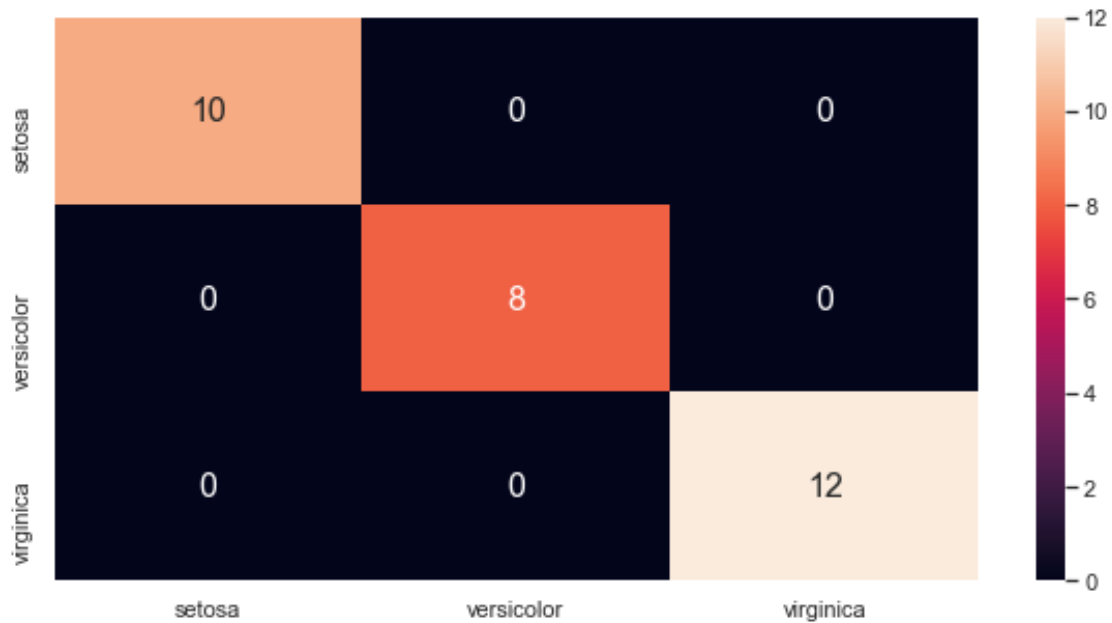
	1	0.88	1.00	0.93	7
	2	1.00	0.92	0.96	13
accuracy				0.97	30
macro avg		0.96	0.97	0.96	30
weighted avg		0.97	0.97	0.97	30

Epoch 0 cost: 62.74173372069596
 Epoch 100 cost: 36.617560475745805
 Epoch 200 cost: 34.95120850100287
 Epoch 300 cost: 2.652966256668732
 Epoch 400 cost: 2.3553250589713106
 Epoch 500 cost: 2.2459702253038953
 Epoch 600 cost: 2.1600723382401372
 Epoch 700 cost: 2.105886478469977
 Epoch 800 cost: 2.0650034316076025
 Epoch 900 cost: 2.0319563411105706
 Epoch 1000 cost: 2.0049118827280727
 Epoch 1100 cost: 1.9816730743385353
 Epoch 1200 cost: 1.960950564223714
 Epoch 1300 cost: 2.4711991472929578
 Epoch 1400 cost: 1.9877132410038048
 Epoch 1500 cost: 1.9788777451358204
 Epoch 1600 cost: 1.9694263232962124
 Epoch 1700 cost: 1.957941760193994
 Epoch 1800 cost: 1.9448542483793485
 Epoch 1900 cost: 1.9318642437299172
 Final cost: 1.933348572371051



	precision	recall	f1-score	support
0	1.00	1.00	1.00	10
1	1.00	1.00	1.00	8
2	1.00	1.00	1.00	12
accuracy			1.00	30
macro avg	1.00	1.00	1.00	30
weighted avg	1.00	1.00	1.00	30

Epoch 0 cost: 85.07867198710639
 Epoch 100 cost: 45.73362034637859
 Epoch 200 cost: 12.241468098370932
 Epoch 300 cost: 2.5264035099631794
 Epoch 400 cost: 2.4802317185832656
 Epoch 500 cost: 2.2961029244434448
 Epoch 600 cost: 2.2252645942029674
 Epoch 700 cost: 2.178858930472833
 Epoch 800 cost: 2.1417476638393755
 Epoch 900 cost: 2.1101072002701664
 Epoch 1000 cost: 2.082255940198187
 Epoch 1100 cost: 2.8294911119469193
 Epoch 1200 cost: 2.0991639639061397
 Epoch 1300 cost: 2.091446708481174
 Epoch 1400 cost: 2.098865408451688
 Epoch 1500 cost: 2.0840170561373217
 Epoch 1600 cost: 2.0643731565081005
 Epoch 1700 cost: 2.0476250905458504
 Epoch 1800 cost: 2.0326518512221883
 Epoch 1900 cost: 2.018571687696576
 Final cost: 2.025918868413879



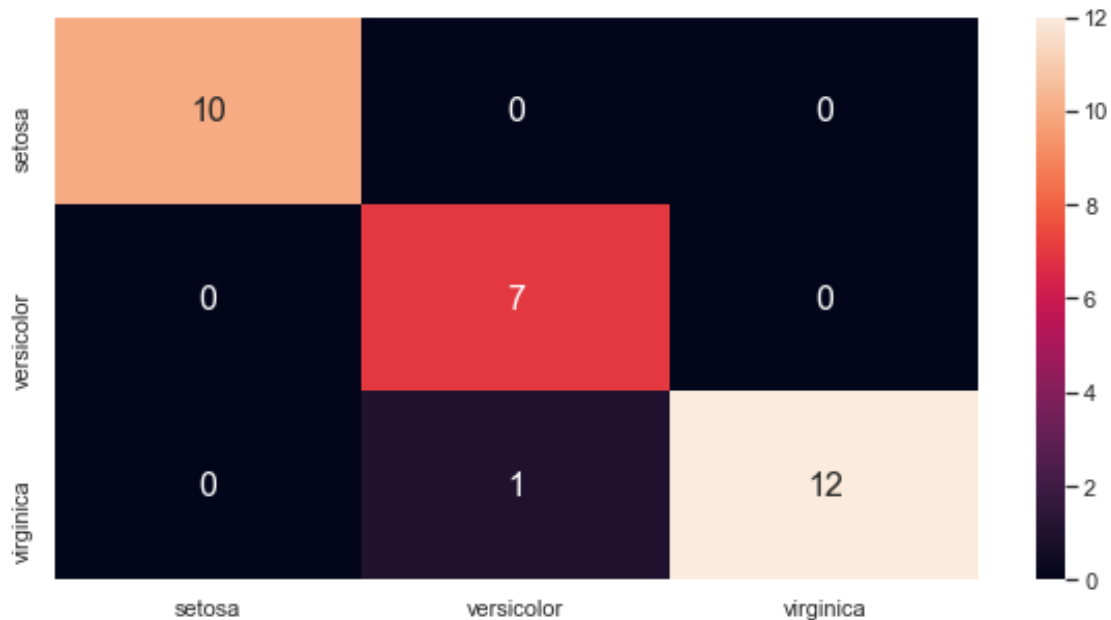
	precision	recall	f1-score	support
0	1.00	1.00	1.00	10
1	1.00	1.00	1.00	8
2	1.00	1.00	1.00	12
accuracy			1.00	30
macro avg	1.00	1.00	1.00	30
weighted avg	1.00	1.00	1.00	30

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Epoch 0 cost: 314.87482309671293
Epoch 100 cost: 117.23450468967292
Epoch 200 cost: 96.10629256944657
Epoch 300 cost: 79.02055276141635
Epoch 400 cost: 2.3108262087487703
Epoch 500 cost: 2.176729665176471
Epoch 600 cost: 2.1132015037316494
Epoch 700 cost: 2.0618793125001162
Epoch 800 cost: 2.0194190253864983
Epoch 900 cost: 1.9816029128854828
Epoch 1000 cost: 1.9300269608570917
Epoch 1100 cost: 1.8638197620307004
Epoch 1200 cost: 1.8378047330183542
Epoch 1300 cost: 1.8150608235162649
Epoch 1400 cost: 1.9078829262662318
Epoch 1500 cost: 1.883750758417029

```

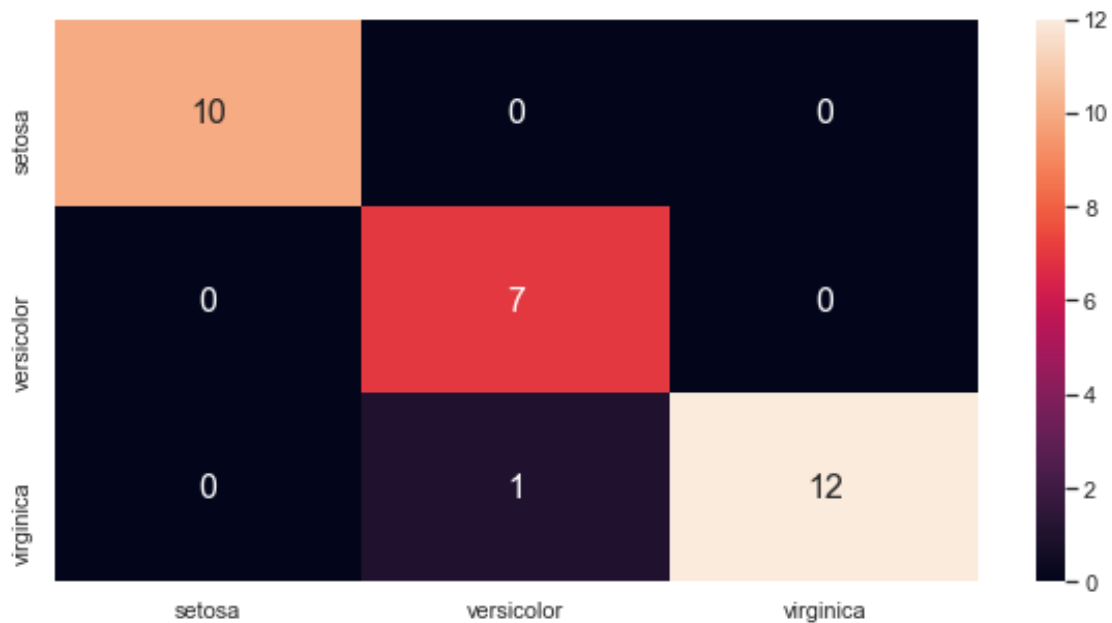
Epoch 1600 cost: 1.8661602636383963
Epoch 1700 cost: 1.8490992422223673
Epoch 1800 cost: 1.8334631366308862
Epoch 1900 cost: 1.8198512018033572
Final cost: 1.7805104138432146



	precision	recall	f1-score	support
0	1.00	1.00	1.00	10
1	0.88	1.00	0.93	7
2	1.00	0.92	0.96	13
accuracy			0.97	30
macro avg	0.96	0.97	0.96	30
weighted avg	0.97	0.97	0.97	30

Epoch 0 cost: 223.92546334450915
Epoch 100 cost: 40.746792224300435
Epoch 200 cost: 47.30312526254771
Epoch 300 cost: 61.54741224806546
Epoch 400 cost: 2.521895048824393
Epoch 500 cost: 2.3590084612674587
Epoch 600 cost: 2.282903526359291
Epoch 700 cost: 2.2252740559881823
Epoch 800 cost: 2.1760257816223127
Epoch 900 cost: 2.129503073935676

Epoch 1000 cost: 2.073312675680368
 Epoch 1100 cost: 2.0182096971673036
 Epoch 1200 cost: 1.9834179010966768
 Epoch 1300 cost: 1.9443770500871587
 Epoch 1400 cost: 2.3818553786943655
 Epoch 1500 cost: 2.061265643993149
 Epoch 1600 cost: 2.0457094477561384
 Epoch 1700 cost: 2.032850034753443
 Epoch 1800 cost: 2.0207546882300793
 Epoch 1900 cost: 2.008969910146327
 Final cost: 1.9418741295968092



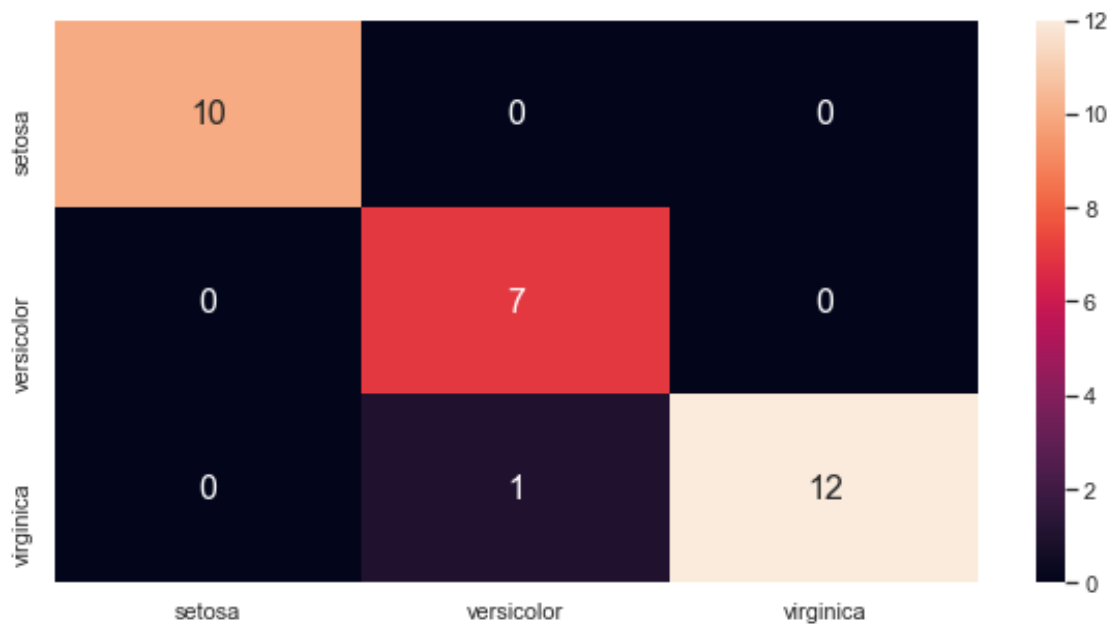
	precision	recall	f1-score	support
0	1.00	1.00	1.00	10
1	0.88	1.00	0.93	7
2	1.00	0.92	0.96	13
accuracy			0.97	30
macro avg	0.96	0.97	0.96	30
weighted avg	0.97	0.97	0.97	30

Epoch 0 cost: 180.40943975014625
 Epoch 100 cost: 48.24453249088919
 Epoch 200 cost: 46.24292711096147
 Epoch 300 cost: 49.27753729774025

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Epoch 400 cost: 2.456858107547948
Epoch 500 cost: 2.251943261992536
Epoch 600 cost: 2.176898187059823
Epoch 700 cost: 2.311081859850259
Epoch 800 cost: 2.2767014428043137
Epoch 900 cost: 2.2445566625018625
Epoch 1000 cost: 2.2150345209078157
Epoch 1100 cost: 2.189530441111196
Epoch 1200 cost: 2.1691684190665317
Epoch 1300 cost: 2.150553458032096
Epoch 1400 cost: 2.1312615783386795
Epoch 1500 cost: 2.111483677505012
Epoch 1600 cost: 2.091678483483548
Epoch 1700 cost: 2.07206752022872
Epoch 1800 cost: 2.052732398947371
Epoch 1900 cost: 2.0337011062577917
Final cost: 1.941414832858623

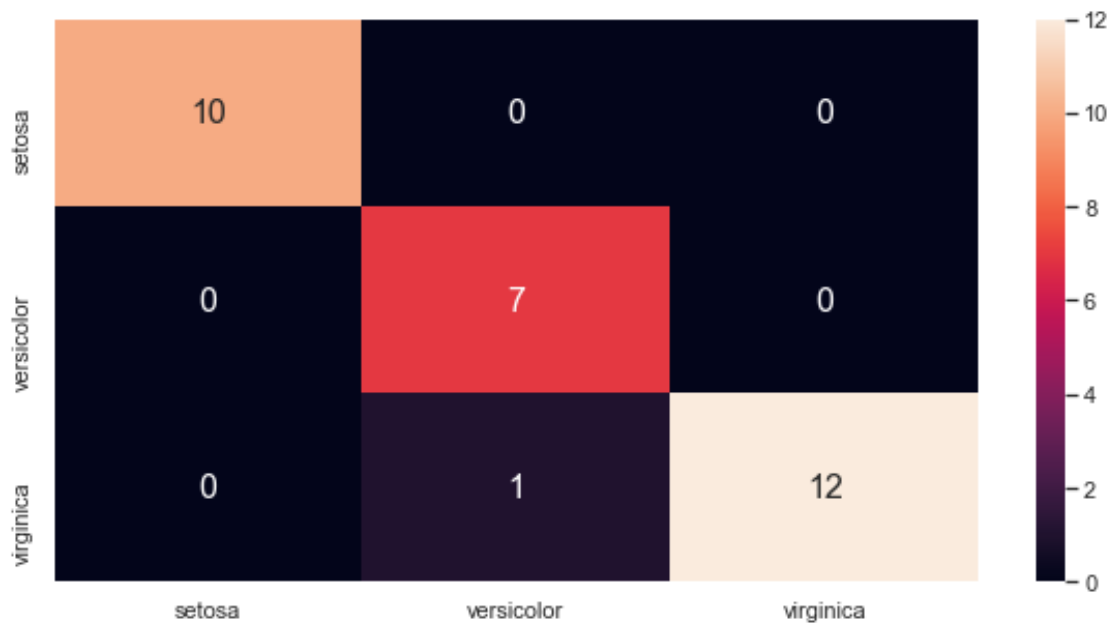
```



	precision	recall	f1-score	support
0	1.00	1.00	1.00	10
1	0.88	1.00	0.93	7
2	1.00	0.92	0.96	13
accuracy			0.97	30
macro avg	0.96	0.97	0.96	30

weighted avg 0.97 0.97 0.97 30

Epoch 0 cost: 191.54641307927764
Epoch 100 cost: 51.70125097229021
Epoch 200 cost: 50.083964633975576
Epoch 300 cost: 42.55300412257264
Epoch 400 cost: 76.08507714698274
Epoch 500 cost: 2.312442282016768
Epoch 600 cost: 2.224986807502777
Epoch 700 cost: 2.1660205484919435
Epoch 800 cost: 2.121791449233127
Epoch 900 cost: 2.085811943396262
Epoch 1000 cost: 2.0540617836351966
Epoch 1100 cost: 2.024414606249327
Epoch 1200 cost: 1.9960518283650477
Epoch 1300 cost: 1.9689446305271563
Epoch 1400 cost: 1.942148330155842
Epoch 1500 cost: 1.9142880574278547
Epoch 1600 cost: 1.8845133717504876
Epoch 1700 cost: 1.8517469389465036
Epoch 1800 cost: 1.8230181065855757
Epoch 1900 cost: 1.9518917966939562
Final cost: 1.8708125685198613



precision recall f1-score support

0	1.00	1.00	1.00	10
1	0.88	1.00	0.93	7
2	1.00	0.92	0.96	13
accuracy			0.97	30
macro avg	0.96	0.97	0.96	30
weighted avg	0.97	0.97	0.97	30

```
In [10]: %matplotlib inline
plt.rcParams['figure.figsize'] = [20,10]
plt.xlabel('lr')
plt.ylabel('loss')
plt.plot(lr, cost)
plt.show()
```

