

worksheet_23

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1 Worksheet 23

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1.0.1 Topics

- Tuning Neural Networks

1.1 Tuning Neural Networks

Nothing to do in this worksheet except follow along in lecture / use this code to better understand Neural Networks.

```
[ ]: import math as m
import numpy as np
import matplotlib.pyplot as plt
import sklearn.datasets as datasets
from tensorflow import keras, math, random, stack
from tensorflow.keras import layers, initializers
from tensorflow.keras.activations import relu

# Set random seed for reproducibility
np.random.seed(1)
random.set_seed(1)

# Data generation - don't modify
centers = [[0, 0]]
t, _ = datasets.make_blobs(n_samples=200, centers=centers, cluster_std=1,
                           random_state=1)

colors = np.array([x for x in 'bgrcmk'])

# CURVE
def generate_curve_data(t):
    # create some space between the classes
    X = np.array(list(filter(lambda x : m.cos(4*x[0]) - x[1] < -.5 or m.
↪ cos(4*x[0]) - x[1] > .5, t)))
    Y = np.array([1 if m.cos(4*x[0]) - x[1] >= 0 else 0 for x in X])
```

```

    return X, Y

# The model - modify this
model = keras.models.Sequential()
model.add(layers.Dense(3, input_dim=2, activation="sigmoid"))
model.add(layers.Dense(1, activation="sigmoid"))
model.compile(loss="binary_crossentropy")

X, Y = generate_curve_data(t)

# plot the data
plt.scatter(X[:,0],X[:,1],color=colors[Y].tolist(), s=100, alpha=.9)
plt.show()

history = model.fit(X, Y, batch_size=50, epochs=200)

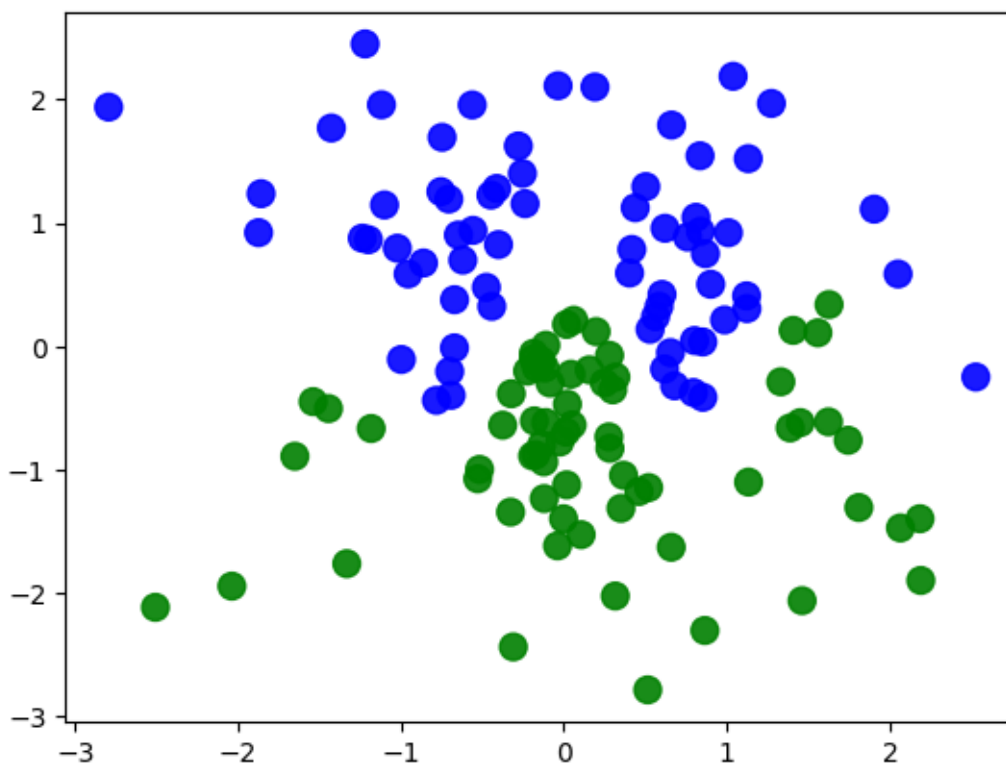
# Plot the decision boundary

# create a mesh to plot in
h = .02 # step size in the mesh
x_min, x_max = X[:, 0].min() - .5, X[:, 0].max() + 1
y_min, y_max = X[:, 1].min() - .5, X[:, 1].max() + 1
xx, yy = np.meshgrid(np.arange(x_min, x_max, h),
                     np.arange(y_min, y_max, h))
meshData = np.c_[xx.ravel(), yy.ravel()]

fig, ax = plt.subplots()
Z = model.predict(meshData)
Z = np.array([0 if x < .5 else 1 for x in Z])
Z = Z.reshape(xx.shape)
ax.contourf(xx, yy, Z, alpha=.3, cmap=plt.cm.Paired)
ax.axis('off')

# Plot also the training points
ax.scatter(X[:, 0], X[:, 1], color=colors[Y].tolist(), s=100, alpha=.9)
plt.title("Decision Boundary")
plt.show()

```



```
Epoch 1/200
3/3 [=====] - 2s 15ms/step - loss: 0.6675
Epoch 2/200
3/3 [=====] - 0s 12ms/step - loss: 0.6627
Epoch 3/200
3/3 [=====] - 0s 9ms/step - loss: 0.6594
Epoch 4/200
3/3 [=====] - 0s 8ms/step - loss: 0.6566
Epoch 5/200
3/3 [=====] - 0s 8ms/step - loss: 0.6541
Epoch 6/200
3/3 [=====] - 0s 9ms/step - loss: 0.6518
Epoch 7/200
3/3 [=====] - 0s 16ms/step - loss: 0.6495
Epoch 8/200
3/3 [=====] - 0s 15ms/step - loss: 0.6475
Epoch 9/200
3/3 [=====] - 0s 16ms/step - loss: 0.6455
Epoch 10/200
3/3 [=====] - 0s 10ms/step - loss: 0.6435
Epoch 11/200
3/3 [=====] - 0s 13ms/step - loss: 0.6415
```

Epoch 12/200
3/3 [=====] - 0s 8ms/step - loss: 0.6396
Epoch 13/200
3/3 [=====] - 0s 9ms/step - loss: 0.6377
Epoch 14/200
3/3 [=====] - 0s 6ms/step - loss: 0.6359
Epoch 15/200
3/3 [=====] - 0s 7ms/step - loss: 0.6342
Epoch 16/200
3/3 [=====] - 0s 9ms/step - loss: 0.6325
Epoch 17/200
3/3 [=====] - 0s 12ms/step - loss: 0.6307
Epoch 18/200
3/3 [=====] - 0s 25ms/step - loss: 0.6289
Epoch 19/200
3/3 [=====] - 0s 20ms/step - loss: 0.6271
Epoch 20/200
3/3 [=====] - 0s 16ms/step - loss: 0.6255
Epoch 21/200
3/3 [=====] - 0s 13ms/step - loss: 0.6238
Epoch 22/200
3/3 [=====] - 0s 6ms/step - loss: 0.6222
Epoch 23/200
3/3 [=====] - 0s 7ms/step - loss: 0.6206
Epoch 24/200
3/3 [=====] - 0s 9ms/step - loss: 0.6191
Epoch 25/200
3/3 [=====] - 0s 6ms/step - loss: 0.6174
Epoch 26/200
3/3 [=====] - 0s 10ms/step - loss: 0.6159
Epoch 27/200
3/3 [=====] - 0s 12ms/step - loss: 0.6143
Epoch 28/200
3/3 [=====] - 0s 11ms/step - loss: 0.6127
Epoch 29/200
3/3 [=====] - 0s 8ms/step - loss: 0.6112
Epoch 30/200
3/3 [=====] - 0s 9ms/step - loss: 0.6097
Epoch 31/200
3/3 [=====] - 0s 22ms/step - loss: 0.6082
Epoch 32/200
3/3 [=====] - 0s 17ms/step - loss: 0.6068
Epoch 33/200
3/3 [=====] - 0s 11ms/step - loss: 0.6054
Epoch 34/200
3/3 [=====] - 0s 16ms/step - loss: 0.6040
Epoch 35/200
3/3 [=====] - 0s 18ms/step - loss: 0.6025

Epoch 36/200
3/3 [=====] - 0s 14ms/step - loss: 0.6011
Epoch 37/200
3/3 [=====] - 0s 19ms/step - loss: 0.5997
Epoch 38/200
3/3 [=====] - 0s 19ms/step - loss: 0.5984
Epoch 39/200
3/3 [=====] - 0s 20ms/step - loss: 0.5971
Epoch 40/200
3/3 [=====] - 0s 19ms/step - loss: 0.5957
Epoch 41/200
3/3 [=====] - 0s 13ms/step - loss: 0.5943
Epoch 42/200
3/3 [=====] - 0s 13ms/step - loss: 0.5929
Epoch 43/200
3/3 [=====] - 0s 11ms/step - loss: 0.5916
Epoch 44/200
3/3 [=====] - 0s 9ms/step - loss: 0.5903
Epoch 45/200
3/3 [=====] - 0s 12ms/step - loss: 0.5890
Epoch 46/200
3/3 [=====] - 0s 12ms/step - loss: 0.5878
Epoch 47/200
3/3 [=====] - 0s 7ms/step - loss: 0.5864
Epoch 48/200
3/3 [=====] - 0s 10ms/step - loss: 0.5852
Epoch 49/200
3/3 [=====] - 0s 7ms/step - loss: 0.5839
Epoch 50/200
3/3 [=====] - 0s 7ms/step - loss: 0.5827
Epoch 51/200
3/3 [=====] - 0s 9ms/step - loss: 0.5815
Epoch 52/200
3/3 [=====] - 0s 18ms/step - loss: 0.5803
Epoch 53/200
3/3 [=====] - 0s 10ms/step - loss: 0.5792
Epoch 54/200
3/3 [=====] - 0s 10ms/step - loss: 0.5780
Epoch 55/200
3/3 [=====] - 0s 34ms/step - loss: 0.5769
Epoch 56/200
3/3 [=====] - 0s 18ms/step - loss: 0.5758
Epoch 57/200
3/3 [=====] - 0s 14ms/step - loss: 0.5746
Epoch 58/200
3/3 [=====] - 0s 21ms/step - loss: 0.5735
Epoch 59/200
3/3 [=====] - 0s 4ms/step - loss: 0.5724

Epoch 60/200
3/3 [=====] - 0s 8ms/step - loss: 0.5713
Epoch 61/200
3/3 [=====] - 0s 22ms/step - loss: 0.5703
Epoch 62/200
3/3 [=====] - 0s 22ms/step - loss: 0.5691
Epoch 63/200
3/3 [=====] - 0s 19ms/step - loss: 0.5681
Epoch 64/200
3/3 [=====] - 0s 25ms/step - loss: 0.5670
Epoch 65/200
3/3 [=====] - 0s 12ms/step - loss: 0.5660
Epoch 66/200
3/3 [=====] - 0s 13ms/step - loss: 0.5649
Epoch 67/200
3/3 [=====] - 0s 15ms/step - loss: 0.5638
Epoch 68/200
3/3 [=====] - 0s 18ms/step - loss: 0.5628
Epoch 69/200
3/3 [=====] - 0s 14ms/step - loss: 0.5618
Epoch 70/200
3/3 [=====] - 0s 10ms/step - loss: 0.5608
Epoch 71/200
3/3 [=====] - 0s 9ms/step - loss: 0.5598
Epoch 72/200
3/3 [=====] - 0s 10ms/step - loss: 0.5588
Epoch 73/200
3/3 [=====] - 0s 10ms/step - loss: 0.5578
Epoch 74/200
3/3 [=====] - 0s 12ms/step - loss: 0.5567
Epoch 75/200
3/3 [=====] - 0s 15ms/step - loss: 0.5557
Epoch 76/200
3/3 [=====] - 0s 21ms/step - loss: 0.5547
Epoch 77/200
3/3 [=====] - 0s 20ms/step - loss: 0.5537
Epoch 78/200
3/3 [=====] - 0s 16ms/step - loss: 0.5528
Epoch 79/200
3/3 [=====] - 0s 12ms/step - loss: 0.5518
Epoch 80/200
3/3 [=====] - 0s 14ms/step - loss: 0.5508
Epoch 81/200
3/3 [=====] - 0s 5ms/step - loss: 0.5498
Epoch 82/200
3/3 [=====] - 0s 24ms/step - loss: 0.5488
Epoch 83/200
3/3 [=====] - 0s 7ms/step - loss: 0.5478

Epoch 84/200
3/3 [=====] - 0s 9ms/step - loss: 0.5468
Epoch 85/200
3/3 [=====] - 0s 10ms/step - loss: 0.5459
Epoch 86/200
3/3 [=====] - 0s 8ms/step - loss: 0.5449
Epoch 87/200
3/3 [=====] - 0s 11ms/step - loss: 0.5440
Epoch 88/200
3/3 [=====] - 0s 14ms/step - loss: 0.5430
Epoch 89/200
3/3 [=====] - 0s 16ms/step - loss: 0.5421
Epoch 90/200
3/3 [=====] - 0s 32ms/step - loss: 0.5412
Epoch 91/200
3/3 [=====] - 0s 12ms/step - loss: 0.5402
Epoch 92/200
3/3 [=====] - 0s 9ms/step - loss: 0.5393
Epoch 93/200
3/3 [=====] - 0s 13ms/step - loss: 0.5385
Epoch 94/200
3/3 [=====] - 0s 16ms/step - loss: 0.5376
Epoch 95/200
3/3 [=====] - 0s 9ms/step - loss: 0.5368
Epoch 96/200
3/3 [=====] - 0s 11ms/step - loss: 0.5358
Epoch 97/200
3/3 [=====] - 0s 16ms/step - loss: 0.5349
Epoch 98/200
3/3 [=====] - 0s 13ms/step - loss: 0.5342
Epoch 99/200
3/3 [=====] - 0s 13ms/step - loss: 0.5332
Epoch 100/200
3/3 [=====] - 0s 14ms/step - loss: 0.5323
Epoch 101/200
3/3 [=====] - 0s 19ms/step - loss: 0.5315
Epoch 102/200
3/3 [=====] - 0s 14ms/step - loss: 0.5306
Epoch 103/200
3/3 [=====] - 0s 8ms/step - loss: 0.5297
Epoch 104/200
3/3 [=====] - 0s 12ms/step - loss: 0.5289
Epoch 105/200
3/3 [=====] - 0s 10ms/step - loss: 0.5280
Epoch 106/200
3/3 [=====] - 0s 12ms/step - loss: 0.5272
Epoch 107/200
3/3 [=====] - 0s 17ms/step - loss: 0.5263

Epoch 108/200
3/3 [=====] - 0s 18ms/step - loss: 0.5254
Epoch 109/200
3/3 [=====] - 0s 14ms/step - loss: 0.5245
Epoch 110/200
3/3 [=====] - 0s 15ms/step - loss: 0.5237
Epoch 111/200
3/3 [=====] - 0s 13ms/step - loss: 0.5228
Epoch 112/200
3/3 [=====] - 0s 13ms/step - loss: 0.5220
Epoch 113/200
3/3 [=====] - 0s 14ms/step - loss: 0.5212
Epoch 114/200
3/3 [=====] - 0s 11ms/step - loss: 0.5203
Epoch 115/200
3/3 [=====] - 0s 13ms/step - loss: 0.5195
Epoch 116/200
3/3 [=====] - 0s 20ms/step - loss: 0.5187
Epoch 117/200
3/3 [=====] - 0s 29ms/step - loss: 0.5178
Epoch 118/200
3/3 [=====] - 0s 15ms/step - loss: 0.5169
Epoch 119/200
3/3 [=====] - 0s 9ms/step - loss: 0.5162
Epoch 120/200
3/3 [=====] - 0s 10ms/step - loss: 0.5154
Epoch 121/200
3/3 [=====] - 0s 12ms/step - loss: 0.5145
Epoch 122/200
3/3 [=====] - 0s 39ms/step - loss: 0.5137
Epoch 123/200
3/3 [=====] - 0s 8ms/step - loss: 0.5129
Epoch 124/200
3/3 [=====] - 0s 10ms/step - loss: 0.5120
Epoch 125/200
3/3 [=====] - 0s 52ms/step - loss: 0.5112
Epoch 126/200
3/3 [=====] - 0s 21ms/step - loss: 0.5104
Epoch 127/200
3/3 [=====] - 0s 10ms/step - loss: 0.5096
Epoch 128/200
3/3 [=====] - 0s 14ms/step - loss: 0.5087
Epoch 129/200
3/3 [=====] - 0s 28ms/step - loss: 0.5079
Epoch 130/200
3/3 [=====] - 0s 48ms/step - loss: 0.5071
Epoch 131/200
3/3 [=====] - 0s 14ms/step - loss: 0.5062

Epoch 132/200
3/3 [=====] - 0s 15ms/step - loss: 0.5054
Epoch 133/200
3/3 [=====] - 0s 18ms/step - loss: 0.5046
Epoch 134/200
3/3 [=====] - 0s 15ms/step - loss: 0.5037
Epoch 135/200
3/3 [=====] - 0s 14ms/step - loss: 0.5029
Epoch 136/200
3/3 [=====] - 0s 13ms/step - loss: 0.5021
Epoch 137/200
3/3 [=====] - 0s 11ms/step - loss: 0.5012
Epoch 138/200
3/3 [=====] - 0s 16ms/step - loss: 0.5004
Epoch 139/200
3/3 [=====] - 0s 14ms/step - loss: 0.4996
Epoch 140/200
3/3 [=====] - 0s 10ms/step - loss: 0.4988
Epoch 141/200
3/3 [=====] - 0s 10ms/step - loss: 0.4981
Epoch 142/200
3/3 [=====] - 0s 12ms/step - loss: 0.4971
Epoch 143/200
3/3 [=====] - 0s 9ms/step - loss: 0.4964
Epoch 144/200
3/3 [=====] - 0s 23ms/step - loss: 0.4955
Epoch 145/200
3/3 [=====] - 0s 16ms/step - loss: 0.4948
Epoch 146/200
3/3 [=====] - 0s 15ms/step - loss: 0.4939
Epoch 147/200
3/3 [=====] - 0s 17ms/step - loss: 0.4931
Epoch 148/200
3/3 [=====] - 0s 14ms/step - loss: 0.4923
Epoch 149/200
3/3 [=====] - 0s 18ms/step - loss: 0.4916
Epoch 150/200
3/3 [=====] - 0s 10ms/step - loss: 0.4907
Epoch 151/200
3/3 [=====] - 0s 6ms/step - loss: 0.4899
Epoch 152/200
3/3 [=====] - 0s 7ms/step - loss: 0.4891
Epoch 153/200
3/3 [=====] - 0s 9ms/step - loss: 0.4883
Epoch 154/200
3/3 [=====] - 0s 9ms/step - loss: 0.4875
Epoch 155/200
3/3 [=====] - 0s 10ms/step - loss: 0.4867

Epoch 156/200
3/3 [=====] - 0s 8ms/step - loss: 0.4858
Epoch 157/200
3/3 [=====] - 0s 9ms/step - loss: 0.4850
Epoch 158/200
3/3 [=====] - 0s 11ms/step - loss: 0.4842
Epoch 159/200
3/3 [=====] - 0s 11ms/step - loss: 0.4834
Epoch 160/200
3/3 [=====] - 0s 8ms/step - loss: 0.4827
Epoch 161/200
3/3 [=====] - 0s 9ms/step - loss: 0.4818
Epoch 162/200
3/3 [=====] - 0s 19ms/step - loss: 0.4811
Epoch 163/200
3/3 [=====] - 0s 13ms/step - loss: 0.4802
Epoch 164/200
3/3 [=====] - 0s 12ms/step - loss: 0.4795
Epoch 165/200
3/3 [=====] - 0s 11ms/step - loss: 0.4787
Epoch 166/200
3/3 [=====] - 0s 19ms/step - loss: 0.4780
Epoch 167/200
3/3 [=====] - 0s 10ms/step - loss: 0.4772
Epoch 168/200
3/3 [=====] - 0s 9ms/step - loss: 0.4763
Epoch 169/200
3/3 [=====] - 0s 9ms/step - loss: 0.4756
Epoch 170/200
3/3 [=====] - 0s 16ms/step - loss: 0.4749
Epoch 171/200
3/3 [=====] - 0s 10ms/step - loss: 0.4740
Epoch 172/200
3/3 [=====] - 0s 7ms/step - loss: 0.4734
Epoch 173/200
3/3 [=====] - 0s 10ms/step - loss: 0.4725
Epoch 174/200
3/3 [=====] - 0s 10ms/step - loss: 0.4717
Epoch 175/200
3/3 [=====] - 0s 9ms/step - loss: 0.4709
Epoch 176/200
3/3 [=====] - 0s 10ms/step - loss: 0.4701
Epoch 177/200
3/3 [=====] - 0s 14ms/step - loss: 0.4693
Epoch 178/200
3/3 [=====] - 0s 11ms/step - loss: 0.4686
Epoch 179/200
3/3 [=====] - 0s 11ms/step - loss: 0.4678

Epoch 180/200
 3/3 [=====] - 0s 10ms/step - loss: 0.4670
 Epoch 181/200
 3/3 [=====] - 0s 10ms/step - loss: 0.4663
 Epoch 182/200
 3/3 [=====] - 0s 9ms/step - loss: 0.4655
 Epoch 183/200
 3/3 [=====] - 0s 11ms/step - loss: 0.4647
 Epoch 184/200
 3/3 [=====] - 0s 10ms/step - loss: 0.4639
 Epoch 185/200
 3/3 [=====] - 0s 11ms/step - loss: 0.4631
 Epoch 186/200
 3/3 [=====] - 0s 13ms/step - loss: 0.4624
 Epoch 187/200
 3/3 [=====] - 0s 11ms/step - loss: 0.4616
 Epoch 188/200
 3/3 [=====] - 0s 10ms/step - loss: 0.4609
 Epoch 189/200
 3/3 [=====] - 0s 10ms/step - loss: 0.4601
 Epoch 190/200
 3/3 [=====] - 0s 12ms/step - loss: 0.4593
 Epoch 191/200
 3/3 [=====] - 0s 12ms/step - loss: 0.4585
 Epoch 192/200
 3/3 [=====] - 0s 19ms/step - loss: 0.4578
 Epoch 193/200
 3/3 [=====] - 0s 14ms/step - loss: 0.4570
 Epoch 194/200
 3/3 [=====] - 0s 12ms/step - loss: 0.4563
 Epoch 195/200
 3/3 [=====] - 0s 10ms/step - loss: 0.4555
 Epoch 196/200
 3/3 [=====] - 0s 10ms/step - loss: 0.4548
 Epoch 197/200
 3/3 [=====] - 0s 9ms/step - loss: 0.4540
 Epoch 198/200
 3/3 [=====] - 0s 9ms/step - loss: 0.4533
 Epoch 199/200
 3/3 [=====] - 0s 15ms/step - loss: 0.4525
 Epoch 200/200
 3/3 [=====] - 0s 11ms/step - loss: 0.4518
 3602/3602 [=====] - 6s 2ms/step

Decision Boundary

