Worksheet 23

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Topics

- Tuning Neural Networks

Tuning Neural Networks

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

In [ ]:
```python
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 'bgrcmyk'])

# 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
    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)
```

```python
# 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()
```
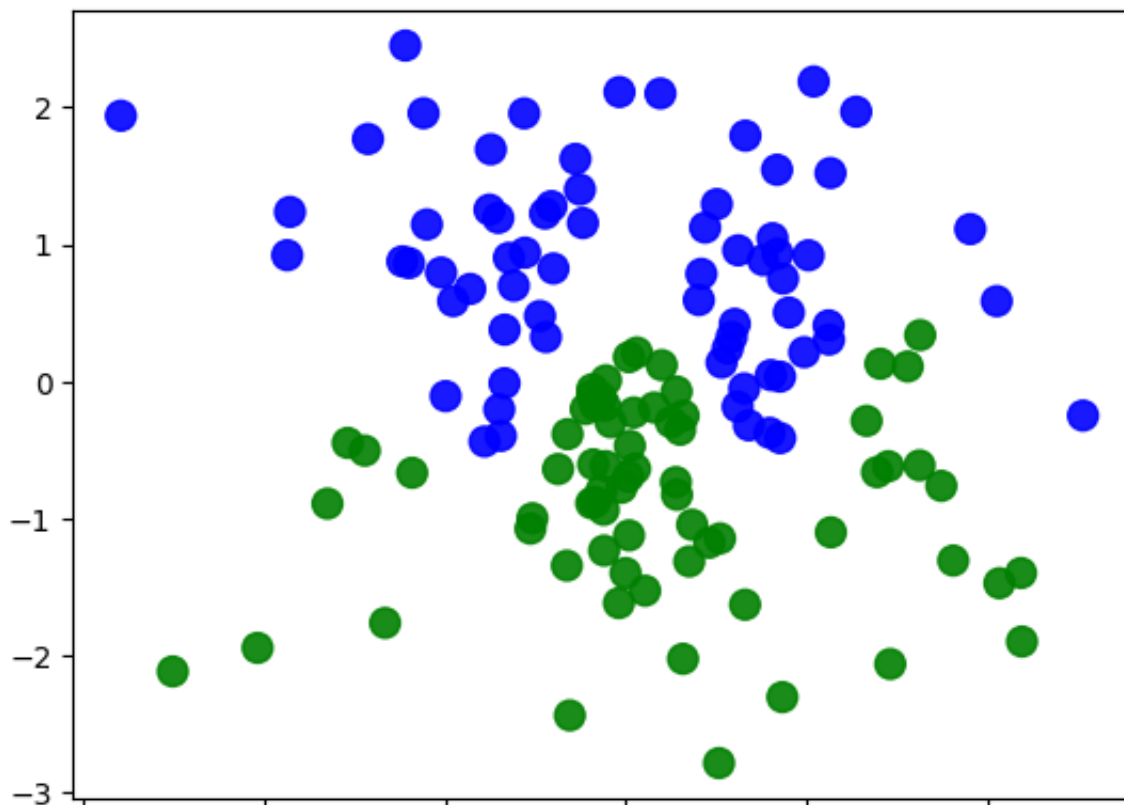
```
          −3           −2           −1            0            1            2

Epoch 1/200
3/3 [==============================] - 1s 8ms/step - loss: 0.7372
Epoch 2/200
3/3 [==============================] - 0s 5ms/step - loss: 0.7330
Epoch 3/200
3/3 [==============================] - 0s 4ms/step - loss: 0.7301
Epoch 4/200
3/3 [==============================] - 0s 4ms/step - loss: 0.7277
Epoch 5/200
3/3 [==============================] - 0s 5ms/step - loss: 0.7255
Epoch 6/200
3/3 [==============================] - 0s 5ms/step - loss: 0.7234
Epoch 7/200
3/3 [==============================] - 0s 4ms/step - loss: 0.7215
Epoch 8/200
3/3 [==============================] - 0s 4ms/step - loss: 0.7197
Epoch 9/200
3/3 [==============================] - 0s 4ms/step - loss: 0.7179
Epoch 10/200
3/3 [==============================] - 0s 4ms/step - loss: 0.7161
Epoch 11/200
3/3 [==============================] - 0s 4ms/step - loss: 0.7143
Epoch 12/200
3/3 [==============================] - 0s 4ms/step - loss: 0.7127
Epoch 13/200
3/3 [==============================] - 0s 4ms/step - loss: 0.7110
Epoch 14/200
3/3 [==============================] - 0s 5ms/step - loss: 0.7094
Epoch 15/200
3/3 [==============================] - 0s 6ms/step - loss: 0.7079
Epoch 16/200
3/3 [==============================] - 0s 7ms/step - loss: 0.7064
Epoch 17/200
3/3 [==============================] - 0s 6ms/step - loss: 0.7048
Epoch 18/200
3/3 [==============================] - 0s 6ms/step - loss: 0.7033
Epoch 19/200
3/3 [==============================] - 0s 5ms/step - loss: 0.7016
Epoch 20/200
3/3 [==============================] - 0s 7ms/step - loss: 0.7002
Epoch 21/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6986
Epoch 22/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6972
Epoch 23/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6957
Epoch 24/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6944
Epoch 25/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6929
Epoch 26/200
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3/3 [==============================] - 0s 5ms/step - loss: 0.6915
Epoch 27/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6900
Epoch 28/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6886
Epoch 29/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6872
Epoch 30/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6859
Epoch 31/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6845
Epoch 32/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6832
Epoch 33/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6819
Epoch 34/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6806
Epoch 35/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6793
Epoch 36/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6781
Epoch 37/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6768
Epoch 38/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6755
Epoch 39/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6743
Epoch 40/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6730
Epoch 41/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6718
Epoch 42/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6705
Epoch 43/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6692
Epoch 44/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6681
Epoch 45/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6668
Epoch 46/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6657
Epoch 47/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6644
Epoch 48/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6633
Epoch 49/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6620
Epoch 50/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6608
Epoch 51/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6597
Epoch 52/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6586
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Epoch 53/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6575
Epoch 54/200
3/3 [==============================] - 0s 7ms/step - loss: 0.6564
Epoch 55/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6553
Epoch 56/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6542
Epoch 57/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6531
Epoch 58/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6521
Epoch 59/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6509
Epoch 60/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6498
Epoch 61/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6488
Epoch 62/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6477
Epoch 63/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6467
Epoch 64/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6456
Epoch 65/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6446
Epoch 66/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6435
Epoch 67/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6425
Epoch 68/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6415
Epoch 69/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6404
Epoch 70/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6394
Epoch 71/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6385
Epoch 72/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6374
Epoch 73/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6364
Epoch 74/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6353
Epoch 75/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6343
Epoch 76/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6333
Epoch 77/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6323
Epoch 78/200
3/3 [==============================] - 0s 7ms/step - loss: 0.6313
Epoch 79/200
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3/3 [==============================] - 0s 4ms/step - loss: 0.6304
Epoch 80/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6293
Epoch 81/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6284
Epoch 82/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6273
Epoch 83/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6263
Epoch 84/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6253
Epoch 85/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6243
Epoch 86/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6233
Epoch 87/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6223
Epoch 88/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6213
Epoch 89/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6203
Epoch 90/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6194
Epoch 91/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6184
Epoch 92/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6174
Epoch 93/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6164
Epoch 94/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6155
Epoch 95/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6146
Epoch 96/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6136
Epoch 97/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6127
Epoch 98/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6119
Epoch 99/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6109
Epoch 100/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6100
Epoch 101/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6091
Epoch 102/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6082
Epoch 103/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6073
Epoch 104/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6064
Epoch 105/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6055
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Epoch 106/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6047
Epoch 107/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6038
Epoch 108/200
3/3 [==============================] - 0s 5ms/step - loss: 0.6028
Epoch 109/200
3/3 [==============================] - 0s 6ms/step - loss: 0.6019
Epoch 110/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6010
Epoch 111/200
3/3 [==============================] - 0s 4ms/step - loss: 0.6001
Epoch 112/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5992
Epoch 113/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5983
Epoch 114/200
3/3 [==============================] - 0s 3ms/step - loss: 0.5974
Epoch 115/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5966
Epoch 116/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5957
Epoch 117/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5948
Epoch 118/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5938
Epoch 119/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5931
Epoch 120/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5922
Epoch 121/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5913
Epoch 122/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5904
Epoch 123/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5895
Epoch 124/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5887
Epoch 125/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5878
Epoch 126/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5869
Epoch 127/200
3/3 [==============================] - 0s 6ms/step - loss: 0.5861
Epoch 128/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5852
Epoch 129/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5843
Epoch 130/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5834
Epoch 131/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5825
Epoch 132/200
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3/3 [==============================] - 0s 6ms/step - loss: 0.5816
Epoch 133/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5807
Epoch 134/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5798
Epoch 135/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5789
Epoch 136/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5781
Epoch 137/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5771
Epoch 138/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5762
Epoch 139/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5753
Epoch 140/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5745
Epoch 141/200
3/3 [==============================] - 0s 8ms/step - loss: 0.5738
Epoch 142/200
3/3 [==============================] - 0s 7ms/step - loss: 0.5727
Epoch 143/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5720
Epoch 144/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5711
Epoch 145/200
3/3 [==============================] - 0s 6ms/step - loss: 0.5703
Epoch 146/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5694
Epoch 147/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5686
Epoch 148/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5677
Epoch 149/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5670
Epoch 150/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5661
Epoch 151/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5652
Epoch 152/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5644
Epoch 153/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5635
Epoch 154/200
3/3 [==============================] - 0s 8ms/step - loss: 0.5626
Epoch 155/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5617
Epoch 156/200
3/3 [==============================] - 0s 6ms/step - loss: 0.5608
Epoch 157/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5600
Epoch 158/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5591
```

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Epoch 159/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5582
Epoch 160/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5575
Epoch 161/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5565
Epoch 162/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5558
Epoch 163/200
3/3 [==============================] - 0s 6ms/step - loss: 0.5549
Epoch 164/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5541
Epoch 165/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5533
Epoch 166/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5525
Epoch 167/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5517
Epoch 168/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5509
Epoch 169/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5500
Epoch 170/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5493
Epoch 171/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5484
Epoch 172/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5477
Epoch 173/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5468
Epoch 174/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5460
Epoch 175/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5452
Epoch 176/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5443
Epoch 177/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5435
Epoch 178/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5427
Epoch 179/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5419
Epoch 180/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5411
Epoch 181/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5403
Epoch 182/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5395
Epoch 183/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5387
Epoch 184/200
3/3 [==============================] - 0s 9ms/step - loss: 0.5379
Epoch 185/200
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3/3 [==============================] - 0s 4ms/step - loss: 0.5371
Epoch 186/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5363
Epoch 187/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5354
Epoch 188/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5347
Epoch 189/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5338
Epoch 190/200
3/3 [==============================] - 0s 6ms/step - loss: 0.5330
Epoch 191/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5321
Epoch 192/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5314
Epoch 193/200
3/3 [==============================] - 0s 5ms/step - loss: 0.5305
Epoch 194/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5297
Epoch 195/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5289
Epoch 196/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5281
Epoch 197/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5273
Epoch 198/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5265
Epoch 199/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5257
Epoch 200/200
3/3 [==============================] - 0s 4ms/step - loss: 0.5249
3602/3602 [==============================] - 5s 1ms/step
```

Decision Boundary