Лабораторная работа 3

Многослойные сети. Алгоритм обратного распространения ошибки

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Цель работы: исследование свойств многослойной нейронной сети прямого распространения и алгоритмов ее обучения, применение сети в задачах классификации и аппроксимации функции

Вариант 19

[1]:
```
import keras
import tensorflow as tf
from keras.layers import *
import matplotlib.pyplot as plt
import numpy as np
```

[ ]:
```
!pip install matplotlib --upgrade
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-
wheels/public/simple/
Requirement already satisfied: matplotlib in /usr/local/lib/python3.7/dist-
packages (3.5.3)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.7/dist-packages (from matplotlib) (4.37.4)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.7/dist-
packages (from matplotlib) (21.3)
Requirement already satisfied: numpy>=1.17 in /usr/local/lib/python3.7/dist-
packages (from matplotlib) (1.21.6)
Requirement already satisfied: pillow>=6.2.0 in /usr/local/lib/python3.7/dist-
packages (from matplotlib) (7.1.2)
Requirement already satisfied: python-dateutil>=2.7 in
/usr/local/lib/python3.7/dist-packages (from matplotlib) (2.8.2)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.7/dist-
packages (from matplotlib) (0.11.0)
Requirement already satisfied: pyparsing>=2.2.1 in
/usr/local/lib/python3.7/dist-packages (from matplotlib) (3.0.9)
Requirement already satisfied: kiwisolver>=1.0.1 in
/usr/local/lib/python3.7/dist-packages (from matplotlib) (1.4.4)
Requirement already satisfied: typing-extensions in
/usr/local/lib/python3.7/dist-packages (from kiwisolver>=1.0.1->matplotlib)
(4.1.1)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.7/dist-
packages (from python-dateutil>=2.7->matplotlib) (1.15.0)
```

Классификация

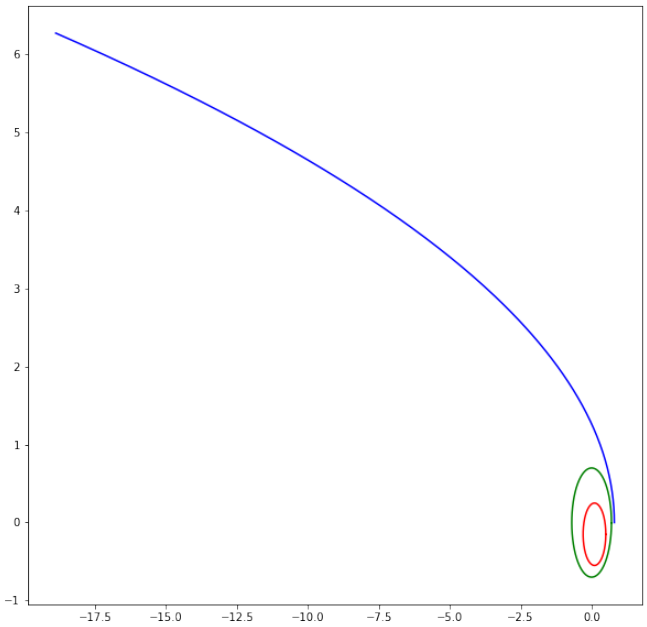
[ ]:
```
# Уравнение эллипса в параметрическом виде.
def ellipse(t, a, b, x0, y0):
    x = x0 + a * np.cos(t)
    y = y0 + b * np.sin(t)
    return x, y

# Уравнение параболы в параметрическом виде.
def parabola(t, p, x0, y0):
    x = x0 + t ** 2 / (2. * p)
    y = y0 + t
    return x, y

# Функция вращения фигуры на заданный угол.
def rotate(x, y, alpha):
    xr = x * np.cos(alpha) - y * np.sin(alpha)
    yr = x * np.sin(alpha) + y * np.cos(alpha)
    return xr, yr
```

[ ]:
```
# Эллипс
a1 = 0.4
b1 = 0.4
alpha1 = 0
x01 = 0.1
y01 = -0.15

# Эллипс
a2 = 0.7
b2 = 0.7
alpha2 = 0
x02 = 0
y02 = 0

# Парабола
p = -1
alpha3 = 0
x03 = 0.8
y03 = 0
```

[ ]:
```
t = np.arange(0, 2 * np.pi, 0.025)
```

[ ]:
```
fig1x, fig1y = ellipse(t, a1, b1, x01, y01)
fig1x, fig1y = rotate(fig1x, fig1y, alpha1)

fig2x, fig2y = ellipse(t, a2, b2, x02, y02)
fig2x, fig2y = rotate(fig2x, fig2y, alpha2)

fig3x, fig3y = parabola(t, p, x03, y03)
```

```
fig3x, fig3y = rotate(fig3x, fig3y, alpha3)

figure = plt.figure(figsize = (10, 10))

plt.plot(fig1x, fig1y, c = 'r')
plt.plot(fig2x, fig2y, c = 'g')
plt.plot(fig3x, fig3y, c = 'b')
plt.show()
```



[ ]:
```
datax = np.concatenate((fig1x, fig2x, fig3x), axis=0)
datay = np.concatenate((fig1y, fig2y, fig3y), axis=0)


data = np.array([datax, datay])

l1 = [[1, 0, 0] for _ in range(len(fig1x))]
l2 = [[0, 1, 0] for _ in range(len(fig2x))]
l3 = [[0, 0, 1] for _ in range(len(fig3x))]

labels = np.array(l1 + l2 + l3)

data = data.transpose()
```

```
(756,)
```

[ ]:
```
from sklearn.model_selection import train_test_split

train, test, train_labels, test_labels = train_test_split(data, labels, test_size =␣
 ↪0.2, random_state = 10,shuffle = True)
```

[ ]:
```
model = keras.models.Sequential()

model.add(Dense(10, input_dim = 2, activation = "tanh",  kernel_initializer = keras.
 ↪initializers.RandomNormal(stddev = 0.01), bias_initializer = keras.initializers.
 ↪Zeros()))
model.add(Dense(20, activation = "tanh"))
model.add(Dense(10, activation = "tanh"))
model.add(Dense(3, activation = "sigmoid"))

model.compile(tf.keras.optimizers.SGD(0.05), 'mse')

hist = model.fit(train, train_labels, batch_size = 1, epochs = 100)
```

```
Epoch 1/100
604/604 [==============================] - 2s 3ms/step - loss: 0.1601
Epoch 2/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1370
Epoch 3/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1319
Epoch 4/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1282
Epoch 5/100
604/604 [==============================] - 2s 3ms/step - loss: 0.1261
Epoch 6/100
604/604 [==============================] - 2s 3ms/step - loss: 0.1233
Epoch 7/100
604/604 [==============================] - 2s 3ms/step - loss: 0.1208
Epoch 8/100
604/604 [==============================] - 2s 4ms/step - loss: 0.1193
Epoch 9/100
604/604 [==============================] - 2s 4ms/step - loss: 0.1172
Epoch 10/100
604/604 [==============================] - 2s 4ms/step - loss: 0.1159
Epoch 11/100
604/604 [==============================] - 2s 4ms/step - loss: 0.1139
Epoch 12/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1121
Epoch 13/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1110
Epoch 14/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1098
Epoch 15/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1089
Epoch 16/100
```

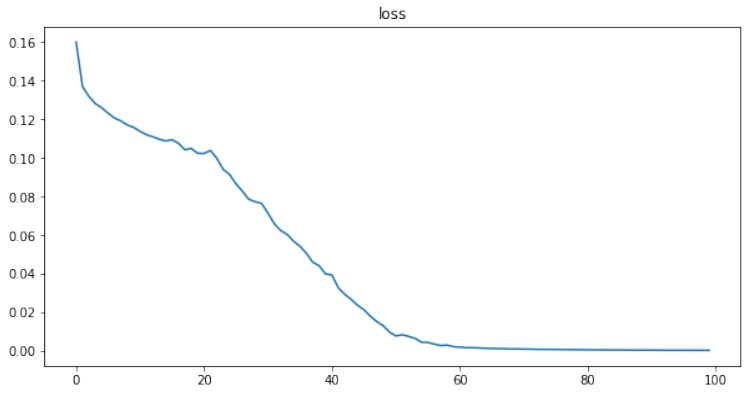
```
604/604 [==============================] - 1s 2ms/step - loss: 0.1096
Epoch 17/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1077
Epoch 18/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1043
Epoch 19/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1051
Epoch 20/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1025
Epoch 21/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1024
Epoch 22/100
604/604 [==============================] - 1s 2ms/step - loss: 0.1040
Epoch 23/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0999
Epoch 24/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0942
Epoch 25/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0915
Epoch 26/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0867
Epoch 27/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0829
Epoch 28/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0787
Epoch 29/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0774
Epoch 30/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0766
Epoch 31/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0715
Epoch 32/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0661
Epoch 33/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0625
Epoch 34/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0606
Epoch 35/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0570
Epoch 36/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0544
Epoch 37/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0508
Epoch 38/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0462
Epoch 39/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0443
Epoch 40/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0401
```

```
Epoch 41/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0395
Epoch 42/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0329
Epoch 43/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0295
Epoch 44/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0269
Epoch 45/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0239
Epoch 46/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0216
Epoch 47/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0182
Epoch 48/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0155
Epoch 49/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0133
Epoch 50/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0100
Epoch 51/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0080
Epoch 52/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0086
Epoch 53/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0077
Epoch 54/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0067
Epoch 55/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0047
Epoch 56/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0046
Epoch 57/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0038
Epoch 58/100
604/604 [==============================] - 2s 3ms/step - loss: 0.0030
Epoch 59/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0032
Epoch 60/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0024
Epoch 61/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0022
Epoch 62/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0019
Epoch 63/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0019
Epoch 64/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0017
Epoch 65/100
```

```
604/604 [==============================] - 1s 2ms/step - loss: 0.0016
Epoch 66/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 67/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0014
Epoch 68/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 69/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 70/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 71/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 72/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 73/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0010
Epoch 74/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0010
Epoch 75/100
604/604 [==============================] - 1s 2ms/step - loss: 0.0010
Epoch 76/100
604/604 [==============================] - 1s 2ms/step - loss: 9.5529e-04
Epoch 77/100
604/604 [==============================] - 1s 2ms/step - loss: 9.0708e-04
Epoch 78/100
604/604 [==============================] - 1s 2ms/step - loss: 8.9844e-04
Epoch 79/100
604/604 [==============================] - 1s 2ms/step - loss: 8.5914e-04
Epoch 80/100
604/604 [==============================] - 1s 2ms/step - loss: 8.4211e-04
Epoch 81/100
604/604 [==============================] - 1s 2ms/step - loss: 7.9347e-04
Epoch 82/100
604/604 [==============================] - 1s 2ms/step - loss: 7.9176e-04
Epoch 83/100
604/604 [==============================] - 1s 2ms/step - loss: 7.4611e-04
Epoch 84/100
604/604 [==============================] - 1s 2ms/step - loss: 7.3905e-04
Epoch 85/100
604/604 [==============================] - 1s 2ms/step - loss: 7.0995e-04
Epoch 86/100
604/604 [==============================] - 1s 2ms/step - loss: 6.9763e-04
Epoch 87/100
604/604 [==============================] - 1s 2ms/step - loss: 6.7816e-04
Epoch 88/100
604/604 [==============================] - 1s 2ms/step - loss: 6.5036e-04
Epoch 89/100
604/604 [==============================] - 1s 2ms/step - loss: 6.4519e-04
```

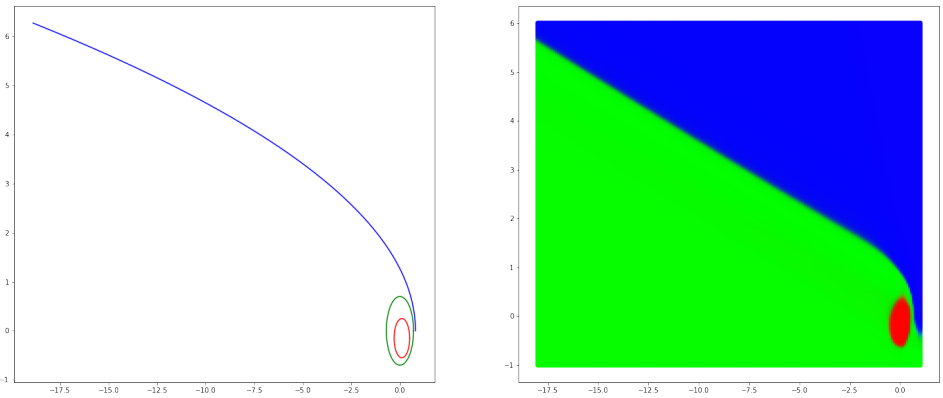
```
Epoch 90/100
604/604 [==============================] - 1s 2ms/step - loss: 6.2581e-04
Epoch 91/100
604/604 [==============================] - 1s 2ms/step - loss: 6.1187e-04
Epoch 92/100
604/604 [==============================] - 1s 2ms/step - loss: 6.0344e-04
Epoch 93/100
604/604 [==============================] - 1s 2ms/step - loss: 5.8378e-04
Epoch 94/100
604/604 [==============================] - 1s 2ms/step - loss: 5.5812e-04
Epoch 95/100
604/604 [==============================] - 1s 2ms/step - loss: 5.6185e-04
Epoch 96/100
604/604 [==============================] - 1s 2ms/step - loss: 5.4588e-04
Epoch 97/100
604/604 [==============================] - 1s 2ms/step - loss: 5.3824e-04
Epoch 98/100
604/604 [==============================] - 1s 2ms/step - loss: 5.2594e-04
Epoch 99/100
604/604 [==============================] - 1s 2ms/step - loss: 5.1615e-04
Epoch 100/100
604/604 [==============================] - 1s 2ms/step - loss: 4.9326e-04
```

[ ]:
```
figure = plt.figure(figsize = (10, 5))
histx = []
for i in range(len(hist.history['loss'])):
    histx.append(i)


plt.plot(histx, hist.history['loss'])
plt.title("loss")
plt.show()
```



[ ]:
```
import itertools

x = np.linspace(-18, 1, 200)
y = np.linspace(-1, 6, 200)

figure = plt.figure(figsize = (24, 10))

ax1 = figure.add_subplot(1, 2, 1)
ax2 = figure.add_subplot(1, 2, 2)

ax1.plot(fig1x, fig1y, c = 'r')
ax1.plot(fig2x, fig2y, c = 'g')
ax1.plot(fig3x, fig3y, c = 'b')

data = np.array(list(itertools.product(x, y)))

xy = data.transpose()

pred = model.predict(data)


ax2.scatter(xy[0], xy[1], c = pred)

plt.show()
```

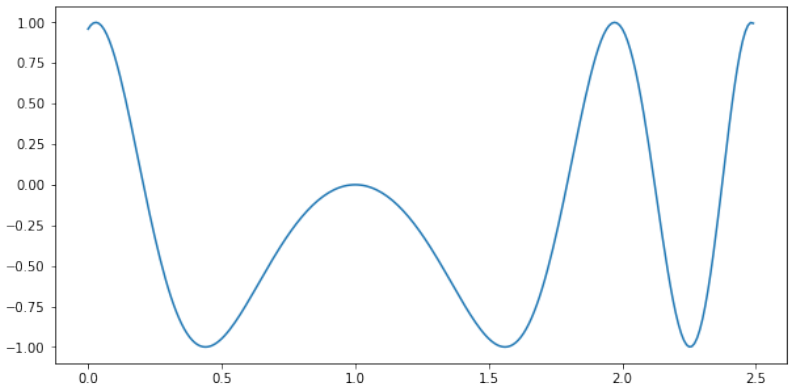
```
1250/1250 [==============================] - 2s 1ms/step
```



Аппроксимация

[ ]:
```
def f(t):
    return np.sin(-5 * t * t + 10 * t - 5)
```

[ ]:
```
t = np.arange(0, 2.5, 0.01)
ft = f(t)


figure = plt.figure(figsize = (10, 5))

plt.plot(t, ft)
plt.show()
```



[ ]:
```
model = keras.models.Sequential()

model.add(Dense(20, input_dim = 1, activation = "tanh",  kernel_initializer = keras.
 ↪initializers.RandomNormal(stddev = 0.01), bias_initializer = keras.initializers.
 ↪Zeros()))
model.add(Dense(80, activation = "tanh"))
model.add(Dense(40, activation = "tanh"))
model.add(Dense(1, activation = "linear"))

model.compile(tf.keras.optimizers.SGD(0.01), 'mse')

hist = model.fit(t, ft, batch_size = 1, epochs = 800, shuffle = True)
```

```
Epoch 1/800
250/250 [==============================] - 1s 2ms/step - loss: 0.4234
Epoch 2/800
250/250 [==============================] - 1s 2ms/step - loss: 0.4099
Epoch 3/800
250/250 [==============================] - 1s 2ms/step - loss: 0.4042
Epoch 4/800
250/250 [==============================] - 0s 2ms/step - loss: 0.4015
Epoch 5/800
250/250 [==============================] - 0s 2ms/step - loss: 0.4081
Epoch 6/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3901
```

```
Epoch 7/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3948
Epoch 8/800
250/250 [==============================] - 1s 2ms/step - loss: 0.4010
Epoch 9/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3998
Epoch 10/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3958
Epoch 11/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3806
Epoch 12/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3962
Epoch 13/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3897
Epoch 14/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3903
Epoch 15/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3910
Epoch 16/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3904
Epoch 17/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3906
Epoch 18/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3936
Epoch 19/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3943
Epoch 20/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3914
Epoch 21/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3931
Epoch 22/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3903
Epoch 23/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3920
Epoch 24/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3863
Epoch 25/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3913
Epoch 26/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3910
Epoch 27/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3825
Epoch 28/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3905
Epoch 29/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3885
Epoch 30/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3902
Epoch 31/800
```

```
250/250 [==============================] - 0s 2ms/step - loss: 0.3919
Epoch 32/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3882
Epoch 33/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3911
Epoch 34/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3877
Epoch 35/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3904
Epoch 36/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3889
Epoch 37/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3906
Epoch 38/800
250/250 [==============================] - 1s 3ms/step - loss: 0.3847
Epoch 39/800
250/250 [==============================] - 1s 3ms/step - loss: 0.3859
Epoch 40/800
250/250 [==============================] - 1s 3ms/step - loss: 0.3879
Epoch 41/800
250/250 [==============================] - 1s 3ms/step - loss: 0.3861
Epoch 42/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3893
Epoch 43/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3894
Epoch 44/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3872
Epoch 45/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3889
Epoch 46/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3874
Epoch 47/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3912
Epoch 48/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3872
Epoch 49/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3839
Epoch 50/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3902
Epoch 51/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3878
Epoch 52/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3858
Epoch 53/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3912
Epoch 54/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3833
Epoch 55/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3876
```

```
Epoch 56/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3842
Epoch 57/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3900
Epoch 58/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3882
Epoch 59/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3888
Epoch 60/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3871
Epoch 61/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3869
Epoch 62/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3863
Epoch 63/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3898
Epoch 64/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3859
Epoch 65/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3898
Epoch 66/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3882
Epoch 67/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3868
Epoch 68/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3872
Epoch 69/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3888
Epoch 70/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3831
Epoch 71/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3888
Epoch 72/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3889
Epoch 73/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3893
Epoch 74/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3881
Epoch 75/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3887
Epoch 76/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3894
Epoch 77/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3857
Epoch 78/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3871
Epoch 79/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3841
Epoch 80/800
```

```
250/250 [==============================] - 0s 2ms/step - loss: 0.3878
Epoch 81/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3873
Epoch 82/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3881
Epoch 83/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3824
Epoch 84/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3885
Epoch 85/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3895
Epoch 86/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3887
Epoch 87/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3866
Epoch 88/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3883
Epoch 89/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3856
Epoch 90/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3884
Epoch 91/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3872
Epoch 92/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3874
Epoch 93/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3881
Epoch 94/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3817
Epoch 95/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3857
Epoch 96/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3872
Epoch 97/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3824
Epoch 98/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3891
Epoch 99/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3882
Epoch 100/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3881
Epoch 101/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3837
Epoch 102/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3875
Epoch 103/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3877
Epoch 104/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3868
```

```
Epoch 105/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3878
Epoch 106/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3859
Epoch 107/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3861
Epoch 108/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3863
Epoch 109/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3891
Epoch 110/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3876
Epoch 111/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3876
Epoch 112/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3864
Epoch 113/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3888
Epoch 114/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3887
Epoch 115/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3882
Epoch 116/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3855
Epoch 117/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3853
Epoch 118/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3886
Epoch 119/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3872
Epoch 120/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3883
Epoch 121/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3866
Epoch 122/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3834
Epoch 123/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3889
Epoch 124/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3882
Epoch 125/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3878
Epoch 126/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3837
Epoch 127/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3840
Epoch 128/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3886
Epoch 129/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.3854
Epoch 130/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3869
Epoch 131/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3887
Epoch 132/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3849
Epoch 133/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3896
Epoch 134/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3855
Epoch 135/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3883
Epoch 136/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3846
Epoch 137/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3822
Epoch 138/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3896
Epoch 139/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3838
Epoch 140/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3854
Epoch 141/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3848
Epoch 142/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3864
Epoch 143/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3858
Epoch 144/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3874
Epoch 145/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3860
Epoch 146/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3853
Epoch 147/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3827
Epoch 148/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3799
Epoch 149/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3823
Epoch 150/800
250/250 [==============================] - 1s 3ms/step - loss: 0.3838
Epoch 151/800
250/250 [==============================] - 1s 3ms/step - loss: 0.3822
Epoch 152/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3810
Epoch 153/800
250/250 [==============================] - 1s 3ms/step - loss: 0.3778
```

```
Epoch 154/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3788
Epoch 155/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3763
Epoch 156/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3754
Epoch 157/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3740
Epoch 158/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3609
Epoch 159/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3671
Epoch 160/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3573
Epoch 161/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3650
Epoch 162/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3609
Epoch 163/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3543
Epoch 164/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3571
Epoch 165/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3530
Epoch 166/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3394
Epoch 167/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3576
Epoch 168/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3555
Epoch 169/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3534
Epoch 170/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3560
Epoch 171/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3557
Epoch 172/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3451
Epoch 173/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3348
Epoch 174/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3496
Epoch 175/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3403
Epoch 176/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3459
Epoch 177/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3449
Epoch 178/800
```

```
250/250 [==============================] - 0s 2ms/step - loss: 0.3412
Epoch 179/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3354
Epoch 180/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3369
Epoch 181/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3332
Epoch 182/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3347
Epoch 183/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3309
Epoch 184/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3338
Epoch 185/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3111
Epoch 186/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3253
Epoch 187/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3228
Epoch 188/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3237
Epoch 189/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3183
Epoch 190/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3186
Epoch 191/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3054
Epoch 192/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3088
Epoch 193/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3129
Epoch 194/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3105
Epoch 195/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3153
Epoch 196/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3072
Epoch 197/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3057
Epoch 198/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3074
Epoch 199/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3005
Epoch 200/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3058
Epoch 201/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3055
Epoch 202/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3051
```

```
Epoch 203/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3039
Epoch 204/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3016
Epoch 205/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3049
Epoch 206/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3020
Epoch 207/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2967
Epoch 208/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3018
Epoch 209/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2994
Epoch 210/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2999
Epoch 211/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2856
Epoch 212/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2898
Epoch 213/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2986
Epoch 214/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2891
Epoch 215/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2880
Epoch 216/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2811
Epoch 217/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2872
Epoch 218/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2804
Epoch 219/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2816
Epoch 220/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2862
Epoch 221/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2861
Epoch 222/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2793
Epoch 223/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2837
Epoch 224/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2842
Epoch 225/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2796
Epoch 226/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2829
Epoch 227/800
```

```
250/250 [==============================] - 0s 2ms/step - loss: 0.2810
Epoch 228/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2841
Epoch 229/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2804
Epoch 230/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2737
Epoch 231/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2836
Epoch 232/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3017
Epoch 233/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2751
Epoch 234/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2926
Epoch 235/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2861
Epoch 236/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2632
Epoch 237/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2742
Epoch 238/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2907
Epoch 239/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2767
Epoch 240/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2733
Epoch 241/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2733
Epoch 242/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2818
Epoch 243/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2722
Epoch 244/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2779
Epoch 245/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2908
Epoch 246/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2905
Epoch 247/800
250/250 [==============================] - 0s 2ms/step - loss: 0.3016
Epoch 248/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2983
Epoch 249/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2756
Epoch 250/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2576
Epoch 251/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2732
```

```
Epoch 252/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2870
Epoch 253/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2855
Epoch 254/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2673
Epoch 255/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2731
Epoch 256/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2707
Epoch 257/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2647
Epoch 258/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2713
Epoch 259/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3095
Epoch 260/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2663
Epoch 261/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2729
Epoch 262/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2732
Epoch 263/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2719
Epoch 264/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2696
Epoch 265/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2786
Epoch 266/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2675
Epoch 267/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2689
Epoch 268/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2804
Epoch 269/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3159
Epoch 270/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2768
Epoch 271/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2620
Epoch 272/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2641
Epoch 273/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2690
Epoch 274/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2694
Epoch 275/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2675
Epoch 276/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.2706
Epoch 277/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2615
Epoch 278/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2791
Epoch 279/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2564
Epoch 280/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2617
Epoch 281/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2607
Epoch 282/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2667
Epoch 283/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2570
Epoch 284/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2485
Epoch 285/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2743
Epoch 286/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2633
Epoch 287/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2567
Epoch 288/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2577
Epoch 289/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2831
Epoch 290/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2550
Epoch 291/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2598
Epoch 292/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2513
Epoch 293/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2489
Epoch 294/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2475
Epoch 295/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2527
Epoch 296/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2517
Epoch 297/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2516
Epoch 298/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2474
Epoch 299/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2338
Epoch 300/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2476
```

```
Epoch 301/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2393
Epoch 302/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2375
Epoch 303/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2391
Epoch 304/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2393
Epoch 305/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2417
Epoch 306/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2381
Epoch 307/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2357
Epoch 308/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2254
Epoch 309/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2317
Epoch 310/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2158
Epoch 311/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2151
Epoch 312/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2163
Epoch 313/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2055
Epoch 314/800
250/250 [==============================] - 0s 2ms/step - loss: 0.2121
Epoch 315/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1939
Epoch 316/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1749
Epoch 317/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1655
Epoch 318/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1517
Epoch 319/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1307
Epoch 320/800
250/250 [==============================] - 0s 2ms/step - loss: 0.1305
Epoch 321/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1238
Epoch 322/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0986
Epoch 323/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1131
Epoch 324/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0861
Epoch 325/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.1025
Epoch 326/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2852
Epoch 327/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2423
Epoch 328/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2521
Epoch 329/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2220
Epoch 330/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2268
Epoch 331/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2323
Epoch 332/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2381
Epoch 333/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2296
Epoch 334/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2271
Epoch 335/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2177
Epoch 336/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2163
Epoch 337/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2042
Epoch 338/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2178
Epoch 339/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2042
Epoch 340/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1798
Epoch 341/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1912
Epoch 342/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1826
Epoch 343/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1813
Epoch 344/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1739
Epoch 345/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1721
Epoch 346/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1406
Epoch 347/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1650
Epoch 348/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1239
Epoch 349/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1148
```

```
Epoch 350/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1188
Epoch 351/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1090
Epoch 352/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1023
Epoch 353/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1170
Epoch 354/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0995
Epoch 355/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0837
Epoch 356/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0789
Epoch 357/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1747
Epoch 358/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1509
Epoch 359/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1317
Epoch 360/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1028
Epoch 361/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1096
Epoch 362/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1121
Epoch 363/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0741
Epoch 364/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0686
Epoch 365/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0745
Epoch 366/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0475
Epoch 367/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1124
Epoch 368/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1479
Epoch 369/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0970
Epoch 370/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0833
Epoch 371/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0783
Epoch 372/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0770
Epoch 373/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0659
Epoch 374/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.0593
Epoch 375/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0575
Epoch 376/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0554
Epoch 377/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0498
Epoch 378/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0540
Epoch 379/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0368
Epoch 380/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0588
Epoch 381/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0287
Epoch 382/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0647
Epoch 383/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0721
Epoch 384/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0745
Epoch 385/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0877
Epoch 386/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0369
Epoch 387/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0354
Epoch 388/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0536
Epoch 389/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0324
Epoch 390/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0349
Epoch 391/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0625
Epoch 392/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1965
Epoch 393/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1757
Epoch 394/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1665
Epoch 395/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1594
Epoch 396/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1427
Epoch 397/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1417
Epoch 398/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1494
```

```
Epoch 399/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1360
Epoch 400/800
250/250 [==============================] - 0s 2ms/step - loss: 0.1413
Epoch 401/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1401
Epoch 402/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1274
Epoch 403/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1326
Epoch 404/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1293
Epoch 405/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1266
Epoch 406/800
250/250 [==============================] - 0s 2ms/step - loss: 0.1296
Epoch 407/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1306
Epoch 408/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1254
Epoch 409/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1147
Epoch 410/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1176
Epoch 411/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1240
Epoch 412/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1147
Epoch 413/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1095
Epoch 414/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1133
Epoch 415/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1072
Epoch 416/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0981
Epoch 417/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1016
Epoch 418/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0985
Epoch 419/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0970
Epoch 420/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0923
Epoch 421/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0889
Epoch 422/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0871
Epoch 423/800
```

```
250/250 [==============================] - 1s 3ms/step - loss: 0.0834
Epoch 424/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0807
Epoch 425/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0716
Epoch 426/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0633
Epoch 427/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0564
Epoch 428/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0535
Epoch 429/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0660
Epoch 430/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0593
Epoch 431/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0646
Epoch 432/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0416
Epoch 433/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0550
Epoch 434/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0501
Epoch 435/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0650
Epoch 436/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0487
Epoch 437/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0403
Epoch 438/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0464
Epoch 439/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0643
Epoch 440/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0414
Epoch 441/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0467
Epoch 442/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0564
Epoch 443/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0265
Epoch 444/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0428
Epoch 445/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0376
Epoch 446/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0191
Epoch 447/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0415
```

```
Epoch 448/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0295
Epoch 449/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0143
Epoch 450/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0552
Epoch 451/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0376
Epoch 452/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0258
Epoch 453/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0296
Epoch 454/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0517
Epoch 455/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0258
Epoch 456/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0525
Epoch 457/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0218
Epoch 458/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0249
Epoch 459/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0423
Epoch 460/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0591
Epoch 461/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0428
Epoch 462/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0179
Epoch 463/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0205
Epoch 464/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0353
Epoch 465/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0201
Epoch 466/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0203
Epoch 467/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0180
Epoch 468/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0161
Epoch 469/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0166
Epoch 470/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0163
Epoch 471/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0556
Epoch 472/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.0158
Epoch 473/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0451
Epoch 474/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0369
Epoch 475/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0169
Epoch 476/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0153
Epoch 477/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0093
Epoch 478/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0133
Epoch 479/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0209
Epoch 480/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0156
Epoch 481/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0540
Epoch 482/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0224
Epoch 483/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0095
Epoch 484/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0194
Epoch 485/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0109
Epoch 486/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0196
Epoch 487/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0062
Epoch 488/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0085
Epoch 489/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0196
Epoch 490/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0190
Epoch 491/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0163
Epoch 492/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0122
Epoch 493/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0063
Epoch 494/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0048
Epoch 495/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0186
Epoch 496/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0072
```

```
Epoch 497/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0404
Epoch 498/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0067
Epoch 499/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0263
Epoch 500/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0135
Epoch 501/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0071
Epoch 502/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0040
Epoch 503/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0130
Epoch 504/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0072
Epoch 505/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0054
Epoch 506/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0027
Epoch 507/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0045
Epoch 508/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0163
Epoch 509/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0051
Epoch 510/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0044
Epoch 511/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0153
Epoch 512/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0134
Epoch 513/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0097
Epoch 514/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0184
Epoch 515/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0217
Epoch 516/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0210
Epoch 517/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0130
Epoch 518/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0423
Epoch 519/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0229
Epoch 520/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0133
Epoch 521/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.0161
Epoch 522/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0091
Epoch 523/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0054
Epoch 524/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0055
Epoch 525/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0077
Epoch 526/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0052
Epoch 527/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0040
Epoch 528/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0240
Epoch 529/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0049
Epoch 530/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0061
Epoch 531/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0097
Epoch 532/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0060
Epoch 533/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0047
Epoch 534/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0038
Epoch 535/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0049
Epoch 536/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0081
Epoch 537/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0037
Epoch 538/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0026
Epoch 539/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0039
Epoch 540/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0036
Epoch 541/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0074
Epoch 542/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0190
Epoch 543/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0378
Epoch 544/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0033
Epoch 545/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0074
```

```
Epoch 546/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0096
Epoch 547/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0038
Epoch 548/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0033
Epoch 549/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0049
Epoch 550/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0151
Epoch 551/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0047
Epoch 552/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0034
Epoch 553/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0025
Epoch 554/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0036
Epoch 555/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0031
Epoch 556/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0026
Epoch 557/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0082
Epoch 558/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0032
Epoch 559/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0041
Epoch 560/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0035
Epoch 561/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0028
Epoch 562/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0021
Epoch 563/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0059
Epoch 564/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0087
Epoch 565/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 566/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0026
Epoch 567/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0029
Epoch 568/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0060
Epoch 569/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0018
Epoch 570/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 571/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0020
Epoch 572/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0026
Epoch 573/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0017
Epoch 574/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0028
Epoch 575/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0020
Epoch 576/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0028
Epoch 577/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0069
Epoch 578/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0036
Epoch 579/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0024
Epoch 580/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0028
Epoch 581/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0025
Epoch 582/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0018
Epoch 583/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0018
Epoch 584/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 585/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 586/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 587/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0028
Epoch 588/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0022
Epoch 589/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0023
Epoch 590/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0275
Epoch 591/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0051
Epoch 592/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0022
Epoch 593/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0039
Epoch 594/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0024
```

```
Epoch 595/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 596/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0020
Epoch 597/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0038
Epoch 598/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0022
Epoch 599/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 600/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0016
Epoch 601/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0038
Epoch 602/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0051
Epoch 603/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0016
Epoch 604/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0060
Epoch 605/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0087
Epoch 606/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0128
Epoch 607/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 608/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0018
Epoch 609/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0020
Epoch 610/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0021
Epoch 611/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0024
Epoch 612/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0010
Epoch 613/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 614/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0310
Epoch 615/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0034
Epoch 616/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 617/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0025
Epoch 618/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0025
Epoch 619/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.0021
Epoch 620/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 621/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0049
Epoch 622/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0018
Epoch 623/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 624/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 625/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 626/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0014
Epoch 627/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 628/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 629/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0033
Epoch 630/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0023
Epoch 631/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0017
Epoch 632/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0348
Epoch 633/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0017
Epoch 634/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0014
Epoch 635/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0014
Epoch 636/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0017
Epoch 637/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0018
Epoch 638/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0014
Epoch 639/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0022
Epoch 640/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0031
Epoch 641/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0020
Epoch 642/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0028
Epoch 643/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0019
```

```
Epoch 644/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 645/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0059
Epoch 646/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 647/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0018
Epoch 648/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0019
Epoch 649/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0014
Epoch 650/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0050
Epoch 651/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0031
Epoch 652/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0026
Epoch 653/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0010
Epoch 654/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0019
Epoch 655/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0024
Epoch 656/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0020
Epoch 657/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 658/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0017
Epoch 659/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 660/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0018
Epoch 661/800
250/250 [==============================] - 1s 2ms/step - loss: 9.0772e-04
Epoch 662/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0022
Epoch 663/800
250/250 [==============================] - 1s 2ms/step - loss: 9.9149e-04
Epoch 664/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0022
Epoch 665/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0021
Epoch 666/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0014
Epoch 667/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 668/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 669/800
250/250 [==============================] - 1s 2ms/step - loss: 9.0405e-04
Epoch 670/800
250/250 [==============================] - 1s 2ms/step - loss: 8.8675e-04
Epoch 671/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 672/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 673/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0037
Epoch 674/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0038
Epoch 675/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0021
Epoch 676/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 677/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0024
Epoch 678/800
250/250 [==============================] - 1s 2ms/step - loss: 8.3516e-04
Epoch 679/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0026
Epoch 680/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0039
Epoch 681/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 682/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 683/800
250/250 [==============================] - 1s 2ms/step - loss: 6.3676e-04
Epoch 684/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0021
Epoch 685/800
250/250 [==============================] - 1s 2ms/step - loss: 8.1871e-04
Epoch 686/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0113
Epoch 687/800
250/250 [==============================] - 1s 2ms/step - loss: 8.7072e-04
Epoch 688/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 689/800
250/250 [==============================] - 1s 2ms/step - loss: 9.2540e-04
Epoch 690/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0014
Epoch 691/800
250/250 [==============================] - 1s 2ms/step - loss: 8.9643e-04
Epoch 692/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0017
```

```
Epoch 693/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 694/800
250/250 [==============================] - 1s 2ms/step - loss: 9.6393e-04
Epoch 695/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 696/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 697/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 698/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0016
Epoch 699/800
250/250 [==============================] - 1s 2ms/step - loss: 9.8158e-04
Epoch 700/800
250/250 [==============================] - 1s 2ms/step - loss: 9.8797e-04
Epoch 701/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 702/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 703/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 704/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0019
Epoch 705/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0010
Epoch 706/800
250/250 [==============================] - 1s 2ms/step - loss: 9.8077e-04
Epoch 707/800
250/250 [==============================] - 1s 2ms/step - loss: 8.9957e-04
Epoch 708/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 709/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0014
Epoch 710/800
250/250 [==============================] - 1s 2ms/step - loss: 6.4515e-04
Epoch 711/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 712/800
250/250 [==============================] - 1s 2ms/step - loss: 7.1823e-04
Epoch 713/800
250/250 [==============================] - 1s 2ms/step - loss: 9.7398e-04
Epoch 714/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 715/800
250/250 [==============================] - 1s 2ms/step - loss: 8.9710e-04
Epoch 716/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0016
Epoch 717/800
```

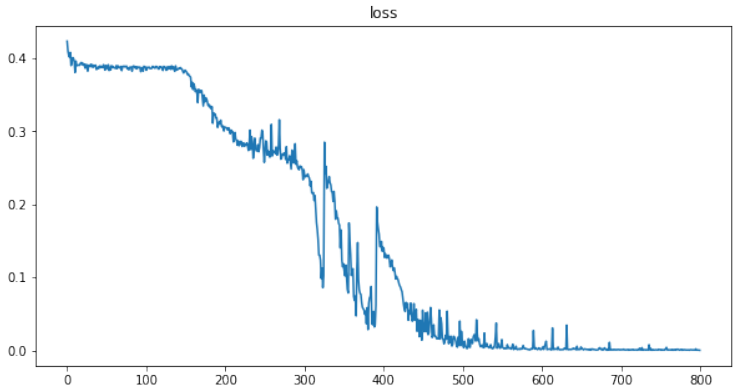
```
250/250 [==============================] - 1s 2ms/step - loss: 8.3712e-04
Epoch 718/800
250/250 [==============================] - 1s 2ms/step - loss: 8.6810e-04
Epoch 719/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0010
Epoch 720/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 721/800
250/250 [==============================] - 1s 2ms/step - loss: 6.1734e-04
Epoch 722/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 723/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0010
Epoch 724/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0032
Epoch 725/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 726/800
250/250 [==============================] - 1s 2ms/step - loss: 8.3292e-04
Epoch 727/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0040
Epoch 728/800
250/250 [==============================] - 1s 2ms/step - loss: 8.0973e-04
Epoch 729/800
250/250 [==============================] - 1s 2ms/step - loss: 7.1635e-04
Epoch 730/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 731/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 732/800
250/250 [==============================] - 1s 2ms/step - loss: 7.3493e-04
Epoch 733/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 734/800
250/250 [==============================] - 1s 2ms/step - loss: 8.9957e-04
Epoch 735/800
250/250 [==============================] - 1s 2ms/step - loss: 7.4144e-04
Epoch 736/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0080
Epoch 737/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 738/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0029
Epoch 739/800
250/250 [==============================] - 1s 2ms/step - loss: 6.9903e-04
Epoch 740/800
250/250 [==============================] - 1s 2ms/step - loss: 6.7666e-04
Epoch 741/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0014
```

```
Epoch 742/800
250/250 [==============================] - 1s 2ms/step - loss: 7.4113e-04
Epoch 743/800
250/250 [==============================] - 1s 2ms/step - loss: 8.4554e-04
Epoch 744/800
250/250 [==============================] - 1s 2ms/step - loss: 8.8666e-04
Epoch 745/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 746/800
250/250 [==============================] - 1s 2ms/step - loss: 9.5212e-04
Epoch 747/800
250/250 [==============================] - 1s 2ms/step - loss: 7.4071e-04
Epoch 748/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0018
Epoch 749/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 750/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0014
Epoch 751/800
250/250 [==============================] - 1s 2ms/step - loss: 6.6242e-04
Epoch 752/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 753/800
250/250 [==============================] - 1s 2ms/step - loss: 6.1221e-04
Epoch 754/800
250/250 [==============================] - 1s 2ms/step - loss: 9.6438e-04
Epoch 755/800
250/250 [==============================] - 1s 2ms/step - loss: 9.7071e-04
Epoch 756/800
250/250 [==============================] - 1s 2ms/step - loss: 7.6107e-04
Epoch 757/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0026
Epoch 758/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0044
Epoch 759/800
250/250 [==============================] - 1s 2ms/step - loss: 9.7848e-04
Epoch 760/800
250/250 [==============================] - 1s 2ms/step - loss: 8.4748e-04
Epoch 761/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 762/800
250/250 [==============================] - 1s 2ms/step - loss: 9.5832e-04
Epoch 763/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 764/800
250/250 [==============================] - 1s 2ms/step - loss: 6.9435e-04
Epoch 765/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0016
Epoch 766/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 6.1033e-04
Epoch 767/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 768/800
250/250 [==============================] - 1s 2ms/step - loss: 8.6988e-04
Epoch 769/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0016
Epoch 770/800
250/250 [==============================] - 1s 2ms/step - loss: 6.8455e-04
Epoch 771/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0013
Epoch 772/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0020
Epoch 773/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0014
Epoch 774/800
250/250 [==============================] - 1s 3ms/step - loss: 8.5267e-04
Epoch 775/800
250/250 [==============================] - 1s 3ms/step - loss: 5.9962e-04
Epoch 776/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0015
Epoch 777/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0016
Epoch 778/800
250/250 [==============================] - 1s 2ms/step - loss: 5.6339e-04
Epoch 779/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 780/800
250/250 [==============================] - 1s 2ms/step - loss: 8.3656e-04
Epoch 781/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 782/800
250/250 [==============================] - 1s 2ms/step - loss: 9.3687e-04
Epoch 783/800
250/250 [==============================] - 1s 2ms/step - loss: 7.5989e-04
Epoch 784/800
250/250 [==============================] - 1s 2ms/step - loss: 8.5697e-04
Epoch 785/800
250/250 [==============================] - 1s 2ms/step - loss: 8.8937e-04
Epoch 786/800
250/250 [==============================] - 1s 2ms/step - loss: 8.5334e-04
Epoch 787/800
250/250 [==============================] - 1s 2ms/step - loss: 5.9392e-04
Epoch 788/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0011
Epoch 789/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0012
Epoch 790/800
250/250 [==============================] - 1s 2ms/step - loss: 9.5157e-04
```

```
Epoch 791/800
250/250 [==============================] - 1s 2ms/step - loss: 9.2130e-04
Epoch 792/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0010
Epoch 793/800
250/250 [==============================] - 1s 2ms/step - loss: 8.0774e-04
Epoch 794/800
250/250 [==============================] - 1s 2ms/step - loss: 8.4950e-04
Epoch 795/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0024
Epoch 796/800
250/250 [==============================] - 1s 2ms/step - loss: 7.5528e-04
Epoch 797/800
250/250 [==============================] - 1s 2ms/step - loss: 8.5205e-04
Epoch 798/800
250/250 [==============================] - 1s 2ms/step - loss: 7.6649e-04
Epoch 799/800
250/250 [==============================] - 1s 2ms/step - loss: 5.7224e-04
Epoch 800/800
250/250 [==============================] - 1s 2ms/step - loss: 4.5440e-04
```

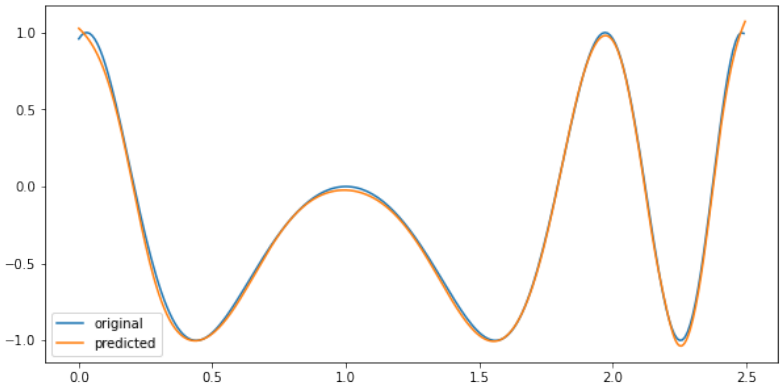
[ ]:
```
figure = plt.figure(figsize = (10, 5))
histx = []
for i in range(len(hist.history['loss'])):
    histx.append(i)


plt.plot(histx, hist.history['loss'])
plt.title("loss")
plt.show()
```



[ ]:
```
t2 = np.arange(0, 2.5, 0.005)
```

```
pred = model.predict(t2)

figure = plt.figure(figsize = (10, 5))

plt.plot(t, ft, label = 'original')
plt.plot(t2, pred, label = 'predicted')
plt.legend()
plt.show()
```

```
16/16 [==============================] - 0s 1ms/step
```



Выводы

Выполнив данную лабораторную работу, я вспомнил, как устроены многослойные сети и реализовал несколько из них, решив задачи аппроксимации и фильтрации.

[ ]: