# Лабораторная работа 4

## Сети с радиальными базисными элементами

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Целью работы: исследование свойств некоторых видов сетей с радиальными базисными элементами, алгоритмов обучения, а также применение сетей в задачах классификации и аппроксимации функции.

Вариант 19

```python
import keras
import tensorflow as tf
from keras.layers import *
import matplotlib.pyplot as plt
import numpy as np
from keras import backend
```

```python
!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: numpy>=1.17 in /usr/local/lib/python3.7/dist-packages (from matplotlib) (1.21.6)
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.7/dist-packages (from matplotlib) (1.4.4)
Requirement already satisfied: pillow>=6.2.0 in /usr/local/lib/python3.7/dist-packages (from matplotlib) (7.1.2)
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: fonttools>=4.22.0 in /usr/local/lib/python3.7/dist-packages (from matplotlib) (4.38.0)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.7/dist-packages (from matplotlib) (21.3)
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.7/dist-packages (from matplotlib) (2.8.2)
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)

Слой RBF

```python
class RBFLayer(keras.layers.Layer):
```

```python
    def __init__(self, output_dim, mu_init = tf.keras.initializers.
→RandomUniform(minval = -1, maxval = 1),**kwargs):
        self.output_dim = output_dim
        self.mu_init = mu_init
        super(RBFLayer, self).__init__(**kwargs)

    def build(self, input_shape):
        self.mu = self.add_weight(name = "mu",
                                  shape = (input_shape[1], self.output_dim),
                                  initializer = self.mu_init,
                                  trainable = True)
        self.sigma = self.add_weight(name = "sigma",
                                     shape = (self.output_dim,),
                                     initializer = "random_normal",
                                     trainable = True)
        super(RBFLayer, self).build(input_shape)

    def call(self, inputs):
        diff = backend.expand_dims(inputs) - self.mu
        output = backend.exp(backend.sum(diff ** 2, axis = 1) * self.sigma)
        return output
```

## Классификация

```python
# 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
```

```python
# Эллипс
a1 = 0.4
b1 = 0.4
alpha1 = 0
x01 = 0.1
y01 = -0.15
```

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

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

```python
t = np.arange(0, 2 * np.pi, 0.025)
```

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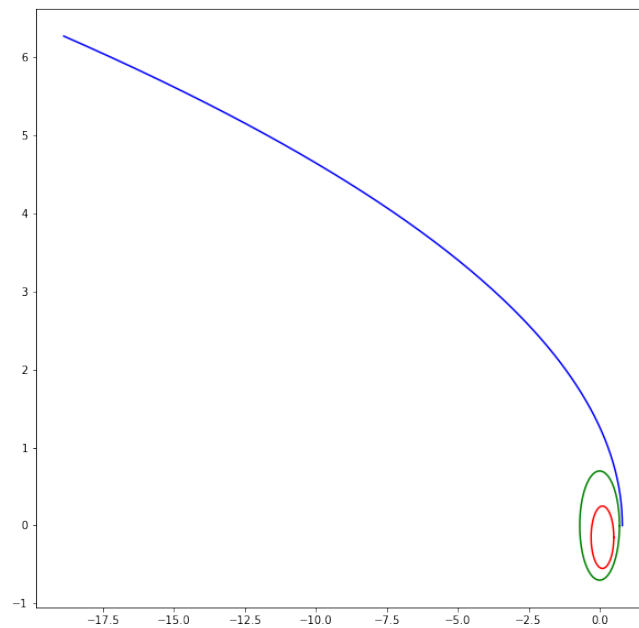
```python
datax = np.concatenate((fig1x, fig2x, fig3x), axis=0)
datay = np.concatenate((fig1y, fig2y, fig3y), axis=0)


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()
```

```python
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)
```

```python
model = keras.models.Sequential()

model.add(RBFLayer(3, input_dim = 2))
model.add(Dense(3, activation = "sigmoid"))

model.compile(tf.keras.optimizers.SGD(0.01), 'mse', ['accuracy'])
```

```
hist = model.fit(train, train_labels, batch_size = 1, epochs = 200)
```

```
Epoch 1/200
604/604 [==============================] - 2s 2ms/step - loss: 0.2716 -
accuracy: 0.3262
Epoch 2/200
604/604 [==============================] - 1s 2ms/step - loss: 0.2298 -
accuracy: 0.3212
Epoch 3/200
604/604 [==============================] - 1s 2ms/step - loss: 0.2165 -
accuracy: 0.3212
Epoch 4/200
604/604 [==============================] - 2s 3ms/step - loss: 0.2090 -
accuracy: 0.4950
Epoch 5/200
604/604 [==============================] - 2s 4ms/step - loss: 0.2032 -
accuracy: 0.5066
Epoch 6/200
604/604 [==============================] - 2s 4ms/step - loss: 0.1979 -
accuracy: 0.4404
Epoch 7/200
604/604 [==============================] - 2s 4ms/step - loss: 0.1930 -
accuracy: 0.5546
Epoch 8/200
604/604 [==============================] - 2s 4ms/step - loss: 0.1885 -
accuracy: 0.4917
Epoch 9/200
604/604 [==============================] - 2s 4ms/step - loss: 0.1844 -
accuracy: 0.5944
Epoch 10/200
604/604 [==============================] - 3s 5ms/step - loss: 0.1805 -
accuracy: 0.5927
Epoch 11/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1769 -
accuracy: 0.6242
Epoch 12/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1736 -
accuracy: 0.6076
Epoch 13/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1706 -
accuracy: 0.6142
Epoch 14/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1678 -
accuracy: 0.6175
Epoch 15/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1652 -
accuracy: 0.6225
Epoch 16/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1628 -
```

```
accuracy: 0.6225
Epoch 17/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1605 -
accuracy: 0.6291
Epoch 18/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1584 -
accuracy: 0.6308
Epoch 19/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1564 -
accuracy: 0.6341
Epoch 20/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1546 -
accuracy: 0.6391
Epoch 21/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1529 -
accuracy: 0.6391
Epoch 22/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1513 -
accuracy: 0.6407
Epoch 23/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1498 -
accuracy: 0.6407
Epoch 24/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1484 -
accuracy: 0.6407
Epoch 25/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1470 -
accuracy: 0.6457
Epoch 26/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1457 -
accuracy: 0.6474
Epoch 27/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1445 -
accuracy: 0.6490
Epoch 28/200
604/604 [==============================] - 2s 4ms/step - loss: 0.1434 -
accuracy: 0.6540
Epoch 29/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1423 -
accuracy: 0.6507
Epoch 30/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1412 -
accuracy: 0.6523
Epoch 31/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1401 -
accuracy: 0.6556
Epoch 32/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1391 -
accuracy: 0.6573
```

```
Epoch 33/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1381 -
accuracy: 0.6540
Epoch 34/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1372 -
accuracy: 0.6589
Epoch 35/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1363 -
accuracy: 0.6589
Epoch 36/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1353 -
accuracy: 0.6573
Epoch 37/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1345 -
accuracy: 0.6589
Epoch 38/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1336 -
accuracy: 0.6606
Epoch 39/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1327 -
accuracy: 0.6589
Epoch 40/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1318 -
accuracy: 0.6838
Epoch 41/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1310 -
accuracy: 0.7003
Epoch 42/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1302 -
accuracy: 0.6656
Epoch 43/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1293 -
accuracy: 0.6623
Epoch 44/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1285 -
accuracy: 0.6722
Epoch 45/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1277 -
accuracy: 0.6887
Epoch 46/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1269 -
accuracy: 0.7185
Epoch 47/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1261 -
accuracy: 0.7434
Epoch 48/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1253 -
accuracy: 0.7666
Epoch 49/200
```

```
604/604 [==============================] - 1s 2ms/step - loss: 0.1245 -
accuracy: 0.7566
Epoch 50/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1237 -
accuracy: 0.7781
Epoch 51/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1229 -
accuracy: 0.7831
Epoch 52/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1222 -
accuracy: 0.7732
Epoch 53/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1214 -
accuracy: 0.7964
Epoch 54/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1206 -
accuracy: 0.7980
Epoch 55/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1199 -
accuracy: 0.8046
Epoch 56/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1191 -
accuracy: 0.8079
Epoch 57/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1184 -
accuracy: 0.8063
Epoch 58/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1176 -
accuracy: 0.8262
Epoch 59/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1169 -
accuracy: 0.8228
Epoch 60/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1162 -
accuracy: 0.8245
Epoch 61/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1154 -
accuracy: 0.8377
Epoch 62/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1147 -
accuracy: 0.8377
Epoch 63/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1140 -
accuracy: 0.8295
Epoch 64/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1133 -
accuracy: 0.8526
Epoch 65/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1126 -
```

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accuracy: 0.8444
Epoch 66/200
604/604 [==============================] - 2s 3ms/step - loss: 0.1119 -
accuracy: 0.8626
Epoch 67/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1112 -
accuracy: 0.8659
Epoch 68/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1105 -
accuracy: 0.8659
Epoch 69/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1098 -
accuracy: 0.8659
Epoch 70/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1091 -
accuracy: 0.8642
Epoch 71/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1085 -
accuracy: 0.8692
Epoch 72/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1078 -
accuracy: 0.8709
Epoch 73/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1072 -
accuracy: 0.8874
Epoch 74/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1065 -
accuracy: 0.8725
Epoch 75/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1059 -
accuracy: 0.8874
Epoch 76/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1053 -
accuracy: 0.8825
Epoch 77/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1045 -
accuracy: 0.8642
Epoch 78/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1040 -
accuracy: 0.8858
Epoch 79/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1033 -
accuracy: 0.8974
Epoch 80/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1027 -
accuracy: 0.8825
Epoch 81/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1022 -
accuracy: 0.8940
```

```
Epoch 82/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1015 -
accuracy: 0.8940
Epoch 83/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1010 -
accuracy: 0.8974
Epoch 84/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1004 -
accuracy: 0.9007
Epoch 85/200
604/604 [==============================] - 2s 3ms/step - loss: 0.0998 -
accuracy: 0.9056
Epoch 86/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0992 -
accuracy: 0.9040
Epoch 87/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0986 -
accuracy: 0.9040
Epoch 88/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0981 -
accuracy: 0.9123
Epoch 89/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0975 -
accuracy: 0.9106
Epoch 90/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0969 -
accuracy: 0.9106
Epoch 91/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0964 -
accuracy: 0.9073
Epoch 92/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0959 -
accuracy: 0.9156
Epoch 93/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0953 -
accuracy: 0.9189
Epoch 94/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0947 -
accuracy: 0.9205
Epoch 95/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0943 -
accuracy: 0.9255
Epoch 96/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0937 -
accuracy: 0.9205
Epoch 97/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0932 -
accuracy: 0.9189
Epoch 98/200
```

```
604/604 [==============================] - 2s 3ms/step - loss: 0.0928 -
accuracy: 0.9222
Epoch 99/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0923 -
accuracy: 0.9338
Epoch 100/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0918 -
accuracy: 0.9238
Epoch 101/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0913 -
accuracy: 0.9354
Epoch 102/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0907 -
accuracy: 0.9272
Epoch 103/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0903 -
accuracy: 0.9470
Epoch 104/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0896 -
accuracy: 0.9288
Epoch 105/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0894 -
accuracy: 0.9619
Epoch 106/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0888 -
accuracy: 0.9222
Epoch 107/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0884 -
accuracy: 0.9619
Epoch 108/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0880 -
accuracy: 0.9288
Epoch 109/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0875 -
accuracy: 0.9586
Epoch 110/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0871 -
accuracy: 0.9503
Epoch 111/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0866 -
accuracy: 0.9421
Epoch 112/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0862 -
accuracy: 0.9354
Epoch 113/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0858 -
accuracy: 0.9404
Epoch 114/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0854 -
```

```
accuracy: 0.9454
Epoch 115/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0848 -
accuracy: 0.9536
Epoch 116/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0846 -
accuracy: 0.9437
Epoch 117/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0841 -
accuracy: 0.9470
Epoch 118/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0837 -
accuracy: 0.9536
Epoch 119/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0833 -
accuracy: 0.9503
Epoch 120/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0828 -
accuracy: 0.9785
Epoch 121/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0825 -
accuracy: 0.9520
Epoch 122/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0823 -
accuracy: 0.9586
Epoch 123/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0818 -
accuracy: 0.9536
Epoch 124/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0814 -
accuracy: 0.9636
Epoch 125/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0810 -
accuracy: 0.9719
Epoch 126/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0807 -
accuracy: 0.9487
Epoch 127/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0802 -
accuracy: 0.9636
Epoch 128/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0800 -
accuracy: 0.9586
Epoch 129/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0796 -
accuracy: 0.9719
Epoch 130/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0792 -
accuracy: 0.9619
```

```
Epoch 131/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0788 -
accuracy: 0.9619
Epoch 132/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0787 -
accuracy: 0.9735
Epoch 133/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0780 -
accuracy: 0.9719
Epoch 134/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0779 -
accuracy: 0.9636
Epoch 135/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0776 -
accuracy: 0.9702
Epoch 136/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0771 -
accuracy: 0.9752
Epoch 137/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0768 -
accuracy: 0.9636
Epoch 138/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0766 -
accuracy: 0.9652
Epoch 139/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0762 -
accuracy: 0.9785
Epoch 140/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0757 -
accuracy: 0.9652
Epoch 141/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0755 -
accuracy: 0.9851
Epoch 142/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0753 -
accuracy: 0.9685
Epoch 143/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0750 -
accuracy: 0.9868
Epoch 144/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0747 -
accuracy: 0.9669
Epoch 145/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0742 -
accuracy: 0.9702
Epoch 146/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0739 -
accuracy: 0.9652
Epoch 147/200
```

```
604/604 [==============================] - 1s 2ms/step - loss: 0.0736 -
accuracy: 0.9636
Epoch 148/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0735 -
accuracy: 0.9851
Epoch 149/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0732 -
accuracy: 0.9702
Epoch 150/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0730 -
accuracy: 0.9818
Epoch 151/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0726 -
accuracy: 0.9785
Epoch 152/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0724 -
accuracy: 0.9785
Epoch 153/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0716 -
accuracy: 0.9669
Epoch 154/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0716 -
accuracy: 0.9752
Epoch 155/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0715 -
accuracy: 0.9801
Epoch 156/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0712 -
accuracy: 0.9785
Epoch 157/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0708 -
accuracy: 0.9685
Epoch 158/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0707 -
accuracy: 0.9801
Epoch 159/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0702 -
accuracy: 0.9719
Epoch 160/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0703 -
accuracy: 0.9719
Epoch 161/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0699 -
accuracy: 0.9752
Epoch 162/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0697 -
accuracy: 0.9735
Epoch 163/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0690 -
```

```
accuracy: 0.9702
Epoch 164/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0692 -
accuracy: 0.9735
Epoch 165/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0688 -
accuracy: 0.9702
Epoch 166/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0685 -
accuracy: 0.9702
Epoch 167/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0685 -
accuracy: 0.9768
Epoch 168/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0680 -
accuracy: 0.9735
Epoch 169/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0677 -
accuracy: 0.9752
Epoch 170/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0676 -
accuracy: 0.9768
Epoch 171/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0674 -
accuracy: 0.9719
Epoch 172/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0671 -
accuracy: 0.9735
Epoch 173/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0669 -
accuracy: 0.9685
Epoch 174/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0668 -
accuracy: 0.9702
Epoch 175/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0666 -
accuracy: 0.9735
Epoch 176/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0663 -
accuracy: 0.9752
Epoch 177/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0662 -
accuracy: 0.9785
Epoch 178/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0658 -
accuracy: 0.9702
Epoch 179/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0655 -
accuracy: 0.9735
```

```
Epoch 180/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0656 -
accuracy: 0.9752
Epoch 181/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0653 -
accuracy: 0.9785
Epoch 182/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0650 -
accuracy: 0.9768
Epoch 183/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0646 -
accuracy: 0.9652
Epoch 184/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0646 -
accuracy: 0.9735
Epoch 185/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0645 -
accuracy: 0.9719
Epoch 186/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0643 -
accuracy: 0.9752
Epoch 187/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0638 -
accuracy: 0.9818
Epoch 188/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0639 -
accuracy: 0.9669
Epoch 189/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0636 -
accuracy: 0.9702
Epoch 190/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0633 -
accuracy: 0.9719
Epoch 191/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0629 -
accuracy: 0.9818
Epoch 192/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0632 -
accuracy: 0.9702
Epoch 193/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0628 -
accuracy: 0.9652
Epoch 194/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0625 -
accuracy: 0.9735
Epoch 195/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0622 -
accuracy: 0.9619
Epoch 196/200
```

```
604/604 [==============================] - 1s 2ms/step - loss: 0.0621 -
accuracy: 0.9685
Epoch 197/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0621 -
accuracy: 0.9785
Epoch 198/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0618 -
accuracy: 0.9636
Epoch 199/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0616 -
accuracy: 0.9735
Epoch 200/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0613 -
accuracy: 0.9636
```

```python
[ ]:  #figure = plt.figure(figsize = (10, 5))
      figure = plt.figure(figsize = (24, 10))
      histx = []
      for i in range(len(hist.history['loss'])):
          histx.append(i)


      figure.add_subplot(1, 2, 1)
      plt.title("loss")
      plt.plot(histx, hist.history['loss'])

      figure.add_subplot(1, 2, 2)
      plt.title("accuracy")
      plt.plot(histx, hist.history['accuracy'])

      plt.show()
```
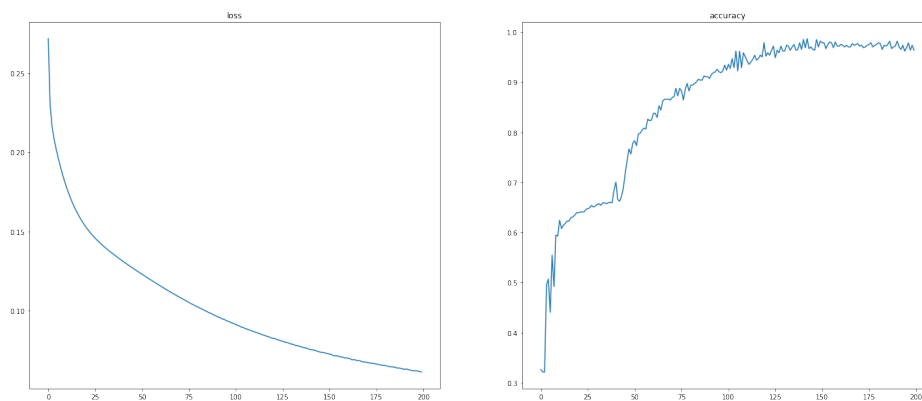
```
import itertools

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)
mu = model.get_layer(index = 0).get_weights()[0]
plt.scatter(mu[0], mu[1], color = "black", marker = "D")

plt.show()
```

1250/1250 [==============================] - 2s 1ms/step
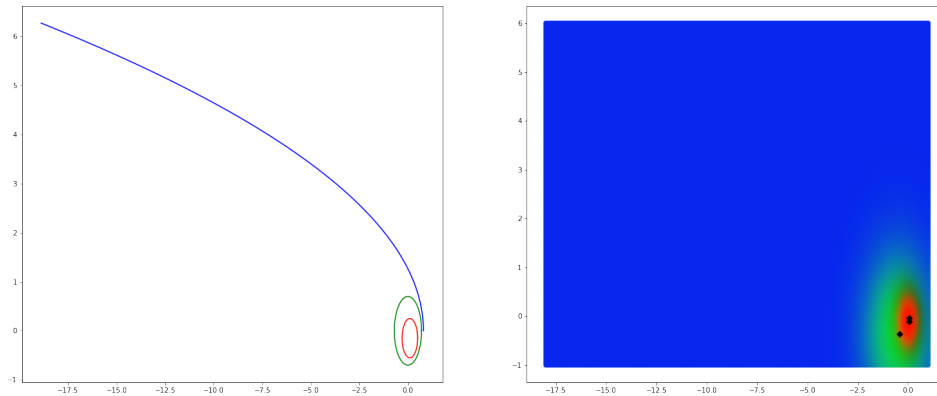
## Аппроксимация

```
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()
```
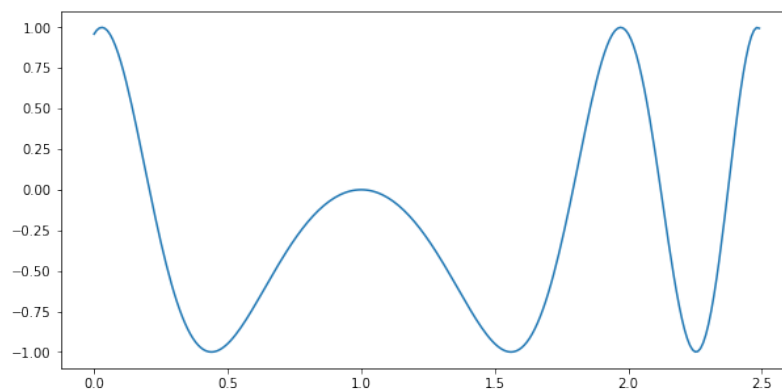


```
model = keras.models.Sequential()

model.add(RBFLayer(13, input_dim = 1, mu_init=keras.initializers.
 →RandomUniform(minval = 0, maxval = 2.5)))
model.add(Dense(13, activation='linear'))
model.add(Dense(1, activation = "linear"))

model.compile(tf.keras.optimizers.RMSprop(0.003), 'mse')

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

```
Epoch 1/800
250/250 [==============================] - 1s 2ms/step - loss: 0.4688
Epoch 2/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3976
Epoch 3/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3963
Epoch 4/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3917
Epoch 5/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3809
```

```
Epoch 6/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3906
Epoch 7/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3794
Epoch 8/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3720
Epoch 9/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3698
Epoch 10/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3699
Epoch 11/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3645
Epoch 12/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3642
Epoch 13/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3633
Epoch 14/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3595
Epoch 15/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3651
Epoch 16/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3521
Epoch 17/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3558
Epoch 18/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3475
Epoch 19/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3524
Epoch 20/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3555
Epoch 21/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3424
Epoch 22/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3502
Epoch 23/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3452
Epoch 24/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3449
Epoch 25/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3490
Epoch 26/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3471
Epoch 27/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3444
Epoch 28/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3383
Epoch 29/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3399
Epoch 30/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.3299
Epoch 31/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3406
Epoch 32/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3365
Epoch 33/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3336
Epoch 34/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3281
Epoch 35/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3359
Epoch 36/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3328
Epoch 37/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3206
Epoch 38/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3169
Epoch 39/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3274
Epoch 40/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3211
Epoch 41/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3321
Epoch 42/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3240
Epoch 43/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3256
Epoch 44/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3263
Epoch 45/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3279
Epoch 46/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3245
Epoch 47/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3246
Epoch 48/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3273
Epoch 49/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3173
Epoch 50/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3245
Epoch 51/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3159
Epoch 52/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3081
Epoch 53/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3206
Epoch 54/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3203
```

```
Epoch 55/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3131
Epoch 56/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3016
Epoch 57/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3167
Epoch 58/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3107
Epoch 59/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3129
Epoch 60/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3125
Epoch 61/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3024
Epoch 62/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3028
Epoch 63/800
250/250 [==============================] - 1s 2ms/step - loss: 0.3016
Epoch 64/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2979
Epoch 65/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2972
Epoch 66/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2960
Epoch 67/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2858
Epoch 68/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2913
Epoch 69/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2863
Epoch 70/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2749
Epoch 71/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2760
Epoch 72/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2653
Epoch 73/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2738
Epoch 74/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2642
Epoch 75/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2639
Epoch 76/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2648
Epoch 77/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2606
Epoch 78/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2569
Epoch 79/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.2575
Epoch 80/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2512
Epoch 81/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2442
Epoch 82/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2438
Epoch 83/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2488
Epoch 84/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2505
Epoch 85/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2466
Epoch 86/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2473
Epoch 87/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2444
Epoch 88/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2409
Epoch 89/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2387
Epoch 90/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2406
Epoch 91/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2426
Epoch 92/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2428
Epoch 93/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2379
Epoch 94/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2389
Epoch 95/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2358
Epoch 96/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2353
Epoch 97/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2344
Epoch 98/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2347
Epoch 99/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2340
Epoch 100/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2313
Epoch 101/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2308
Epoch 102/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2317
Epoch 103/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2328
```

```
Epoch 104/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2313
Epoch 105/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2283
Epoch 106/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2284
Epoch 107/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2264
Epoch 108/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2225
Epoch 109/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2276
Epoch 110/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2286
Epoch 111/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2261
Epoch 112/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2223
Epoch 113/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2239
Epoch 114/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2219
Epoch 115/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2236
Epoch 116/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2228
Epoch 117/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2221
Epoch 118/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2215
Epoch 119/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2197
Epoch 120/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2190
Epoch 121/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2185
Epoch 122/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2191
Epoch 123/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2179
Epoch 124/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2182
Epoch 125/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2169
Epoch 126/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2151
Epoch 127/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2141
Epoch 128/800
```

```
250/250 [==============================] - 1s 3ms/step - loss: 0.2084
Epoch 129/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2201
Epoch 130/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2157
Epoch 131/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2117
Epoch 132/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2138
Epoch 133/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2143
Epoch 134/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2130
Epoch 135/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2141
Epoch 136/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2118
Epoch 137/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2117
Epoch 138/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2100
Epoch 139/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2157
Epoch 140/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2089
Epoch 141/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2070
Epoch 142/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2086
Epoch 143/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2079
Epoch 144/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2095
Epoch 145/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2069
Epoch 146/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2072
Epoch 147/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2044
Epoch 148/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2058
Epoch 149/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2046
Epoch 150/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2064
Epoch 151/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2041
Epoch 152/800
250/250 [==============================] - 1s 3ms/step - loss: 0.2029
```

```
Epoch 153/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2072
Epoch 154/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2065
Epoch 155/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2014
Epoch 156/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2016
Epoch 157/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1821
Epoch 158/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2094
Epoch 159/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2076
Epoch 160/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2002
Epoch 161/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2042
Epoch 162/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2042
Epoch 163/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2053
Epoch 164/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2055
Epoch 165/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2076
Epoch 166/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2101
Epoch 167/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2022
Epoch 168/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1981
Epoch 169/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2036
Epoch 170/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2056
Epoch 171/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2008
Epoch 172/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2034
Epoch 173/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2022
Epoch 174/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1980
Epoch 175/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2006
Epoch 176/800
250/250 [==============================] - 1s 3ms/step - loss: 0.1899
Epoch 177/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.2058
Epoch 178/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2007
Epoch 179/800
250/250 [==============================] - 1s 2ms/step - loss: 0.2017
Epoch 180/800
250/250 [==============================] - 1s 3ms/step - loss: 0.2002
Epoch 181/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1980
Epoch 182/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1986
Epoch 183/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1991
Epoch 184/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1975
Epoch 185/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1972
Epoch 186/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1935
Epoch 187/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1879
Epoch 188/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1922
Epoch 189/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1974
Epoch 190/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1931
Epoch 191/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1904
Epoch 192/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1899
Epoch 193/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1921
Epoch 194/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1886
Epoch 195/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1951
Epoch 196/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1906
Epoch 197/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1957
Epoch 198/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1860
Epoch 199/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1927
Epoch 200/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1851
Epoch 201/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1896
```

```
Epoch 202/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1906
Epoch 203/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1897
Epoch 204/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1839
Epoch 205/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1887
Epoch 206/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1836
Epoch 207/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1822
Epoch 208/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1779
Epoch 209/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1864
Epoch 210/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1799
Epoch 211/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1812
Epoch 212/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1798
Epoch 213/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1770
Epoch 214/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1749
Epoch 215/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1753
Epoch 216/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1798
Epoch 217/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1754
Epoch 218/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1703
Epoch 219/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1753
Epoch 220/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1724
Epoch 221/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1662
Epoch 222/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1735
Epoch 223/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1692
Epoch 224/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1711
Epoch 225/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1677
Epoch 226/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.1723
Epoch 227/800
250/250 [==============================] - 1s 3ms/step - loss: 0.1627
Epoch 228/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1708
Epoch 229/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1662
Epoch 230/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1627
Epoch 231/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1652
Epoch 232/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1637
Epoch 233/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1648
Epoch 234/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1626
Epoch 235/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1605
Epoch 236/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1628
Epoch 237/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1603
Epoch 238/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1559
Epoch 239/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1545
Epoch 240/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1594
Epoch 241/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1536
Epoch 242/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1542
Epoch 243/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1579
Epoch 244/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1562
Epoch 245/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1573
Epoch 246/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1535
Epoch 247/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1556
Epoch 248/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1535
Epoch 249/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1547
Epoch 250/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1469
```

```
Epoch 251/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1494
Epoch 252/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1473
Epoch 253/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1453
Epoch 254/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1487
Epoch 255/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1511
Epoch 256/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1449
Epoch 257/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1502
Epoch 258/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1441
Epoch 259/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1372
Epoch 260/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1378
Epoch 261/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1455
Epoch 262/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1390
Epoch 263/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1449
Epoch 264/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1419
Epoch 265/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1381
Epoch 266/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1420
Epoch 267/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1394
Epoch 268/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1371
Epoch 269/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1361
Epoch 270/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1370
Epoch 271/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1387
Epoch 272/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1394
Epoch 273/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1325
Epoch 274/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1326
Epoch 275/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.1299
Epoch 276/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1270
Epoch 277/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1307
Epoch 278/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1223
Epoch 279/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1186
Epoch 280/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1145
Epoch 281/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1191
Epoch 282/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1155
Epoch 283/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1079
Epoch 284/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1079
Epoch 285/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1054
Epoch 286/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1073
Epoch 287/800
250/250 [==============================] - 1s 2ms/step - loss: 0.1023
Epoch 288/800
250/250 [==============================] - 1s 3ms/step - loss: 0.1005
Epoch 289/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0998
Epoch 290/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0946
Epoch 291/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0990
Epoch 292/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0953
Epoch 293/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0912
Epoch 294/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0906
Epoch 295/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0814
Epoch 296/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0835
Epoch 297/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0745
Epoch 298/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0836
Epoch 299/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0729
```

```
Epoch 300/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0692
Epoch 301/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0690
Epoch 302/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0662
Epoch 303/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0596
Epoch 304/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0680
Epoch 305/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0605
Epoch 306/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0634
Epoch 307/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0647
Epoch 308/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0615
Epoch 309/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0602
Epoch 310/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0517
Epoch 311/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0538
Epoch 312/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0624
Epoch 313/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0588
Epoch 314/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0542
Epoch 315/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0560
Epoch 316/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0555
Epoch 317/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0533
Epoch 318/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0508
Epoch 319/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0528
Epoch 320/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0508
Epoch 321/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0502
Epoch 322/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0494
Epoch 323/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0429
Epoch 324/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.0486
Epoch 325/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0517
Epoch 326/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0459
Epoch 327/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0450
Epoch 328/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0415
Epoch 329/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0436
Epoch 330/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0390
Epoch 331/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0407
Epoch 332/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0409
Epoch 333/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0401
Epoch 334/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0392
Epoch 335/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0450
Epoch 336/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0382
Epoch 337/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0379
Epoch 338/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0390
Epoch 339/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0351
Epoch 340/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0304
Epoch 341/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0352
Epoch 342/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0330
Epoch 343/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0340
Epoch 344/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0354
Epoch 345/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0348
Epoch 346/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0309
Epoch 347/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0337
Epoch 348/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0359
```

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Epoch 349/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0290
Epoch 350/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0336
Epoch 351/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0268
Epoch 352/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0310
Epoch 353/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0321
Epoch 354/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0307
Epoch 355/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0270
Epoch 356/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0265
Epoch 357/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0321
Epoch 358/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0283
Epoch 359/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0311
Epoch 360/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0281
Epoch 361/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0283
Epoch 362/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0283
Epoch 363/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0281
Epoch 364/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0290
Epoch 365/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0252
Epoch 366/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0241
Epoch 367/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0279
Epoch 368/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0245
Epoch 369/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0272
Epoch 370/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0235
Epoch 371/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0229
Epoch 372/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0231
Epoch 373/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.0275
Epoch 374/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0206
Epoch 375/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0241
Epoch 376/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0233
Epoch 377/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0215
Epoch 378/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0216
Epoch 379/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0210
Epoch 380/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0225
Epoch 381/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0190
Epoch 382/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0181
Epoch 383/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0212
Epoch 384/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0218
Epoch 385/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0200
Epoch 386/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0183
Epoch 387/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0185
Epoch 388/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0202
Epoch 389/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0170
Epoch 390/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0189
Epoch 391/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0185
Epoch 392/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0207
Epoch 393/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0197
Epoch 394/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0190
Epoch 395/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0180
Epoch 396/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0193
Epoch 397/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0200
```

```
Epoch 398/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0187
Epoch 399/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0173
Epoch 400/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0166
Epoch 401/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0177
Epoch 402/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0149
Epoch 403/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0175
Epoch 404/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0171
Epoch 405/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0200
Epoch 406/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0181
Epoch 407/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0141
Epoch 408/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0179
Epoch 409/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0183
Epoch 410/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0157
Epoch 411/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0157
Epoch 412/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0147
Epoch 413/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0171
Epoch 414/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0152
Epoch 415/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0163
Epoch 416/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0166
Epoch 417/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0161
Epoch 418/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0149
Epoch 419/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0150
Epoch 420/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0161
Epoch 421/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0162
Epoch 422/800
```

```
250/250 [==============================] - 1s 2ms/step - loss: 0.0157
Epoch 423/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0159
Epoch 424/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0156
Epoch 425/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0158
Epoch 426/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0139
Epoch 427/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0137
Epoch 428/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0145
Epoch 429/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0143
Epoch 430/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0150
Epoch 431/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0153
Epoch 432/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0137
Epoch 433/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0151
Epoch 434/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0135
Epoch 435/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0138
Epoch 436/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0138
Epoch 437/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0142
Epoch 438/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0143
Epoch 439/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0134
Epoch 440/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0121
Epoch 441/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0140
Epoch 442/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0137
Epoch 443/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0123
Epoch 444/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0128
Epoch 445/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0119
Epoch 446/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0128
```

```
Epoch 447/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0132
Epoch 448/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0114
Epoch 449/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0134
Epoch 450/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0124
Epoch 451/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0128
Epoch 452/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0138
Epoch 453/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0119
Epoch 454/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0133
Epoch 455/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0113
Epoch 456/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0106
Epoch 457/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0114
Epoch 458/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0102
Epoch 459/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0120
Epoch 460/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0119
Epoch 461/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0109
Epoch 462/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0101
Epoch 463/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0111
Epoch 464/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0097
Epoch 465/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0100
Epoch 466/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0121
Epoch 467/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0123
Epoch 468/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0101
Epoch 469/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0094
Epoch 470/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0095
Epoch 471/800
```

```
250/250 [==============================] - 1s 3ms/step - loss: 0.0103
Epoch 472/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0110
Epoch 473/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0099
Epoch 474/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0095
Epoch 475/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0113
Epoch 476/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0104
Epoch 477/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0109
Epoch 478/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0098
Epoch 479/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0103
Epoch 480/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0094
Epoch 481/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0101
Epoch 482/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0095
Epoch 483/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0101
Epoch 484/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0085
Epoch 485/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0093
Epoch 486/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0091
Epoch 487/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0090
Epoch 488/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0093
Epoch 489/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0087
Epoch 490/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0099
Epoch 491/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0084
Epoch 492/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0089
Epoch 493/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0107
Epoch 494/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0106
Epoch 495/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0083
```

```
Epoch 496/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0092
Epoch 497/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0088
Epoch 498/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0099
Epoch 499/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0083
Epoch 500/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0091
Epoch 501/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0095
Epoch 502/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0077
Epoch 503/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0073
Epoch 504/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0077
Epoch 505/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0083
Epoch 506/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0097
Epoch 507/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0086
Epoch 508/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0081
Epoch 509/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0076
Epoch 510/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0068
Epoch 511/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0082
Epoch 512/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0083
Epoch 513/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0086
Epoch 514/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0078
Epoch 515/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0072
Epoch 516/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0080
Epoch 517/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0077
Epoch 518/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0078
Epoch 519/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0081
Epoch 520/800
```

```
250/250 [==============================] - 1s 3ms/step - loss: 0.0071
Epoch 521/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0082
Epoch 522/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0075
Epoch 523/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0076
Epoch 524/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0078
Epoch 525/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0081
Epoch 526/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0069
Epoch 527/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0078
Epoch 528/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0066
Epoch 529/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0069
Epoch 530/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0075
Epoch 531/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0064
Epoch 532/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0072
Epoch 533/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0072
Epoch 534/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0080
Epoch 535/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0075
Epoch 536/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0068
Epoch 537/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0068
Epoch 538/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0072
Epoch 539/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0066
Epoch 540/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0067
Epoch 541/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0066
Epoch 542/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0072
Epoch 543/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0069
Epoch 544/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0069
```

```
Epoch 545/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0066
Epoch 546/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0062
Epoch 547/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0063
Epoch 548/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0066
Epoch 549/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0069
Epoch 550/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0065
Epoch 551/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0057
Epoch 552/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0071
Epoch 553/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0062
Epoch 554/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0062
Epoch 555/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0069
Epoch 556/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0064
Epoch 557/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0065
Epoch 558/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0060
Epoch 559/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0063
Epoch 560/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0055
Epoch 561/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0063
Epoch 562/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0065
Epoch 563/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0058
Epoch 564/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0063
Epoch 565/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0057
Epoch 566/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0054
Epoch 567/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0052
Epoch 568/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0062
Epoch 569/800
```

```
250/250 [==============================] - 1s 3ms/step - loss: 0.0053
Epoch 570/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0059
Epoch 571/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0057
Epoch 572/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0058
Epoch 573/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0056
Epoch 574/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0061
Epoch 575/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0061
Epoch 576/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0061
Epoch 577/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0057
Epoch 578/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0054
Epoch 579/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0061
Epoch 580/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0051
Epoch 581/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0051
Epoch 582/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0060
Epoch 583/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0054
Epoch 584/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0052
Epoch 585/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0055
Epoch 586/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0054
Epoch 587/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0059
Epoch 588/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0061
Epoch 589/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0054
Epoch 590/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0056
Epoch 591/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0053
Epoch 592/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0060
Epoch 593/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0052
```

```
Epoch 594/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0049
Epoch 595/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0052
Epoch 596/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0054
Epoch 597/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0057
Epoch 598/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0057
Epoch 599/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0049
Epoch 600/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0055
Epoch 601/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0051
Epoch 602/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0055
Epoch 603/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0048
Epoch 604/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0052
Epoch 605/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0049
Epoch 606/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0048
Epoch 607/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0050
Epoch 608/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0047
Epoch 609/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0044
Epoch 610/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0050
Epoch 611/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0051
Epoch 612/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0055
Epoch 613/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0052
Epoch 614/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0045
Epoch 615/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0054
Epoch 616/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0046
Epoch 617/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0051
Epoch 618/800
```

```
250/250 [==============================] - 1s 3ms/step - loss: 0.0045
Epoch 619/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0047
Epoch 620/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0049
Epoch 621/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0047
Epoch 622/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0049
Epoch 623/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0046
Epoch 624/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0040
Epoch 625/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0046
Epoch 626/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0042
Epoch 627/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0047
Epoch 628/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0043
Epoch 629/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0044
Epoch 630/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0039
Epoch 631/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0046
Epoch 632/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0048
Epoch 633/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0044
Epoch 634/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0045
Epoch 635/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0042
Epoch 636/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0046
Epoch 637/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0049
Epoch 638/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0039
Epoch 639/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0045
Epoch 640/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0046
Epoch 641/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0043
Epoch 642/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0046
```

```
Epoch 643/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0044
Epoch 644/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0043
Epoch 645/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0039
Epoch 646/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0037
Epoch 647/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0041
Epoch 648/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0045
Epoch 649/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0040
Epoch 650/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0041
Epoch 651/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0042
Epoch 652/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0036
Epoch 653/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0039
Epoch 654/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0043
Epoch 655/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0036
Epoch 656/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0040
Epoch 657/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0037
Epoch 658/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0042
Epoch 659/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0040
Epoch 660/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0043
Epoch 661/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0040
Epoch 662/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0040
Epoch 663/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0040
Epoch 664/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0040
Epoch 665/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0039
Epoch 666/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0039
Epoch 667/800
```

```
250/250 [==============================] - 1s 3ms/step - loss: 0.0040
Epoch 668/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0038
Epoch 669/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 670/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0037
Epoch 671/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0039
Epoch 672/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0041
Epoch 673/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0043
Epoch 674/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0038
Epoch 675/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0037
Epoch 676/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0038
Epoch 677/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0044
Epoch 678/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0039
Epoch 679/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0038
Epoch 680/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0035
Epoch 681/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0040
Epoch 682/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0035
Epoch 683/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0038
Epoch 684/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0035
Epoch 685/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0038
Epoch 686/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0038
Epoch 687/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0036
Epoch 688/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0037
Epoch 689/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0041
Epoch 690/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0036
Epoch 691/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0036
```

```
Epoch 692/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0039
Epoch 693/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 694/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0036
Epoch 695/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 696/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0038
Epoch 697/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 698/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0036
Epoch 699/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0033
Epoch 700/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0036
Epoch 701/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0033
Epoch 702/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 703/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 704/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0038
Epoch 705/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0033
Epoch 706/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0038
Epoch 707/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0036
Epoch 708/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0031
Epoch 709/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 710/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0035
Epoch 711/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0035
Epoch 712/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0032
Epoch 713/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0035
Epoch 714/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 715/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0033
Epoch 716/800
```

```
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 717/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0037
Epoch 718/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0036
Epoch 719/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0037
Epoch 720/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 721/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0032
Epoch 722/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0036
Epoch 723/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0032
Epoch 724/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 725/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0035
Epoch 726/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 727/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 728/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0031
Epoch 729/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0033
Epoch 730/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
Epoch 731/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 732/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0032
Epoch 733/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0031
Epoch 734/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0033
Epoch 735/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0027
Epoch 736/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0030
Epoch 737/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0035
Epoch 738/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0032
Epoch 739/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0033
Epoch 740/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0033
```

```
Epoch 741/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0031
Epoch 742/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0035
Epoch 743/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0035
Epoch 744/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0033
Epoch 745/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0033
Epoch 746/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0028
Epoch 747/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0031
Epoch 748/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0027
Epoch 749/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0033
Epoch 750/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0032
Epoch 751/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0032
Epoch 752/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0030
Epoch 753/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0030
Epoch 754/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0030
Epoch 755/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0030
Epoch 756/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0030
Epoch 757/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0030
Epoch 758/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 759/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0030
Epoch 760/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 761/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0028
Epoch 762/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 763/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0028
Epoch 764/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 765/800
```

```
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 766/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0028
Epoch 767/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 768/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0026
Epoch 769/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0028
Epoch 770/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0024
Epoch 771/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0027
Epoch 772/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0027
Epoch 773/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0030
Epoch 774/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0031
Epoch 775/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0027
Epoch 776/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 777/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0030
Epoch 778/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 779/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0028
Epoch 780/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0032
Epoch 781/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0026
Epoch 782/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0026
Epoch 783/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0025
Epoch 784/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0029
Epoch 785/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 786/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0027
Epoch 787/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0030
Epoch 788/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0027
Epoch 789/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0034
```

```
Epoch 790/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0027
Epoch 791/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0027
Epoch 792/800
250/250 [==============================] - 1s 2ms/step - loss: 0.0028
Epoch 793/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0032
Epoch 794/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0026
Epoch 795/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0027
Epoch 796/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0026
Epoch 797/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0030
Epoch 798/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 799/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0029
Epoch 800/800
250/250 [==============================] - 1s 3ms/step - loss: 0.0031
```

```python
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()
```
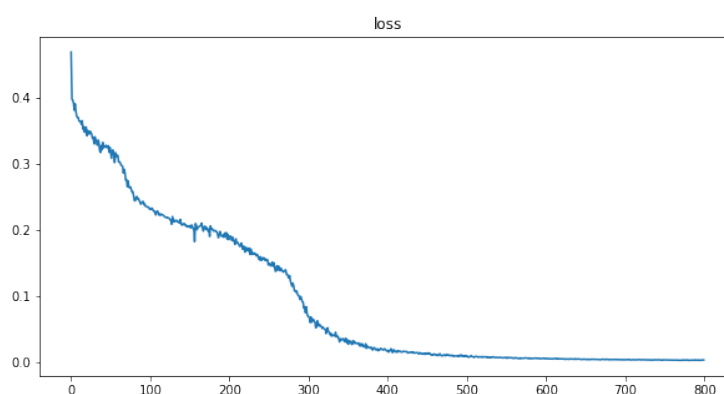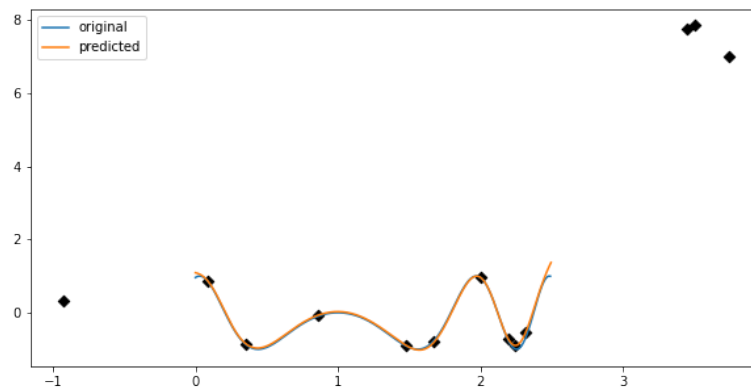
```
t2 = np.arange(0, 2.5, 0.005)

pred = model.predict(t2)

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

plt.plot(t, ft, label = 'original')
plt.plot(t2, pred, label = 'predicted')
mu = model.get_layer(index = 0).get_weights()[0][0]
plt.scatter(mu, model.predict(mu), color = "black", marker = "D")
plt.legend()
plt.show()
```

```
16/16 [==============================] - 0s 2ms/step
1/1 [==============================] - 0s 17ms/step
```



```
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
```
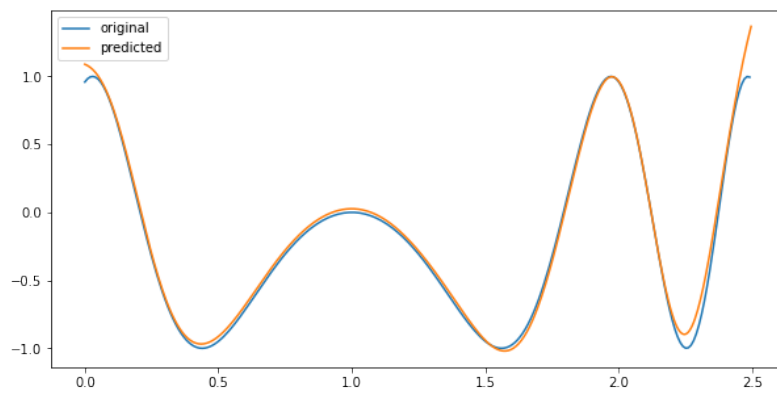
## Выводы

Выполнив данную лабораторную работу, я изучил, как устроены многослойные сети со слоями RBF и реализовал несколько из них, решив задачи аппроксимации и классификации.

[ ]: