Лабораторная работа 4

Сети с радиальными базисными элементами

Тимофеев А. В., М8О-407Б-19

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

Вариант 12

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

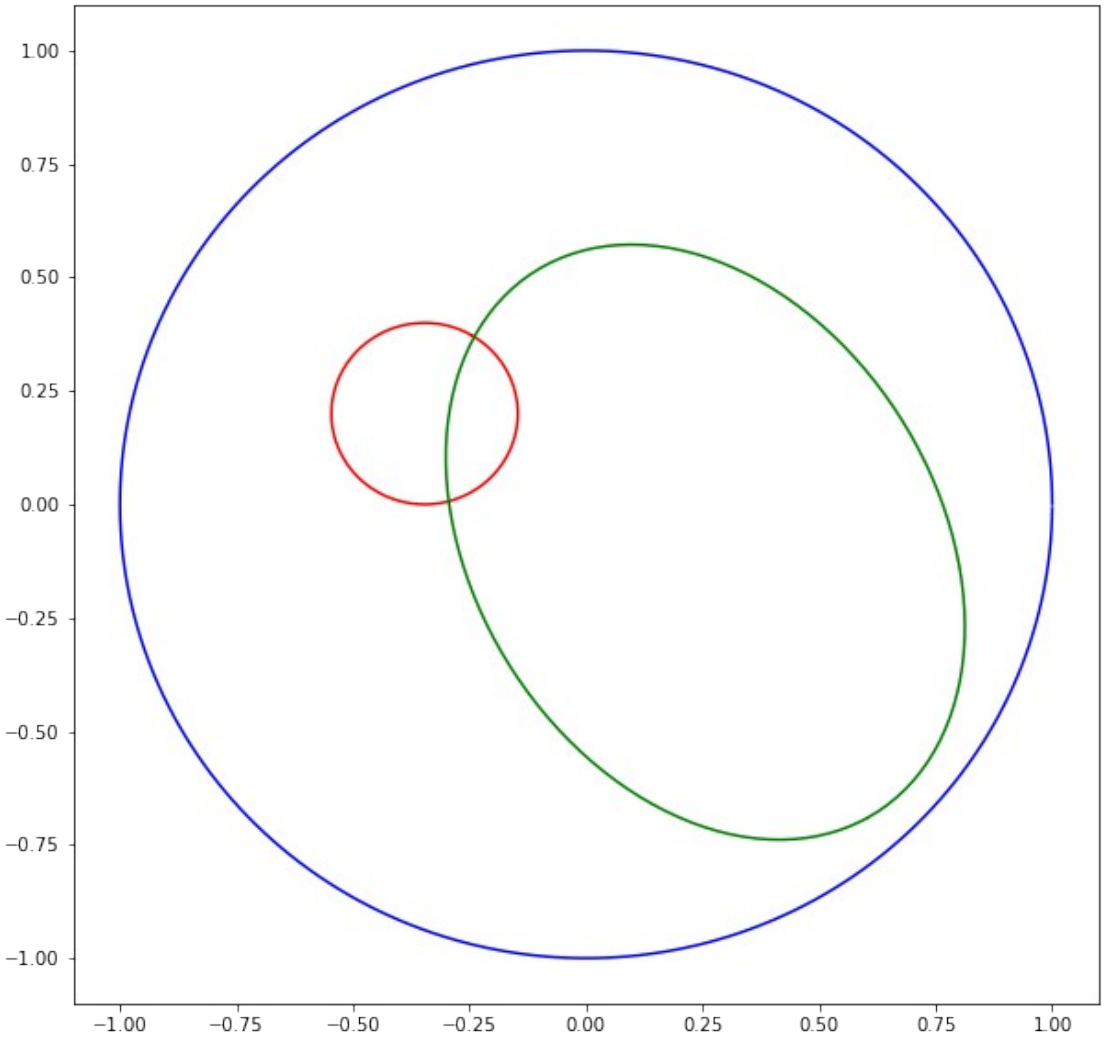
Слой RBF

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

```
# 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

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

# Эллипс
a1 = 0.2
b1 = 0.2
alpha1 = np.pi/3
x01 = 0
y01 = 0.4

# Эллипс
a2 = 0.7
b2 = 0.5
alpha2 = -np.pi/3
x02 = 0.2
y02 = 0.18

# Эллипс
a3 = 1
b3 = 1
alpha3 = 0
x03 = 0
y03 = 0


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

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

fig1x, fig1y = ellipse(t, a1, b1, x01, y01)
fig1x, fig1y = rotate(fig1x, fig1y, alpha1)

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

fig3x, fig3y = ellipse(t, a3, b3, x03, y03)
fig3x, fig3y = rotate(fig3x, fig3y, alpha3)

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

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




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


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

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

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

data = data.transpose()
```

```
from sklearn.model_selection import train_test_split

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

model = keras.models.Sequential()

model.add(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 [==============================] - 1s 665us/step - loss:
0.2265 - accuracy: 0.3493
Epoch 2/200
604/604 [==============================] - 0s 695us/step - loss:
0.2190 - accuracy: 0.3493
Epoch 3/200
604/604 [==============================] - 0s 716us/step - loss:
0.2152 - accuracy: 0.3543
Epoch 4/200
604/604 [==============================] - 0s 667us/step - loss:
0.2113 - accuracy: 0.4619
Epoch 5/200
604/604 [==============================] - 0s 667us/step - loss:
0.2077 - accuracy: 0.4553
Epoch 6/200
604/604 [==============================] - 0s 690us/step - loss:
0.2032 - accuracy: 0.4669
Epoch 7/200
604/604 [==============================] - 0s 660us/step - loss:
0.1976 - accuracy: 0.4685
Epoch 8/200
604/604 [==============================] - 0s 663us/step - loss:
0.1919 - accuracy: 0.5381
Epoch 9/200
604/604 [==============================] - 0s 680us/step - loss:
0.1849 - accuracy: 0.6275
Epoch 10/200
604/604 [==============================] - 0s 667us/step - loss:
0.1776 - accuracy: 0.6871
Epoch 11/200
604/604 [==============================] - 0s 675us/step - loss:
0.1701 - accuracy: 0.7368
Epoch 12/200
604/604 [==============================] - 0s 645us/step - loss:
0.1625 - accuracy: 0.7881
```

```
Epoch 13/200
604/604 [==============================] - 0s 706us/step - loss:
0.1549 - accuracy: 0.8212
Epoch 14/200
604/604 [==============================] - 0s 677us/step - loss:
0.1477 - accuracy: 0.7864
Epoch 15/200
604/604 [==============================] - 0s 672us/step - loss:
0.1411 - accuracy: 0.7666
Epoch 16/200
604/604 [==============================] - 1s 847us/step - loss:
0.1349 - accuracy: 0.7781
Epoch 17/200
604/604 [==============================] - 0s 657us/step - loss:
0.1295 - accuracy: 0.7550
Epoch 18/200
604/604 [==============================] - 0s 648us/step - loss:
0.1249 - accuracy: 0.7616
Epoch 19/200
604/604 [==============================] - 0s 667us/step - loss:
0.1210 - accuracy: 0.7798
Epoch 20/200
604/604 [==============================] - 0s 751us/step - loss:
0.1177 - accuracy: 0.7765
Epoch 21/200
604/604 [==============================] - 0s 655us/step - loss:
0.1149 - accuracy: 0.7881
Epoch 22/200
604/604 [==============================] - 0s 633us/step - loss:
0.1123 - accuracy: 0.7881
Epoch 23/200
604/604 [==============================] - 0s 665us/step - loss:
0.1100 - accuracy: 0.8030
Epoch 24/200
604/604 [==============================] - 0s 682us/step - loss:
0.1074 - accuracy: 0.7997
Epoch 25/200
604/604 [==============================] - 0s 693us/step - loss:
0.1059 - accuracy: 0.8278
Epoch 26/200
604/604 [==============================] - 0s 675us/step - loss:
0.1040 - accuracy: 0.8179
Epoch 27/200
604/604 [==============================] - 0s 631us/step - loss:
0.1021 - accuracy: 0.8311
Epoch 28/200
604/604 [==============================] - 0s 638us/step - loss:
0.1006 - accuracy: 0.8311
Epoch 29/200
604/604 [==============================] - 0s 629us/step - loss:
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0.0988 - accuracy: 0.8311
Epoch 30/200
604/604 [==============================] - 0s 633us/step - loss:
0.0973 - accuracy: 0.8394
Epoch 31/200
604/604 [==============================] - 0s 633us/step - loss:
0.0959 - accuracy: 0.8510
Epoch 32/200
604/604 [==============================] - 0s 629us/step - loss:
0.0948 - accuracy: 0.8427
Epoch 33/200
604/604 [==============================] - 0s 627us/step - loss:
0.0931 - accuracy: 0.8411
Epoch 34/200
604/604 [==============================] - 0s 653us/step - loss:
0.0918 - accuracy: 0.8576
Epoch 35/200
604/604 [==============================] - 0s 692us/step - loss:
0.0908 - accuracy: 0.8626
Epoch 36/200
604/604 [==============================] - 0s 672us/step - loss:
0.0896 - accuracy: 0.8593
Epoch 37/200
604/604 [==============================] - 0s 660us/step - loss:
0.0882 - accuracy: 0.8675
Epoch 38/200
604/604 [==============================] - 0s 642us/step - loss:
0.0872 - accuracy: 0.8709
Epoch 39/200
604/604 [==============================] - 0s 648us/step - loss:
0.0859 - accuracy: 0.8775
Epoch 40/200
604/604 [==============================] - 0s 650us/step - loss:
0.0844 - accuracy: 0.8841
Epoch 41/200
604/604 [==============================] - 0s 648us/step - loss:
0.0839 - accuracy: 0.8758
Epoch 42/200
604/604 [==============================] - 0s 721us/step - loss:
0.0828 - accuracy: 0.8825
Epoch 43/200
604/604 [==============================] - 0s 693us/step - loss:
0.0818 - accuracy: 0.8891
Epoch 44/200
604/604 [==============================] - 0s 647us/step - loss:
0.0807 - accuracy: 0.8891
Epoch 45/200
604/604 [==============================] - 0s 652us/step - loss:
0.0800 - accuracy: 0.8874
Epoch 46/200
```

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604/604 [==============================] - 0s 760us/step - loss:
0.0791 - accuracy: 0.8858
Epoch 47/200
604/604 [==============================] - 0s 665us/step - loss:
0.0782 - accuracy: 0.8974
Epoch 48/200
604/604 [==============================] - 0s 650us/step - loss:
0.0773 - accuracy: 0.8924
Epoch 49/200
604/604 [==============================] - 0s 632us/step - loss:
0.0761 - accuracy: 0.9056
Epoch 50/200
604/604 [==============================] - 0s 630us/step - loss:
0.0748 - accuracy: 0.9089
Epoch 51/200
604/604 [==============================] - 0s 665us/step - loss:
0.0746 - accuracy: 0.9056
Epoch 52/200
604/604 [==============================] - 0s 769us/step - loss:
0.0739 - accuracy: 0.9023
Epoch 53/200
604/604 [==============================] - 0s 680us/step - loss:
0.0729 - accuracy: 0.9040
Epoch 54/200
604/604 [==============================] - 0s 688us/step - loss:
0.0725 - accuracy: 0.9040
Epoch 55/200
604/604 [==============================] - 0s 630us/step - loss:
0.0718 - accuracy: 0.9056
Epoch 56/200
604/604 [==============================] - 0s 682us/step - loss:
0.0708 - accuracy: 0.9089
Epoch 57/200
604/604 [==============================] - 0s 658us/step - loss:
0.0700 - accuracy: 0.9106
Epoch 58/200
604/604 [==============================] - 0s 718us/step - loss:
0.0696 - accuracy: 0.9040
Epoch 59/200
604/604 [==============================] - 0s 672us/step - loss:
0.0693 - accuracy: 0.9023
Epoch 60/200
604/604 [==============================] - 0s 629us/step - loss:
0.0686 - accuracy: 0.9089
Epoch 61/200
604/604 [==============================] - 0s 645us/step - loss:
0.0678 - accuracy: 0.9123
Epoch 62/200
604/604 [==============================] - 0s 683us/step - loss:
0.0673 - accuracy: 0.9123
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Epoch 63/200
604/604 [==============================] - 0s 743us/step - loss:
0.0666 - accuracy: 0.9172
Epoch 64/200
604/604 [==============================] - 0s 721us/step - loss:
0.0657 - accuracy: 0.9172
Epoch 65/200
604/604 [==============================] - 0s 750us/step - loss:
0.0655 - accuracy: 0.9123
Epoch 66/200
604/604 [==============================] - 0s 728us/step - loss:
0.0651 - accuracy: 0.9089
Epoch 67/200
604/604 [==============================] - 0s 673us/step - loss:
0.0648 - accuracy: 0.9189
Epoch 68/200
604/604 [==============================] - 0s 640us/step - loss:
0.0641 - accuracy: 0.9123
Epoch 69/200
604/604 [==============================] - 0s 635us/step - loss:
0.0636 - accuracy: 0.9222
Epoch 70/200
604/604 [==============================] - 0s 647us/step - loss:
0.0634 - accuracy: 0.9205
Epoch 71/200
604/604 [==============================] - 0s 712us/step - loss:
0.0626 - accuracy: 0.9205
Epoch 72/200
604/604 [==============================] - 0s 650us/step - loss:
0.0620 - accuracy: 0.9172
Epoch 73/200
604/604 [==============================] - 0s 648us/step - loss:
0.0614 - accuracy: 0.9205
Epoch 74/200
604/604 [==============================] - 0s 648us/step - loss:
0.0616 - accuracy: 0.9222
Epoch 75/200
604/604 [==============================] - 0s 650us/step - loss:
0.0608 - accuracy: 0.9205
Epoch 76/200
604/604 [==============================] - 0s 632us/step - loss:
0.0608 - accuracy: 0.9205
Epoch 77/200
604/604 [==============================] - 0s 665us/step - loss:
0.0596 - accuracy: 0.9238
Epoch 78/200
604/604 [==============================] - 0s 652us/step - loss:
0.0599 - accuracy: 0.9156
Epoch 79/200
604/604 [==============================] - 0s 650us/step - loss:
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0.0592 - accuracy: 0.9255
Epoch 80/200
604/604 [==============================] - 0s 645us/step - loss:
0.0593 - accuracy: 0.9255
Epoch 81/200
604/604 [==============================] - 0s 657us/step - loss:
0.0590 - accuracy: 0.9205
Epoch 82/200
604/604 [==============================] - 0s 657us/step - loss:
0.0585 - accuracy: 0.9205
Epoch 83/200
604/604 [==============================] - 0s 653us/step - loss:
0.0579 - accuracy: 0.9272
Epoch 84/200
604/604 [==============================] - 0s 677us/step - loss:
0.0575 - accuracy: 0.9272
Epoch 85/200
604/604 [==============================] - 0s 650us/step - loss:
0.0574 - accuracy: 0.9238
Epoch 86/200
604/604 [==============================] - 0s 670us/step - loss:
0.0573 - accuracy: 0.9255
Epoch 87/200
604/604 [==============================] - 0s 657us/step - loss:
0.0564 - accuracy: 0.9305
Epoch 88/200
604/604 [==============================] - 0s 640us/step - loss:
0.0562 - accuracy: 0.9272
Epoch 89/200
604/604 [==============================] - 0s 645us/step - loss:
0.0561 - accuracy: 0.9288
Epoch 90/200
604/604 [==============================] - 0s 640us/step - loss:
0.0551 - accuracy: 0.9272
Epoch 91/200
604/604 [==============================] - 0s 638us/step - loss:
0.0558 - accuracy: 0.9321
Epoch 92/200
604/604 [==============================] - 0s 648us/step - loss:
0.0553 - accuracy: 0.9238
Epoch 93/200
604/604 [==============================] - 0s 638us/step - loss:
0.0553 - accuracy: 0.9255
Epoch 94/200
604/604 [==============================] - 0s 653us/step - loss:
0.0543 - accuracy: 0.9272
Epoch 95/200
604/604 [==============================] - 0s 662us/step - loss:
0.0544 - accuracy: 0.9288
Epoch 96/200
```

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604/604 [==============================] - 0s 652us/step - loss:
0.0544 - accuracy: 0.9338
Epoch 97/200
604/604 [==============================] - 0s 637us/step - loss:
0.0540 - accuracy: 0.9288
Epoch 98/200
604/604 [==============================] - 0s 667us/step - loss:
0.0540 - accuracy: 0.9305
Epoch 99/200
604/604 [==============================] - 0s 653us/step - loss:
0.0533 - accuracy: 0.9305
Epoch 100/200
604/604 [==============================] - 0s 667us/step - loss:
0.0535 - accuracy: 0.9255
Epoch 101/200
604/604 [==============================] - 0s 665us/step - loss:
0.0529 - accuracy: 0.9338
Epoch 102/200
604/604 [==============================] - 0s 665us/step - loss:
0.0530 - accuracy: 0.9272
Epoch 103/200
604/604 [==============================] - 0s 703us/step - loss:
0.0525 - accuracy: 0.9338
Epoch 104/200
604/604 [==============================] - 0s 708us/step - loss:
0.0525 - accuracy: 0.9272
Epoch 105/200
604/604 [==============================] - 0s 781us/step - loss:
0.0517 - accuracy: 0.9272
Epoch 106/200
604/604 [==============================] - 0s 685us/step - loss:
0.0517 - accuracy: 0.9338
Epoch 107/200
604/604 [==============================] - 0s 781us/step - loss:
0.0514 - accuracy: 0.9354
Epoch 108/200
604/604 [==============================] - 0s 706us/step - loss:
0.0512 - accuracy: 0.9288
Epoch 109/200
604/604 [==============================] - 0s 648us/step - loss:
0.0510 - accuracy: 0.9305
Epoch 110/200
604/604 [==============================] - 0s 642us/step - loss:
0.0507 - accuracy: 0.9321
Epoch 111/200
604/604 [==============================] - 0s 781us/step - loss:
0.0507 - accuracy: 0.9338
Epoch 112/200
604/604 [==============================] - 0s 680us/step - loss:
0.0501 - accuracy: 0.9354
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Epoch 113/200
604/604 [==============================] - 0s 668us/step - loss:
0.0503 - accuracy: 0.9288
Epoch 114/200
604/604 [==============================] - 0s 643us/step - loss:
0.0495 - accuracy: 0.9371
Epoch 115/200
604/604 [==============================] - 0s 705us/step - loss:
0.0494 - accuracy: 0.9338
Epoch 116/200
604/604 [==============================] - 0s 688us/step - loss:
0.0497 - accuracy: 0.9338
Epoch 117/200
604/604 [==============================] - 0s 655us/step - loss:
0.0492 - accuracy: 0.9371
Epoch 118/200
604/604 [==============================] - 0s 643us/step - loss:
0.0492 - accuracy: 0.9371
Epoch 119/200
604/604 [==============================] - 0s 640us/step - loss:
0.0491 - accuracy: 0.9321
Epoch 120/200
604/604 [==============================] - 0s 640us/step - loss:
0.0486 - accuracy: 0.9321
Epoch 121/200
604/604 [==============================] - 0s 645us/step - loss:
0.0486 - accuracy: 0.9371
Epoch 122/200
604/604 [==============================] - 0s 663us/step - loss:
0.0481 - accuracy: 0.9321
Epoch 123/200
604/604 [==============================] - 0s 648us/step - loss:
0.0486 - accuracy: 0.9354
Epoch 124/200
604/604 [==============================] - 0s 650us/step - loss:
0.0478 - accuracy: 0.9305
Epoch 125/200
604/604 [==============================] - 0s 680us/step - loss:
0.0475 - accuracy: 0.9338
Epoch 126/200
604/604 [==============================] - 0s 667us/step - loss:
0.0477 - accuracy: 0.9387
Epoch 127/200
604/604 [==============================] - 0s 645us/step - loss:
0.0473 - accuracy: 0.9338
Epoch 128/200
604/604 [==============================] - 0s 697us/step - loss:
0.0478 - accuracy: 0.9288
Epoch 129/200
604/604 [==============================] - 0s 673us/step - loss:
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0.0474 - accuracy: 0.9354
Epoch 130/200
604/604 [==============================] - 0s 662us/step - loss:
0.0473 - accuracy: 0.9354
Epoch 131/200
604/604 [==============================] - 0s 657us/step - loss:
0.0470 - accuracy: 0.9371
Epoch 132/200
604/604 [==============================] - 0s 658us/step - loss:
0.0462 - accuracy: 0.9371
Epoch 133/200
604/604 [==============================] - 0s 668us/step - loss:
0.0469 - accuracy: 0.9354
Epoch 134/200
604/604 [==============================] - 0s 630us/step - loss:
0.0465 - accuracy: 0.9404
Epoch 135/200
604/604 [==============================] - 0s 673us/step - loss:
0.0461 - accuracy: 0.9387
Epoch 136/200
604/604 [==============================] - 0s 642us/step - loss:
0.0462 - accuracy: 0.9371
Epoch 137/200
604/604 [==============================] - 0s 690us/step - loss:
0.0462 - accuracy: 0.9354
Epoch 138/200
604/604 [==============================] - 0s 678us/step - loss:
0.0462 - accuracy: 0.9354
Epoch 139/200
604/604 [==============================] - 0s 667us/step - loss:
0.0464 - accuracy: 0.9354
Epoch 140/200
604/604 [==============================] - 0s 642us/step - loss:
0.0450 - accuracy: 0.9387
Epoch 141/200
604/604 [==============================] - 0s 667us/step - loss:
0.0461 - accuracy: 0.9371
Epoch 142/200
604/604 [==============================] - 0s 662us/step - loss:
0.0452 - accuracy: 0.9387
Epoch 143/200
604/604 [==============================] - 0s 635us/step - loss:
0.0457 - accuracy: 0.9387
Epoch 144/200
604/604 [==============================] - 0s 642us/step - loss:
0.0457 - accuracy: 0.9371
Epoch 145/200
604/604 [==============================] - 0s 658us/step - loss:
0.0461 - accuracy: 0.9338
Epoch 146/200
```

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604/604 [==============================] - 0s 673us/step - loss:
0.0449 - accuracy: 0.9371
Epoch 147/200
604/604 [==============================] - 0s 664us/step - loss:
0.0456 - accuracy: 0.9387
Epoch 148/200
604/604 [==============================] - 0s 632us/step - loss:
0.0460 - accuracy: 0.9371
Epoch 149/200
604/604 [==============================] - 0s 638us/step - loss:
0.0450 - accuracy: 0.9354
Epoch 150/200
604/604 [==============================] - 0s 633us/step - loss:
0.0449 - accuracy: 0.9387
Epoch 151/200
604/604 [==============================] - 0s 647us/step - loss:
0.0450 - accuracy: 0.9404
Epoch 152/200
604/604 [==============================] - 0s 642us/step - loss:
0.0441 - accuracy: 0.9371
Epoch 153/200
604/604 [==============================] - 0s 638us/step - loss:
0.0446 - accuracy: 0.9354
Epoch 154/200
604/604 [==============================] - 0s 640us/step - loss:
0.0442 - accuracy: 0.9354
Epoch 155/200
604/604 [==============================] - 0s 648us/step - loss:
0.0440 - accuracy: 0.9387
Epoch 156/200
604/604 [==============================] - 0s 640us/step - loss:
0.0452 - accuracy: 0.9387
Epoch 157/200
604/604 [==============================] - 0s 655us/step - loss:
0.0440 - accuracy: 0.9437
Epoch 158/200
604/604 [==============================] - 0s 673us/step - loss:
0.0447 - accuracy: 0.9404
Epoch 159/200
604/604 [==============================] - 0s 650us/step - loss:
0.0434 - accuracy: 0.9387
Epoch 160/200
604/604 [==============================] - 0s 642us/step - loss:
0.0443 - accuracy: 0.9354
Epoch 161/200
604/604 [==============================] - 0s 638us/step - loss:
0.0439 - accuracy: 0.9354
Epoch 162/200
604/604 [==============================] - 0s 632us/step - loss:
0.0436 - accuracy: 0.9404
```

```
Epoch 163/200
604/604 [==============================] - 0s 703us/step - loss:
0.0442 - accuracy: 0.9354
Epoch 164/200
604/604 [==============================] - 0s 653us/step - loss:
0.0437 - accuracy: 0.9338
Epoch 165/200
604/604 [==============================] - 0s 663us/step - loss:
0.0428 - accuracy: 0.9371
Epoch 166/200
604/604 [==============================] - 0s 665us/step - loss:
0.0429 - accuracy: 0.9421
Epoch 167/200
604/604 [==============================] - 0s 648us/step - loss:
0.0440 - accuracy: 0.9354
Epoch 168/200
604/604 [==============================] - 0s 635us/step - loss:
0.0431 - accuracy: 0.9404
Epoch 169/200
604/604 [==============================] - 0s 697us/step - loss:
0.0439 - accuracy: 0.9404
Epoch 170/200
604/604 [==============================] - 0s 637us/step - loss:
0.0428 - accuracy: 0.9387
Epoch 171/200
604/604 [==============================] - 0s 647us/step - loss:
0.0434 - accuracy: 0.9404
Epoch 172/200
604/604 [==============================] - 0s 630us/step - loss:
0.0440 - accuracy: 0.9371
Epoch 173/200
604/604 [==============================] - 0s 682us/step - loss:
0.0437 - accuracy: 0.9354
Epoch 174/200
604/604 [==============================] - 0s 662us/step - loss:
0.0440 - accuracy: 0.9371
Epoch 175/200
604/604 [==============================] - 0s 677us/step - loss:
0.0426 - accuracy: 0.9421
Epoch 176/200
604/604 [==============================] - 0s 667us/step - loss:
0.0423 - accuracy: 0.9371
Epoch 177/200
604/604 [==============================] - 0s 647us/step - loss:
0.0431 - accuracy: 0.9371
Epoch 178/200
604/604 [==============================] - 0s 632us/step - loss:
0.0433 - accuracy: 0.9387
Epoch 179/200
604/604 [==============================] - 0s 652us/step - loss:
```

```
0.0429 - accuracy: 0.9354
Epoch 180/200
604/604 [==============================] - 0s 652us/step - loss:
0.0425 - accuracy: 0.9387
Epoch 181/200
604/604 [==============================] - 0s 645us/step - loss:
0.0421 - accuracy: 0.9404
Epoch 182/200
604/604 [==============================] - 0s 647us/step - loss:
0.0421 - accuracy: 0.9404
Epoch 183/200
604/604 [==============================] - 0s 668us/step - loss:
0.0427 - accuracy: 0.9437
Epoch 184/200
604/604 [==============================] - 0s 629us/step - loss:
0.0416 - accuracy: 0.9371
Epoch 185/200
604/604 [==============================] - 0s 645us/step - loss:
0.0432 - accuracy: 0.9354
Epoch 186/200
604/604 [==============================] - 0s 643us/step - loss:
0.0425 - accuracy: 0.9404
Epoch 187/200
604/604 [==============================] - 0s 675us/step - loss:
0.0430 - accuracy: 0.9338
Epoch 188/200
604/604 [==============================] - 0s 663us/step - loss:
0.0418 - accuracy: 0.9437
Epoch 189/200
604/604 [==============================] - 0s 633us/step - loss:
0.0426 - accuracy: 0.9454
Epoch 190/200
604/604 [==============================] - 0s 677us/step - loss:
0.0417 - accuracy: 0.9354
Epoch 191/200
604/604 [==============================] - 0s 653us/step - loss:
0.0420 - accuracy: 0.9387
Epoch 192/200
604/604 [==============================] - 0s 643us/step - loss:
0.0425 - accuracy: 0.9421
Epoch 193/200
604/604 [==============================] - 0s 642us/step - loss:
0.0417 - accuracy: 0.9454
Epoch 194/200
604/604 [==============================] - 0s 677us/step - loss:
0.0415 - accuracy: 0.9354
Epoch 195/200
604/604 [==============================] - 0s 690us/step - loss:
0.0422 - accuracy: 0.9321
Epoch 196/200
```

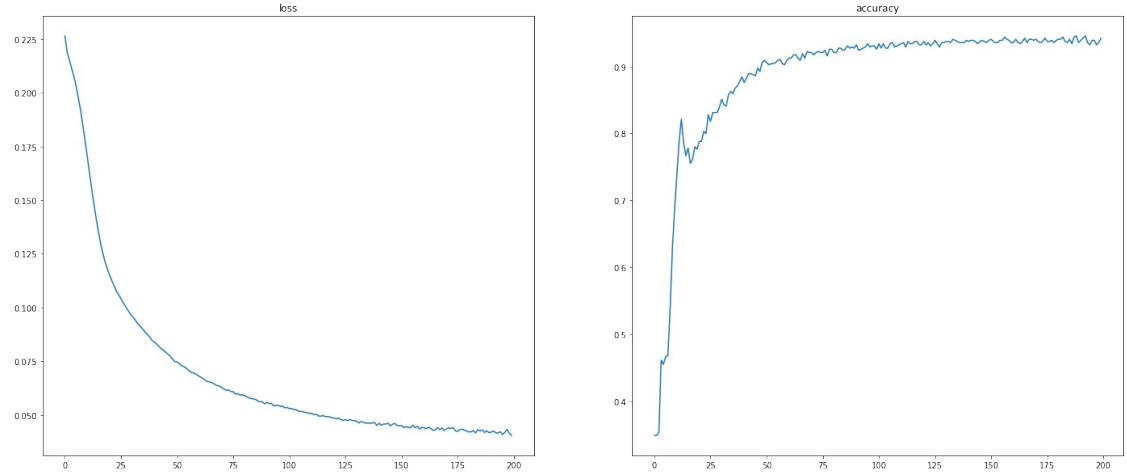
```
604/604 [==============================] - 0s 653us/step - loss:
0.0409 - accuracy: 0.9387
Epoch 197/200
604/604 [==============================] - 0s 658us/step - loss:
0.0418 - accuracy: 0.9387
Epoch 198/200
604/604 [==============================] - 0s 632us/step - loss:
0.0433 - accuracy: 0.9321
Epoch 199/200
604/604 [==============================] - 0s 632us/step - loss:
0.0415 - accuracy: 0.9354
Epoch 200/200
604/604 [==============================] - 0s 630us/step - loss:
0.0404 - accuracy: 0.9421
```

```
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(-5, 5, 200)
y = np.linspace(-5, 5, 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)))

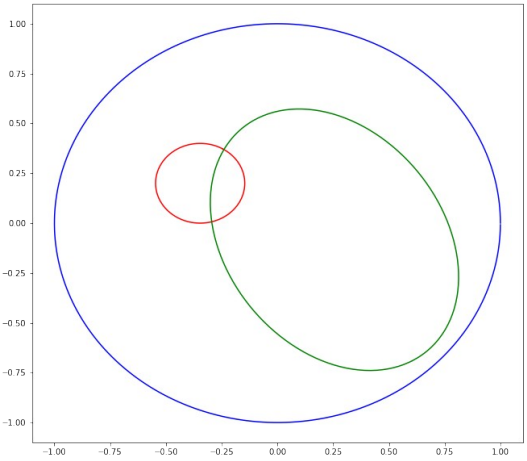
xy = data.transpose()

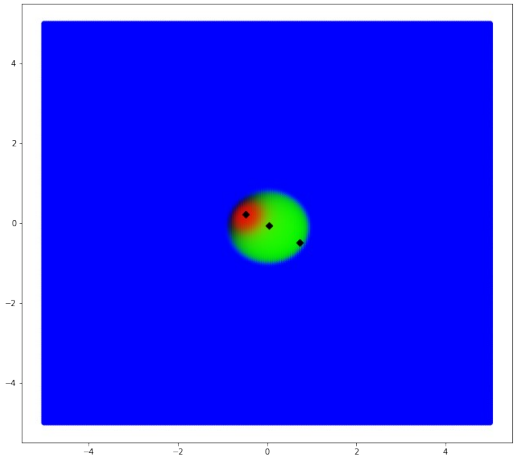
pred = model.predict(data)


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 [==============================] - 1s 554us/step
```





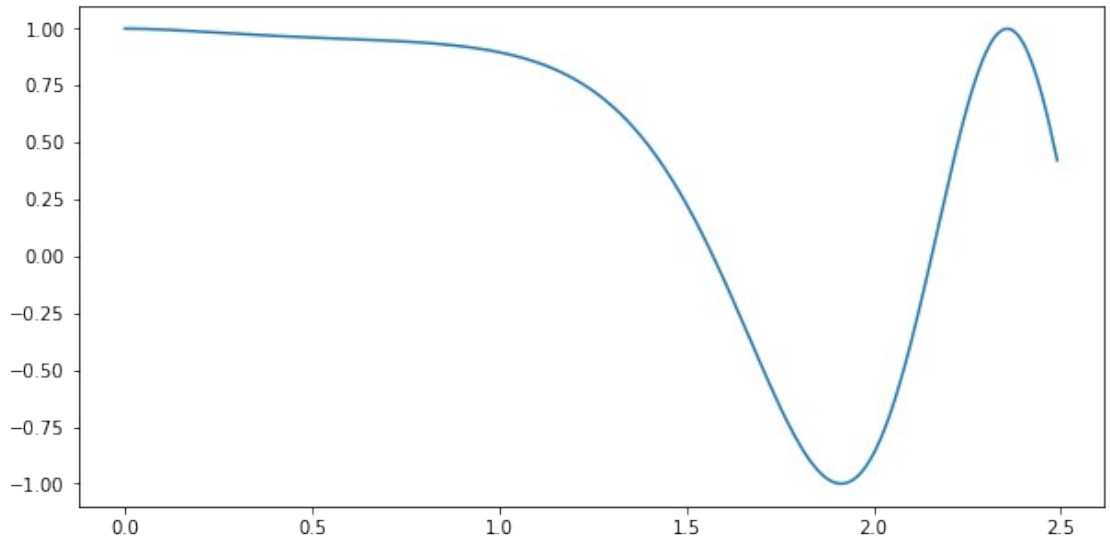
Аппроксимация

```
def f(t):
    return np.cos(-(np.cos(t)) * t**2 + t)

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 691us/step - loss:
0.3738
Epoch 2/800
250/250 [==============================] - 0s 671us/step - loss:
0.3178
Epoch 3/800
250/250 [==============================] - 0s 711us/step - loss:
0.2940
Epoch 4/800
250/250 [==============================] - 0s 671us/step - loss:
0.2827
Epoch 5/800
250/250 [==============================] - 0s 655us/step - loss:
0.2475
Epoch 6/800
250/250 [==============================] - 0s 659us/step - loss:
0.2352
Epoch 7/800
```

```
250/250 [==============================] - 0s 703us/step - loss:
0.2001
Epoch 8/800
250/250 [==============================] - 0s 695us/step - loss:
0.1562
Epoch 9/800
250/250 [==============================] - 0s 683us/step - loss:
0.1204
Epoch 10/800
250/250 [==============================] - 0s 667us/step - loss:
0.0890
Epoch 11/800
250/250 [==============================] - 0s 679us/step - loss:
0.0655
Epoch 12/800
250/250 [==============================] - 0s 679us/step - loss:
0.0594
Epoch 13/800
250/250 [==============================] - 0s 663us/step - loss:
0.0484
Epoch 14/800
250/250 [==============================] - 0s 683us/step - loss:
0.0523
Epoch 15/800
250/250 [==============================] - 0s 763us/step - loss:
0.0494
Epoch 16/800
250/250 [==============================] - 0s 667us/step - loss:
0.0520
Epoch 17/800
250/250 [==============================] - 0s 719us/step - loss:
0.0492
Epoch 18/800
250/250 [==============================] - 0s 687us/step - loss:
0.0472
Epoch 19/800
250/250 [==============================] - 0s 655us/step - loss:
0.0458
Epoch 20/800
250/250 [==============================] - 0s 663us/step - loss:
0.0421
Epoch 21/800
250/250 [==============================] - 0s 622us/step - loss:
0.0408
Epoch 22/800
250/250 [==============================] - 0s 618us/step - loss:
0.0405
Epoch 23/800
250/250 [==============================] - 0s 635us/step - loss:
0.0427
```

```
Epoch 24/800
250/250 [==============================] - 0s 651us/step - loss:
0.0371
Epoch 25/800
250/250 [==============================] - 0s 639us/step - loss:
0.0404
Epoch 26/800
250/250 [==============================] - 0s 627us/step - loss:
0.0366
Epoch 27/800
250/250 [==============================] - 0s 622us/step - loss:
0.0366
Epoch 28/800
250/250 [==============================] - 0s 627us/step - loss:
0.0322
Epoch 29/800
250/250 [==============================] - 0s 659us/step - loss:
0.0325
Epoch 30/800
250/250 [==============================] - 0s 651us/step - loss:
0.0318
Epoch 31/800
250/250 [==============================] - 0s 659us/step - loss:
0.0308
Epoch 32/800
250/250 [==============================] - 0s 659us/step - loss:
0.0331
Epoch 33/800
250/250 [==============================] - 0s 703us/step - loss:
0.0317
Epoch 34/800
250/250 [==============================] - 0s 687us/step - loss:
0.0277
Epoch 35/800
250/250 [==============================] - 0s 671us/step - loss:
0.0298
Epoch 36/800
250/250 [==============================] - 0s 787us/step - loss:
0.0280
Epoch 37/800
250/250 [==============================] - 0s 631us/step - loss:
0.0295
Epoch 38/800
250/250 [==============================] - 0s 635us/step - loss:
0.0276
Epoch 39/800
250/250 [==============================] - 0s 683us/step - loss:
0.0292
Epoch 40/800
250/250 [==============================] - 0s 703us/step - loss:
```

```
0.0261
Epoch 41/800
250/250 [==============================] - 0s 639us/step - loss:
0.0275
Epoch 42/800
250/250 [==============================] - 0s 631us/step - loss:
0.0268
Epoch 43/800
250/250 [==============================] - 0s 631us/step - loss:
0.0249
Epoch 44/800
250/250 [==============================] - 0s 643us/step - loss:
0.0252
Epoch 45/800
250/250 [==============================] - 0s 627us/step - loss:
0.0244
Epoch 46/800
250/250 [==============================] - 0s 627us/step - loss:
0.0238
Epoch 47/800
250/250 [==============================] - 0s 627us/step - loss:
0.0239
Epoch 48/800
250/250 [==============================] - 0s 631us/step - loss:
0.0238
Epoch 49/800
250/250 [==============================] - 0s 631us/step - loss:
0.0234
Epoch 50/800
250/250 [==============================] - 0s 639us/step - loss:
0.0229
Epoch 51/800
250/250 [==============================] - 0s 627us/step - loss:
0.0212
Epoch 52/800
250/250 [==============================] - 0s 627us/step - loss:
0.0235
Epoch 53/800
250/250 [==============================] - 0s 622us/step - loss:
0.0210
Epoch 54/800
250/250 [==============================] - 0s 622us/step - loss:
0.0201
Epoch 55/800
250/250 [==============================] - 0s 622us/step - loss:
0.0204
Epoch 56/800
250/250 [==============================] - 0s 636us/step - loss:
0.0196
Epoch 57/800
```

```
250/250 [==============================] - 0s 622us/step - loss:
0.0199
Epoch 58/800
250/250 [==============================] - 0s 627us/step - loss:
0.0205
Epoch 59/800
250/250 [==============================] - 0s 627us/step - loss:
0.0197
Epoch 60/800
250/250 [==============================] - 0s 683us/step - loss:
0.0174
Epoch 61/800
250/250 [==============================] - 0s 667us/step - loss:
0.0202
Epoch 62/800
250/250 [==============================] - 0s 671us/step - loss:
0.0172
Epoch 63/800
250/250 [==============================] - 0s 643us/step - loss:
0.0178
Epoch 64/800
250/250 [==============================] - 0s 635us/step - loss:
0.0199
Epoch 65/800
250/250 [==============================] - 0s 627us/step - loss:
0.0176
Epoch 66/800
250/250 [==============================] - 0s 627us/step - loss:
0.0173
Epoch 67/800
250/250 [==============================] - 0s 623us/step - loss:
0.0180
Epoch 68/800
250/250 [==============================] - 0s 627us/step - loss:
0.0171
Epoch 69/800
250/250 [==============================] - 0s 631us/step - loss:
0.0148
Epoch 70/800
250/250 [==============================] - 0s 627us/step - loss:
0.0162
Epoch 71/800
250/250 [==============================] - 0s 629us/step - loss:
0.0160
Epoch 72/800
250/250 [==============================] - 0s 626us/step - loss:
0.0147
Epoch 73/800
250/250 [==============================] - 0s 647us/step - loss:
0.0159
```

```
Epoch 74/800
250/250 [==============================] - 0s 635us/step - loss:
0.0142
Epoch 75/800
250/250 [==============================] - 0s 647us/step - loss:
0.0139
Epoch 76/800
250/250 [==============================] - 0s 651us/step - loss:
0.0137
Epoch 77/800
250/250 [==============================] - 0s 639us/step - loss:
0.0129
Epoch 78/800
250/250 [==============================] - 0s 639us/step - loss:
0.0133
Epoch 79/800
250/250 [==============================] - 0s 679us/step - loss:
0.0141
Epoch 80/800
250/250 [==============================] - 0s 691us/step - loss:
0.0133
Epoch 81/800
250/250 [==============================] - 0s 643us/step - loss:
0.0132
Epoch 82/800
250/250 [==============================] - 0s 662us/step - loss:
0.0127
Epoch 83/800
250/250 [==============================] - 0s 639us/step - loss:
0.0129
Epoch 84/800
250/250 [==============================] - 0s 627us/step - loss:
0.0133
Epoch 85/800
250/250 [==============================] - 0s 631us/step - loss:
0.0121
Epoch 86/800
250/250 [==============================] - 0s 635us/step - loss:
0.0129
Epoch 87/800
250/250 [==============================] - 0s 647us/step - loss:
0.0116
Epoch 88/800
250/250 [==============================] - 0s 635us/step - loss:
0.0112
Epoch 89/800
250/250 [==============================] - 0s 647us/step - loss:
0.0115
Epoch 90/800
250/250 [==============================] - 0s 631us/step - loss:
```

```
0.0107
Epoch 91/800
250/250 [==============================] - 0s 643us/step - loss:
0.0111
Epoch 92/800
250/250 [==============================] - 0s 687us/step - loss:
0.0109
Epoch 93/800
250/250 [==============================] - 0s 635us/step - loss:
0.0104
Epoch 94/800
250/250 [==============================] - 0s 622us/step - loss:
0.0111
Epoch 95/800
250/250 [==============================] - 0s 635us/step - loss:
0.0093
Epoch 96/800
250/250 [==============================] - 0s 635us/step - loss:
0.0101
Epoch 97/800
250/250 [==============================] - 0s 635us/step - loss:
0.0096
Epoch 98/800
250/250 [==============================] - 0s 643us/step - loss:
0.0099
Epoch 99/800
250/250 [==============================] - 0s 635us/step - loss:
0.0089
Epoch 100/800
250/250 [==============================] - 0s 627us/step - loss:
0.0084
Epoch 101/800
250/250 [==============================] - 0s 631us/step - loss:
0.0087
Epoch 102/800
250/250 [==============================] - 0s 622us/step - loss:
0.0079
Epoch 103/800
250/250 [==============================] - 0s 627us/step - loss:
0.0077
Epoch 104/800
250/250 [==============================] - 0s 643us/step - loss:
0.0073
Epoch 105/800
250/250 [==============================] - 0s 635us/step - loss:
0.0081
Epoch 106/800
250/250 [==============================] - 0s 647us/step - loss:
0.0074
Epoch 107/800
```

```
250/250 [==============================] - 0s 651us/step - loss:
0.0087
Epoch 108/800
250/250 [==============================] - 0s 631us/step - loss:
0.0074
Epoch 109/800
250/250 [==============================] - 0s 627us/step - loss:
0.0080
Epoch 110/800
250/250 [==============================] - 0s 703us/step - loss:
0.0072
Epoch 111/800
250/250 [==============================] - 0s 631us/step - loss:
0.0078
Epoch 112/800
250/250 [==============================] - 0s 631us/step - loss:
0.0066
Epoch 113/800
250/250 [==============================] - 0s 635us/step - loss:
0.0062
Epoch 114/800
250/250 [==============================] - 0s 631us/step - loss:
0.0058
Epoch 115/800
250/250 [==============================] - 0s 631us/step - loss:
0.0056
Epoch 116/800
250/250 [==============================] - 0s 635us/step - loss:
0.0062
Epoch 117/800
250/250 [==============================] - 0s 651us/step - loss:
0.0059
Epoch 118/800
250/250 [==============================] - 0s 631us/step - loss:
0.0051
Epoch 119/800
250/250 [==============================] - 0s 631us/step - loss:
0.0056
Epoch 120/800
250/250 [==============================] - 0s 631us/step - loss:
0.0055
Epoch 121/800
250/250 [==============================] - 0s 627us/step - loss:
0.0053
Epoch 122/800
250/250 [==============================] - 0s 639us/step - loss:
0.0050
Epoch 123/800
250/250 [==============================] - 0s 635us/step - loss:
0.0045
```

```
Epoch 124/800
250/250 [==============================] - 0s 631us/step - loss:
0.0041
Epoch 125/800
250/250 [==============================] - 0s 631us/step - loss:
0.0042
Epoch 126/800
250/250 [==============================] - 0s 647us/step - loss:
0.0042
Epoch 127/800
250/250 [==============================] - 0s 631us/step - loss:
0.0037
Epoch 128/800
250/250 [==============================] - 0s 647us/step - loss:
0.0042
Epoch 129/800
250/250 [==============================] - 0s 639us/step - loss:
0.0038
Epoch 130/800
250/250 [==============================] - 0s 631us/step - loss:
0.0044
Epoch 131/800
250/250 [==============================] - 0s 647us/step - loss:
0.0039
Epoch 132/800
250/250 [==============================] - 0s 667us/step - loss:
0.0038
Epoch 133/800
250/250 [==============================] - 0s 631us/step - loss:
0.0032
Epoch 134/800
250/250 [==============================] - 0s 647us/step - loss:
0.0038
Epoch 135/800
250/250 [==============================] - 0s 639us/step - loss:
0.0036
Epoch 136/800
250/250 [==============================] - 0s 622us/step - loss:
0.0028
Epoch 137/800
250/250 [==============================] - 0s 631us/step - loss:
0.0035
Epoch 138/800
250/250 [==============================] - 0s 635us/step - loss:
0.0033
Epoch 139/800
250/250 [==============================] - 0s 627us/step - loss:
0.0030
Epoch 140/800
250/250 [==============================] - 0s 635us/step - loss:
```

```
0.0030
Epoch 141/800
250/250 [==============================] - 0s 635us/step - loss:
0.0025
Epoch 142/800
250/250 [==============================] - 0s 627us/step - loss:
0.0034
Epoch 143/800
250/250 [==============================] - 0s 622us/step - loss:
0.0025
Epoch 144/800
250/250 [==============================] - 0s 643us/step - loss:
0.0035
Epoch 145/800
250/250 [==============================] - 0s 655us/step - loss:
0.0030
Epoch 146/800
250/250 [==============================] - 0s 627us/step - loss:
0.0033
Epoch 147/800
250/250 [==============================] - 0s 626us/step - loss:
0.0028
Epoch 148/800
250/250 [==============================] - 0s 639us/step - loss:
0.0030
Epoch 149/800
250/250 [==============================] - 0s 643us/step - loss:
0.0023
Epoch 150/800
250/250 [==============================] - 0s 626us/step - loss:
0.0029
Epoch 151/800
250/250 [==============================] - 0s 631us/step - loss:
0.0028
Epoch 152/800
250/250 [==============================] - 0s 622us/step - loss:
0.0026
Epoch 153/800
250/250 [==============================] - 0s 631us/step - loss:
0.0026
Epoch 154/800
250/250 [==============================] - 0s 635us/step - loss:
0.0024
Epoch 155/800
250/250 [==============================] - 0s 635us/step - loss:
0.0028
Epoch 156/800
250/250 [==============================] - 0s 631us/step - loss:
0.0023
Epoch 157/800
```

```
250/250 [==============================] - 0s 631us/step - loss:
0.0022
Epoch 158/800
250/250 [==============================] - 0s 622us/step - loss:
0.0024
Epoch 159/800
250/250 [==============================] - 0s 631us/step - loss:
0.0023
Epoch 160/800
250/250 [==============================] - 0s 635us/step - loss:
0.0025
Epoch 161/800
250/250 [==============================] - 0s 627us/step - loss:
0.0021
Epoch 162/800
250/250 [==============================] - 0s 627us/step - loss:
0.0025
Epoch 163/800
250/250 [==============================] - 0s 631us/step - loss:
0.0022
Epoch 164/800
250/250 [==============================] - 0s 630us/step - loss:
0.0021
Epoch 165/800
250/250 [==============================] - 0s 631us/step - loss:
0.0022
Epoch 166/800
250/250 [==============================] - 0s 635us/step - loss:
0.0023
Epoch 167/800
250/250 [==============================] - 0s 711us/step - loss:
0.0025
Epoch 168/800
250/250 [==============================] - 0s 643us/step - loss:
0.0021
Epoch 169/800
250/250 [==============================] - 0s 627us/step - loss:
0.0024
Epoch 170/800
250/250 [==============================] - 0s 635us/step - loss:
0.0024
Epoch 171/800
250/250 [==============================] - 0s 659us/step - loss:
0.0022
Epoch 172/800
250/250 [==============================] - 0s 639us/step - loss:
0.0021
Epoch 173/800
250/250 [==============================] - 0s 635us/step - loss:
0.0019
```

```
Epoch 174/800
250/250 [==============================] - 0s 627us/step - loss:
0.0024
Epoch 175/800
250/250 [==============================] - 0s 643us/step - loss:
0.0021
Epoch 176/800
250/250 [==============================] - 0s 631us/step - loss:
0.0022
Epoch 177/800
250/250 [==============================] - 0s 622us/step - loss:
0.0021
Epoch 178/800
250/250 [==============================] - 0s 622us/step - loss:
0.0021
Epoch 179/800
250/250 [==============================] - 0s 639us/step - loss:
0.0017
Epoch 180/800
250/250 [==============================] - 0s 635us/step - loss:
0.0020
Epoch 181/800
250/250 [==============================] - 0s 622us/step - loss:
0.0020
Epoch 182/800
250/250 [==============================] - 0s 627us/step - loss:
0.0021
Epoch 183/800
250/250 [==============================] - 0s 675us/step - loss:
0.0020
Epoch 184/800
250/250 [==============================] - 0s 655us/step - loss:
0.0019
Epoch 185/800
250/250 [==============================] - 0s 639us/step - loss:
0.0017
Epoch 186/800
250/250 [==============================] - 0s 631us/step - loss:
0.0018
Epoch 187/800
250/250 [==============================] - 0s 635us/step - loss:
0.0019
Epoch 188/800
250/250 [==============================] - 0s 651us/step - loss:
0.0019
Epoch 189/800
250/250 [==============================] - 0s 639us/step - loss:
0.0020
Epoch 190/800
250/250 [==============================] - 0s 622us/step - loss:
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0.0017
Epoch 191/800
250/250 [==============================] - 0s 622us/step - loss:
0.0015
Epoch 192/800
250/250 [==============================] - 0s 627us/step - loss:
0.0016
Epoch 193/800
250/250 [==============================] - 0s 679us/step - loss:
0.0018
Epoch 194/800
250/250 [==============================] - 0s 631us/step - loss:
0.0019
Epoch 195/800
250/250 [==============================] - 0s 622us/step - loss:
0.0018
Epoch 196/800
250/250 [==============================] - 0s 622us/step - loss:
0.0017
Epoch 197/800
250/250 [==============================] - 0s 622us/step - loss:
0.0014
Epoch 198/800
250/250 [==============================] - 0s 627us/step - loss:
0.0015
Epoch 199/800
250/250 [==============================] - 0s 627us/step - loss:
0.0019
Epoch 200/800
250/250 [==============================] - 0s 631us/step - loss:
0.0019
Epoch 201/800
250/250 [==============================] - 0s 622us/step - loss:
0.0016
Epoch 202/800
250/250 [==============================] - 0s 622us/step - loss:
0.0017
Epoch 203/800
250/250 [==============================] - 0s 618us/step - loss:
0.0017
Epoch 204/800
250/250 [==============================] - 0s 622us/step - loss:
0.0017
Epoch 205/800
250/250 [==============================] - 0s 622us/step - loss:
0.0017
Epoch 206/800
250/250 [==============================] - 0s 627us/step - loss:
0.0020
Epoch 207/800
```

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250/250 [==============================] - 0s 626us/step - loss:
0.0019
Epoch 208/800
250/250 [==============================] - 0s 622us/step - loss:
0.0015
Epoch 209/800
250/250 [==============================] - 0s 622us/step - loss:
0.0018
Epoch 210/800
250/250 [==============================] - 0s 622us/step - loss:
0.0015
Epoch 211/800
250/250 [==============================] - 0s 622us/step - loss:
0.0017
Epoch 212/800
250/250 [==============================] - 0s 626us/step - loss:
0.0016
Epoch 213/800
250/250 [==============================] - 0s 622us/step - loss:
0.0015
Epoch 214/800
250/250 [==============================] - 0s 627us/step - loss:
0.0015
Epoch 215/800
250/250 [==============================] - 0s 618us/step - loss:
0.0015
Epoch 216/800
250/250 [==============================] - 0s 622us/step - loss:
0.0017
Epoch 217/800
250/250 [==============================] - 0s 622us/step - loss:
0.0014
Epoch 218/800
250/250 [==============================] - 0s 627us/step - loss:
0.0014
Epoch 219/800
250/250 [==============================] - 0s 622us/step - loss:
0.0012
Epoch 220/800
250/250 [==============================] - 0s 622us/step - loss:
0.0014
Epoch 221/800
250/250 [==============================] - 0s 622us/step - loss:
0.0017
Epoch 222/800
250/250 [==============================] - 0s 624us/step - loss:
0.0014
Epoch 223/800
250/250 [==============================] - 0s 627us/step - loss:
0.0016
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Epoch 224/800
250/250 [==============================] - 0s 631us/step - loss:
0.0016
Epoch 225/800
250/250 [==============================] - 0s 627us/step - loss:
0.0013
Epoch 226/800
250/250 [==============================] - 0s 622us/step - loss:
0.0016
Epoch 227/800
250/250 [==============================] - 0s 622us/step - loss:
0.0014
Epoch 228/800
250/250 [==============================] - 0s 622us/step - loss:
0.0015
Epoch 229/800
250/250 [==============================] - 0s 618us/step - loss:
0.0015
Epoch 230/800
250/250 [==============================] - 0s 622us/step - loss:
0.0010
Epoch 231/800
250/250 [==============================] - 0s 622us/step - loss:
0.0016
Epoch 232/800
250/250 [==============================] - 0s 627us/step - loss:
0.0014
Epoch 233/800
250/250 [==============================] - 0s 627us/step - loss:
0.0014
Epoch 234/800
250/250 [==============================] - 0s 683us/step - loss:
0.0013
Epoch 235/800
250/250 [==============================] - 0s 635us/step - loss:
0.0013
Epoch 236/800
250/250 [==============================] - 0s 627us/step - loss:
0.0013
Epoch 237/800
250/250 [==============================] - 0s 627us/step - loss:
0.0013
Epoch 238/800
250/250 [==============================] - 0s 631us/step - loss:
0.0014
Epoch 239/800
250/250 [==============================] - 0s 627us/step - loss:
0.0013
Epoch 240/800
250/250 [==============================] - 0s 635us/step - loss:
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0.0012
Epoch 241/800
250/250 [==============================] - 0s 647us/step - loss:
0.0012
Epoch 242/800
250/250 [==============================] - 0s 643us/step - loss:
0.0012
Epoch 243/800
250/250 [==============================] - 0s 675us/step - loss:
0.0013
Epoch 244/800
250/250 [==============================] - 0s 683us/step - loss:
0.0015
Epoch 245/800
250/250 [==============================] - 0s 687us/step - loss:
0.0014
Epoch 246/800
250/250 [==============================] - 0s 703us/step - loss:
0.0013
Epoch 247/800
250/250 [==============================] - 0s 651us/step - loss:
0.0013
Epoch 248/800
250/250 [==============================] - 0s 678us/step - loss:
0.0014
Epoch 249/800
250/250 [==============================] - 0s 639us/step - loss:
0.0011
Epoch 250/800
250/250 [==============================] - 0s 627us/step - loss:
0.0011
Epoch 251/800
250/250 [==============================] - 0s 627us/step - loss:
0.0011
Epoch 252/800
250/250 [==============================] - 0s 647us/step - loss:
0.0010
Epoch 253/800
250/250 [==============================] - 0s 627us/step - loss:
0.0012
Epoch 254/800
250/250 [==============================] - 0s 671us/step - loss:
0.0011
Epoch 255/800
250/250 [==============================] - 0s 655us/step - loss:
0.0013
Epoch 256/800
250/250 [==============================] - 0s 643us/step - loss:
9.5360e-04
Epoch 257/800
```

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250/250 [==============================] - 0s 672us/step - loss:
0.0011
Epoch 258/800
250/250 [==============================] - 0s 779us/step - loss:
0.0011
Epoch 259/800
250/250 [==============================] - 0s 655us/step - loss:
0.0011
Epoch 260/800
250/250 [==============================] - 0s 639us/step - loss:
9.8112e-04
Epoch 261/800
250/250 [==============================] - 0s 675us/step - loss:
9.8831e-04
Epoch 262/800
250/250 [==============================] - 0s 671us/step - loss:
9.4101e-04
Epoch 263/800
250/250 [==============================] - 0s 667us/step - loss:
0.0011
Epoch 264/800
250/250 [==============================] - 0s 675us/step - loss:
0.0011
Epoch 265/800
250/250 [==============================] - 0s 699us/step - loss:
0.0010
Epoch 266/800
250/250 [==============================] - 0s 675us/step - loss:
9.6184e-04
Epoch 267/800
250/250 [==============================] - 0s 647us/step - loss:
0.0010
Epoch 268/800
250/250 [==============================] - 0s 659us/step - loss:
0.0010
Epoch 269/800
250/250 [==============================] - 0s 659us/step - loss:
9.2246e-04
Epoch 270/800
250/250 [==============================] - 0s 639us/step - loss:
8.6374e-04
Epoch 271/800
250/250 [==============================] - 0s 655us/step - loss:
0.0010
Epoch 272/800
250/250 [==============================] - 0s 631us/step - loss:
9.9226e-04
Epoch 273/800
250/250 [==============================] - 0s 671us/step - loss:
9.4839e-04
```

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Epoch 274/800
250/250 [==============================] - 0s 807us/step - loss:
8.2602e-04
Epoch 275/800
250/250 [==============================] - 0s 755us/step - loss:
7.9898e-04
Epoch 276/800
250/250 [==============================] - 0s 715us/step - loss:
9.5712e-04
Epoch 277/800
250/250 [==============================] - 0s 643us/step - loss:
8.9056e-04
Epoch 278/800
250/250 [==============================] - 0s 743us/step - loss:
7.6328e-04
Epoch 279/800
250/250 [==============================] - 0s 639us/step - loss:
8.7086e-04
Epoch 280/800
250/250 [==============================] - 0s 631us/step - loss:
8.8541e-04
Epoch 281/800
250/250 [==============================] - 0s 687us/step - loss:
9.0502e-04
Epoch 282/800
250/250 [==============================] - 0s 631us/step - loss:
8.4951e-04
Epoch 283/800
250/250 [==============================] - 0s 627us/step - loss:
8.5121e-04
Epoch 284/800
250/250 [==============================] - 0s 627us/step - loss:
7.7447e-04
Epoch 285/800
250/250 [==============================] - 0s 622us/step - loss:
7.5781e-04
Epoch 286/800
250/250 [==============================] - 0s 618us/step - loss:
8.0657e-04
Epoch 287/800
250/250 [==============================] - 0s 631us/step - loss:
7.9680e-04
Epoch 288/800
250/250 [==============================] - 0s 622us/step - loss:
8.3744e-04
Epoch 289/800
250/250 [==============================] - 0s 618us/step - loss:
8.2176e-04
Epoch 290/800
250/250 [==============================] - 0s 622us/step - loss:
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8.3527e-04
Epoch 291/800
250/250 [==============================] - 0s 631us/step - loss:
8.4093e-04
Epoch 292/800
250/250 [==============================] - 0s 618us/step - loss:
7.9248e-04
Epoch 293/800
250/250 [==============================] - 0s 622us/step - loss:
8.2141e-04
Epoch 294/800
250/250 [==============================] - 0s 631us/step - loss:
8.1293e-04
Epoch 295/800
250/250 [==============================] - 0s 631us/step - loss:
7.3410e-04
Epoch 296/800
250/250 [==============================] - 0s 627us/step - loss:
7.2885e-04
Epoch 297/800
250/250 [==============================] - 0s 622us/step - loss:
8.4473e-04
Epoch 298/800
250/250 [==============================] - 0s 675us/step - loss:
7.3993e-04
Epoch 299/800
250/250 [==============================] - 0s 627us/step - loss:
7.5274e-04
Epoch 300/800
250/250 [==============================] - 0s 622us/step - loss:
7.6926e-04
Epoch 301/800
250/250 [==============================] - 0s 627us/step - loss:
6.6684e-04
Epoch 302/800
250/250 [==============================] - 0s 627us/step - loss:
6.6064e-04
Epoch 303/800
250/250 [==============================] - 0s 622us/step - loss:
7.5223e-04
Epoch 304/800
250/250 [==============================] - 0s 635us/step - loss:
7.9716e-04
Epoch 305/800
250/250 [==============================] - 0s 627us/step - loss:
7.2745e-04
Epoch 306/800
250/250 [==============================] - 0s 627us/step - loss:
7.8974e-04
Epoch 307/800
```

```
250/250 [==============================] - 0s 627us/step - loss:
6.7914e-04
Epoch 308/800
250/250 [==============================] - 0s 626us/step - loss:
7.5478e-04
Epoch 309/800
250/250 [==============================] - 0s 622us/step - loss:
6.5087e-04
Epoch 310/800
250/250 [==============================] - 0s 618us/step - loss:
7.3166e-04
Epoch 311/800
250/250 [==============================] - 0s 622us/step - loss:
6.4851e-04
Epoch 312/800
250/250 [==============================] - 0s 635us/step - loss:
7.2309e-04
Epoch 313/800
250/250 [==============================] - 0s 618us/step - loss:
6.6053e-04
Epoch 314/800
250/250 [==============================] - 0s 622us/step - loss:
6.8857e-04
Epoch 315/800
250/250 [==============================] - 0s 618us/step - loss:
6.3775e-04
Epoch 316/800
250/250 [==============================] - 0s 627us/step - loss:
6.7930e-04
Epoch 317/800
250/250 [==============================] - 0s 627us/step - loss:
7.3980e-04
Epoch 318/800
250/250 [==============================] - 0s 627us/step - loss:
7.0045e-04
Epoch 319/800
250/250 [==============================] - 0s 627us/step - loss:
6.6731e-04
Epoch 320/800
250/250 [==============================] - 0s 627us/step - loss:
6.6712e-04
Epoch 321/800
250/250 [==============================] - 0s 622us/step - loss:
6.1821e-04
Epoch 322/800
250/250 [==============================] - 0s 675us/step - loss:
6.8135e-04
Epoch 323/800
250/250 [==============================] - 0s 621us/step - loss:
6.5274e-04
```

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Epoch 324/800
250/250 [==============================] - 0s 627us/step - loss:
6.4198e-04
Epoch 325/800
250/250 [==============================] - 0s 631us/step - loss:
6.1474e-04
Epoch 326/800
250/250 [==============================] - 0s 622us/step - loss:
6.4608e-04
Epoch 327/800
250/250 [==============================] - 0s 629us/step - loss:
6.3302e-04
Epoch 328/800
250/250 [==============================] - 0s 622us/step - loss:
6.2039e-04
Epoch 329/800
250/250 [==============================] - 0s 635us/step - loss:
6.1707e-04
Epoch 330/800
250/250 [==============================] - 0s 627us/step - loss:
6.0003e-04
Epoch 331/800
250/250 [==============================] - 0s 627us/step - loss:
6.5152e-04
Epoch 332/800
250/250 [==============================] - 0s 627us/step - loss:
5.7473e-04
Epoch 333/800
250/250 [==============================] - 0s 622us/step - loss:
5.7153e-04
Epoch 334/800
250/250 [==============================] - 0s 622us/step - loss:
5.2641e-04
Epoch 335/800
250/250 [==============================] - 0s 622us/step - loss:
5.7685e-04
Epoch 336/800
250/250 [==============================] - 0s 627us/step - loss:
6.2787e-04
Epoch 337/800
250/250 [==============================] - 0s 627us/step - loss:
6.1888e-04
Epoch 338/800
250/250 [==============================] - 0s 627us/step - loss:
6.4199e-04
Epoch 339/800
250/250 [==============================] - 0s 683us/step - loss:
6.0546e-04
Epoch 340/800
250/250 [==============================] - 0s 711us/step - loss:
```

```
6.1738e-04
Epoch 341/800
250/250 [==============================] - 0s 639us/step - loss:
6.2499e-04
Epoch 342/800
250/250 [==============================] - 0s 671us/step - loss:
5.5262e-04
Epoch 343/800
250/250 [==============================] - 0s 755us/step - loss:
5.7856e-04
Epoch 344/800
250/250 [==============================] - 0s 719us/step - loss:
6.3130e-04
Epoch 345/800
250/250 [==============================] - 0s 647us/step - loss:
5.8497e-04
Epoch 346/800
250/250 [==============================] - 0s 707us/step - loss:
5.5177e-04
Epoch 347/800
250/250 [==============================] - 0s 679us/step - loss:
5.5525e-04
Epoch 348/800
250/250 [==============================] - 0s 643us/step - loss:
5.7725e-04
Epoch 349/800
250/250 [==============================] - 0s 643us/step - loss:
5.5941e-04
Epoch 350/800
250/250 [==============================] - 0s 663us/step - loss:
6.6241e-04
Epoch 351/800
250/250 [==============================] - 0s 667us/step - loss:
5.3588e-04
Epoch 352/800
250/250 [==============================] - 0s 659us/step - loss:
5.4712e-04
Epoch 353/800
250/250 [==============================] - 0s 663us/step - loss:
5.4880e-04
Epoch 354/800
250/250 [==============================] - 0s 663us/step - loss:
6.0392e-04
Epoch 355/800
250/250 [==============================] - 0s 655us/step - loss:
5.2438e-04
Epoch 356/800
250/250 [==============================] - 0s 663us/step - loss:
5.5774e-04
Epoch 357/800
```

```
250/250 [==============================] - 0s 643us/step - loss:
5.4596e-04
Epoch 358/800
250/250 [==============================] - 0s 659us/step - loss:
5.5992e-04
Epoch 359/800
250/250 [==============================] - 0s 679us/step - loss:
5.0777e-04
Epoch 360/800
250/250 [==============================] - 0s 667us/step - loss:
5.9225e-04
Epoch 361/800
250/250 [==============================] - 0s 699us/step - loss:
5.5910e-04
Epoch 362/800
250/250 [==============================] - 0s 667us/step - loss:
5.9939e-04
Epoch 363/800
250/250 [==============================] - 0s 659us/step - loss:
5.4399e-04
Epoch 364/800
250/250 [==============================] - 0s 655us/step - loss:
5.3695e-04
Epoch 365/800
250/250 [==============================] - 0s 647us/step - loss:
5.1363e-04
Epoch 366/800
250/250 [==============================] - 0s 655us/step - loss:
5.5784e-04
Epoch 367/800
250/250 [==============================] - 0s 687us/step - loss:
5.4997e-04
Epoch 368/800
250/250 [==============================] - 0s 763us/step - loss:
5.3503e-04
Epoch 369/800
250/250 [==============================] - 0s 695us/step - loss:
5.2979e-04
Epoch 370/800
250/250 [==============================] - 0s 699us/step - loss:
5.4690e-04
Epoch 371/800
250/250 [==============================] - 0s 707us/step - loss:
4.7299e-04
Epoch 372/800
250/250 [==============================] - 0s 711us/step - loss:
4.9069e-04
Epoch 373/800
250/250 [==============================] - 0s 695us/step - loss:
5.1634e-04
```

```
Epoch 374/800
250/250 [==============================] - 0s 707us/step - loss:
4.5384e-04
Epoch 375/800
250/250 [==============================] - 0s 707us/step - loss:
5.0959e-04
Epoch 376/800
250/250 [==============================] - 0s 687us/step - loss:
5.2651e-04
Epoch 377/800
250/250 [==============================] - 0s 675us/step - loss:
4.8824e-04
Epoch 378/800
250/250 [==============================] - 0s 703us/step - loss:
4.7162e-04
Epoch 379/800
250/250 [==============================] - 0s 671us/step - loss:
4.3919e-04
Epoch 380/800
250/250 [==============================] - 0s 707us/step - loss:
4.4772e-04
Epoch 381/800
250/250 [==============================] - 0s 691us/step - loss:
5.0914e-04
Epoch 382/800
250/250 [==============================] - 0s 683us/step - loss:
4.7331e-04
Epoch 383/800
250/250 [==============================] - 0s 699us/step - loss:
5.0938e-04
Epoch 384/800
250/250 [==============================] - 0s 683us/step - loss:
4.9866e-04
Epoch 385/800
250/250 [==============================] - 0s 667us/step - loss:
5.0190e-04
Epoch 386/800
250/250 [==============================] - 0s 675us/step - loss:
5.3612e-04
Epoch 387/800
250/250 [==============================] - 0s 659us/step - loss:
5.0860e-04
Epoch 388/800
250/250 [==============================] - 0s 659us/step - loss:
4.1796e-04
Epoch 389/800
250/250 [==============================] - 0s 659us/step - loss:
4.8104e-04
Epoch 390/800
250/250 [==============================] - 0s 711us/step - loss:
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4.8140e-04
Epoch 391/800
250/250 [==============================] - 0s 651us/step - loss:
3.9416e-04
Epoch 392/800
250/250 [==============================] - 0s 639us/step - loss:
4.6124e-04
Epoch 393/800
250/250 [==============================] - 0s 663us/step - loss:
4.7074e-04
Epoch 394/800
250/250 [==============================] - 0s 659us/step - loss:
4.1921e-04
Epoch 395/800
250/250 [==============================] - 0s 651us/step - loss:
4.6145e-04
Epoch 396/800
250/250 [==============================] - 0s 671us/step - loss:
4.4112e-04
Epoch 397/800
250/250 [==============================] - 0s 647us/step - loss:
4.4816e-04
Epoch 398/800
250/250 [==============================] - 0s 655us/step - loss:
4.3520e-04
Epoch 399/800
250/250 [==============================] - 0s 643us/step - loss:
4.3645e-04
Epoch 400/800
250/250 [==============================] - 0s 647us/step - loss:
4.5155e-04
Epoch 401/800
250/250 [==============================] - 0s 647us/step - loss:
4.3537e-04
Epoch 402/800
250/250 [==============================] - 0s 647us/step - loss:
4.5475e-04
Epoch 403/800
250/250 [==============================] - 0s 643us/step - loss:
4.9258e-04
Epoch 404/800
250/250 [==============================] - 0s 651us/step - loss:
4.2377e-04
Epoch 405/800
250/250 [==============================] - 0s 651us/step - loss:
4.5368e-04
Epoch 406/800
250/250 [==============================] - 0s 731us/step - loss:
4.1257e-04
Epoch 407/800
```

```
250/250 [==============================] - 0s 663us/step - loss:
4.6617e-04
Epoch 408/800
250/250 [==============================] - 0s 663us/step - loss:
4.2230e-04
Epoch 409/800
250/250 [==============================] - 0s 639us/step - loss:
4.3076e-04
Epoch 410/800
250/250 [==============================] - 0s 627us/step - loss:
4.7740e-04
Epoch 411/800
250/250 [==============================] - 0s 622us/step - loss:
4.7830e-04
Epoch 412/800
250/250 [==============================] - 0s 627us/step - loss:
4.2862e-04
Epoch 413/800
250/250 [==============================] - 0s 627us/step - loss:
4.8227e-04
Epoch 414/800
250/250 [==============================] - 0s 631us/step - loss:
4.1157e-04
Epoch 415/800
250/250 [==============================] - 0s 631us/step - loss:
4.7224e-04
Epoch 416/800
250/250 [==============================] - 0s 631us/step - loss:
4.1817e-04
Epoch 417/800
250/250 [==============================] - 0s 627us/step - loss:
4.1047e-04
Epoch 418/800
250/250 [==============================] - 0s 622us/step - loss:
4.7881e-04
Epoch 419/800
250/250 [==============================] - 0s 639us/step - loss:
4.4628e-04
Epoch 420/800
250/250 [==============================] - 0s 707us/step - loss:
4.0240e-04
Epoch 421/800
250/250 [==============================] - 0s 647us/step - loss:
3.7224e-04
Epoch 422/800
250/250 [==============================] - 0s 647us/step - loss:
4.1419e-04
Epoch 423/800
250/250 [==============================] - 0s 667us/step - loss:
3.9489e-04
```

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Epoch 424/800
250/250 [==============================] - 0s 647us/step - loss:
4.5747e-04
Epoch 425/800
250/250 [==============================] - 0s 647us/step - loss:
4.4568e-04
Epoch 426/800
250/250 [==============================] - 0s 707us/step - loss:
4.0934e-04
Epoch 427/800
250/250 [==============================] - 0s 622us/step - loss:
4.0714e-04
Epoch 428/800
250/250 [==============================] - 0s 622us/step - loss:
4.1537e-04
Epoch 429/800
250/250 [==============================] - 0s 655us/step - loss:
4.1039e-04
Epoch 430/800
250/250 [==============================] - 0s 659us/step - loss:
4.5116e-04
Epoch 431/800
250/250 [==============================] - 0s 639us/step - loss:
4.2203e-04
Epoch 432/800
250/250 [==============================] - 0s 635us/step - loss:
4.3847e-04
Epoch 433/800
250/250 [==============================] - 0s 655us/step - loss:
3.8673e-04
Epoch 434/800
250/250 [==============================] - 0s 655us/step - loss:
4.2969e-04
Epoch 435/800
250/250 [==============================] - 0s 679us/step - loss:
4.3229e-04
Epoch 436/800
250/250 [==============================] - 0s 651us/step - loss:
4.1985e-04
Epoch 437/800
250/250 [==============================] - 0s 639us/step - loss:
4.8340e-04
Epoch 438/800
250/250 [==============================] - 0s 647us/step - loss:
3.9390e-04
Epoch 439/800
250/250 [==============================] - 0s 643us/step - loss:
3.9128e-04
Epoch 440/800
250/250 [==============================] - 0s 627us/step - loss:
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4.2097e-04
Epoch 441/800
250/250 [==============================] - 0s 635us/step - loss:
4.0212e-04
Epoch 442/800
250/250 [==============================] - 0s 631us/step - loss:
4.1111e-04
Epoch 443/800
250/250 [==============================] - 0s 711us/step - loss:
4.2976e-04
Epoch 444/800
250/250 [==============================] - 0s 647us/step - loss:
4.0255e-04
Epoch 445/800
250/250 [==============================] - 0s 627us/step - loss:
4.2927e-04
Epoch 446/800
250/250 [==============================] - 0s 622us/step - loss:
4.1611e-04
Epoch 447/800
250/250 [==============================] - 0s 639us/step - loss:
4.0501e-04
Epoch 448/800
250/250 [==============================] - 0s 687us/step - loss:
4.0248e-04
Epoch 449/800
250/250 [==============================] - 0s 655us/step - loss:
4.0473e-04
Epoch 450/800
250/250 [==============================] - 0s 647us/step - loss:
4.4583e-04
Epoch 451/800
250/250 [==============================] - 0s 651us/step - loss:
4.3211e-04
Epoch 452/800
250/250 [==============================] - 0s 639us/step - loss:
4.2401e-04
Epoch 453/800
250/250 [==============================] - 0s 635us/step - loss:
4.3113e-04
Epoch 454/800
250/250 [==============================] - 0s 651us/step - loss:
4.5114e-04
Epoch 455/800
250/250 [==============================] - 0s 639us/step - loss:
3.9757e-04
Epoch 456/800
250/250 [==============================] - 0s 635us/step - loss:
3.8158e-04
Epoch 457/800
```

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250/250 [==============================] - 0s 635us/step - loss:
3.7272e-04
Epoch 458/800
250/250 [==============================] - 0s 643us/step - loss:
3.6822e-04
Epoch 459/800
250/250 [==============================] - 0s 622us/step - loss:
4.4097e-04
Epoch 460/800
250/250 [==============================] - 0s 643us/step - loss:
4.6663e-04
Epoch 461/800
250/250 [==============================] - 0s 699us/step - loss:
4.0106e-04
Epoch 462/800
250/250 [==============================] - 0s 635us/step - loss:
3.7178e-04
Epoch 463/800
250/250 [==============================] - 0s 635us/step - loss:
4.1168e-04
Epoch 464/800
250/250 [==============================] - 0s 627us/step - loss:
4.5072e-04
Epoch 465/800
250/250 [==============================] - 0s 651us/step - loss:
4.8068e-04
Epoch 466/800
250/250 [==============================] - 0s 635us/step - loss:
4.2541e-04
Epoch 467/800
250/250 [==============================] - 0s 643us/step - loss:
3.5891e-04
Epoch 468/800
250/250 [==============================] - 0s 631us/step - loss:
4.1398e-04
Epoch 469/800
250/250 [==============================] - 0s 622us/step - loss:
3.7449e-04
Epoch 470/800
250/250 [==============================] - 0s 627us/step - loss:
3.9268e-04
Epoch 471/800
250/250 [==============================] - 0s 627us/step - loss:
4.1501e-04
Epoch 472/800
250/250 [==============================] - 0s 663us/step - loss:
4.0141e-04
Epoch 473/800
250/250 [==============================] - 0s 671us/step - loss:
3.9458e-04
```

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Epoch 474/800
250/250 [==============================] - 0s 712us/step - loss:
4.4011e-04
Epoch 475/800
250/250 [==============================] - 0s 671us/step - loss:
3.9577e-04
Epoch 476/800
250/250 [==============================] - 0s 719us/step - loss:
3.4891e-04
Epoch 477/800
250/250 [==============================] - 0s 679us/step - loss:
3.7017e-04
Epoch 478/800
250/250 [==============================] - 0s 711us/step - loss:
4.0633e-04
Epoch 479/800
250/250 [==============================] - 0s 663us/step - loss:
4.3224e-04
Epoch 480/800
250/250 [==============================] - 0s 647us/step - loss:
3.6741e-04
Epoch 481/800
250/250 [==============================] - 0s 639us/step - loss:
3.8175e-04
Epoch 482/800
250/250 [==============================] - 0s 626us/step - loss:
4.2924e-04
Epoch 483/800
250/250 [==============================] - 0s 631us/step - loss:
3.7061e-04
Epoch 484/800
250/250 [==============================] - 0s 639us/step - loss:
3.8485e-04
Epoch 485/800
250/250 [==============================] - 0s 643us/step - loss:
3.8721e-04
Epoch 486/800
250/250 [==============================] - 0s 639us/step - loss:
4.4422e-04
Epoch 487/800
250/250 [==============================] - 0s 635us/step - loss:
4.1270e-04
Epoch 488/800
250/250 [==============================] - 0s 631us/step - loss:
3.7468e-04
Epoch 489/800
250/250 [==============================] - 0s 627us/step - loss:
3.9310e-04
Epoch 490/800
250/250 [==============================] - 0s 627us/step - loss:
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3.3457e-04
Epoch 491/800
250/250 [==============================] - 0s 622us/step - loss:
3.7585e-04
Epoch 492/800
250/250 [==============================] - 0s 631us/step - loss:
3.4035e-04
Epoch 493/800
250/250 [==============================] - 0s 622us/step - loss:
3.5234e-04
Epoch 494/800
250/250 [==============================] - 0s 683us/step - loss:
4.1725e-04
Epoch 495/800
250/250 [==============================] - 0s 614us/step - loss:
3.7511e-04
Epoch 496/800
250/250 [==============================] - 0s 618us/step - loss:
4.4768e-04
Epoch 497/800
250/250 [==============================] - 0s 626us/step - loss:
3.9713e-04
Epoch 498/800
250/250 [==============================] - 0s 618us/step - loss:
4.0685e-04
Epoch 499/800
250/250 [==============================] - 0s 631us/step - loss:
4.2599e-04
Epoch 500/800
250/250 [==============================] - 0s 622us/step - loss:
3.9473e-04
Epoch 501/800
250/250 [==============================] - 0s 627us/step - loss:
4.0479e-04
Epoch 502/800
250/250 [==============================] - 0s 618us/step - loss:
4.3566e-04
Epoch 503/800
250/250 [==============================] - 0s 618us/step - loss:
3.7023e-04
Epoch 504/800
250/250 [==============================] - 0s 627us/step - loss:
4.0017e-04
Epoch 505/800
250/250 [==============================] - 0s 622us/step - loss:
3.7038e-04
Epoch 506/800
250/250 [==============================] - 0s 618us/step - loss:
4.2748e-04
Epoch 507/800
```

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250/250 [==============================] - 0s 618us/step - loss:
4.0817e-04
Epoch 508/800
250/250 [==============================] - 0s 618us/step - loss:
3.4580e-04
Epoch 509/800
250/250 [==============================] - 0s 671us/step - loss:
4.2434e-04
Epoch 510/800
250/250 [==============================] - 0s 622us/step - loss:
4.2317e-04
Epoch 511/800
250/250 [==============================] - 0s 627us/step - loss:
4.1919e-04
Epoch 512/800
250/250 [==============================] - 0s 618us/step - loss:
4.0746e-04
Epoch 513/800
250/250 [==============================] - 0s 627us/step - loss:
4.1409e-04
Epoch 514/800
250/250 [==============================] - 0s 622us/step - loss:
4.3070e-04
Epoch 515/800
250/250 [==============================] - 0s 631us/step - loss:
4.2029e-04
Epoch 516/800
250/250 [==============================] - 0s 622us/step - loss:
4.3613e-04
Epoch 517/800
250/250 [==============================] - 0s 627us/step - loss:
3.6644e-04
Epoch 518/800
250/250 [==============================] - 0s 627us/step - loss:
4.0169e-04
Epoch 519/800
250/250 [==============================] - 0s 618us/step - loss:
3.9008e-04
Epoch 520/800
250/250 [==============================] - 0s 618us/step - loss:
3.7918e-04
Epoch 521/800
250/250 [==============================] - 0s 622us/step - loss:
4.2555e-04
Epoch 522/800
250/250 [==============================] - 0s 622us/step - loss:
3.6956e-04
Epoch 523/800
250/250 [==============================] - 0s 631us/step - loss:
3.7780e-04
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Epoch 524/800
250/250 [==============================] - 0s 683us/step - loss:
3.3674e-04
Epoch 525/800
250/250 [==============================] - 0s 627us/step - loss:
3.7005e-04
Epoch 526/800
250/250 [==============================] - 0s 643us/step - loss:
3.3593e-04
Epoch 527/800
250/250 [==============================] - 0s 682us/step - loss:
3.7804e-04
Epoch 528/800
250/250 [==============================] - 0s 663us/step - loss:
3.7620e-04
Epoch 529/800
250/250 [==============================] - 0s 627us/step - loss:
4.0474e-04
Epoch 530/800
250/250 [==============================] - 0s 631us/step - loss:
3.5038e-04
Epoch 531/800
250/250 [==============================] - 0s 631us/step - loss:
4.2049e-04
Epoch 532/800
250/250 [==============================] - 0s 627us/step - loss:
3.7358e-04
Epoch 533/800
250/250 [==============================] - 0s 647us/step - loss:
3.6838e-04
Epoch 534/800
250/250 [==============================] - 0s 767us/step - loss:
3.8718e-04
Epoch 535/800
250/250 [==============================] - 0s 731us/step - loss:
3.9940e-04
Epoch 536/800
250/250 [==============================] - 0s 667us/step - loss:
3.4108e-04
Epoch 537/800
250/250 [==============================] - 0s 659us/step - loss:
3.6355e-04
Epoch 538/800
250/250 [==============================] - 0s 647us/step - loss:
3.7467e-04
Epoch 539/800
250/250 [==============================] - 0s 719us/step - loss:
3.5654e-04
Epoch 540/800
250/250 [==============================] - 0s 655us/step - loss:
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3.5134e-04
Epoch 541/800
250/250 [==============================] - 0s 655us/step - loss:
3.5636e-04
Epoch 542/800
250/250 [==============================] - 0s 663us/step - loss:
3.4364e-04
Epoch 543/800
250/250 [==============================] - 0s 639us/step - loss:
3.7429e-04
Epoch 544/800
250/250 [==============================] - 0s 622us/step - loss:
3.5718e-04
Epoch 545/800
250/250 [==============================] - 0s 643us/step - loss:
3.8746e-04
Epoch 546/800
250/250 [==============================] - 0s 643us/step - loss:
3.4532e-04
Epoch 547/800
250/250 [==============================] - 0s 622us/step - loss:
4.2052e-04
Epoch 548/800
250/250 [==============================] - 0s 631us/step - loss:
3.4140e-04
Epoch 549/800
250/250 [==============================] - 0s 643us/step - loss:
3.4899e-04
Epoch 550/800
250/250 [==============================] - 0s 647us/step - loss:
3.6629e-04
Epoch 551/800
250/250 [==============================] - 0s 643us/step - loss:
3.7383e-04
Epoch 552/800
250/250 [==============================] - 0s 695us/step - loss:
3.2863e-04
Epoch 553/800
250/250 [==============================] - 0s 671us/step - loss:
3.4866e-04
Epoch 554/800
250/250 [==============================] - 0s 655us/step - loss:
3.5404e-04
Epoch 555/800
250/250 [==============================] - 0s 679us/step - loss:
3.7225e-04
Epoch 556/800
250/250 [==============================] - 0s 687us/step - loss:
3.6418e-04
Epoch 557/800
```

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250/250 [==============================] - 0s 751us/step - loss:
3.6866e-04
Epoch 558/800
250/250 [==============================] - 0s 779us/step - loss:
3.9259e-04
Epoch 559/800
250/250 [==============================] - 0s 675us/step - loss:
3.6191e-04
Epoch 560/800
250/250 [==============================] - 0s 679us/step - loss:
3.9851e-04
Epoch 561/800
250/250 [==============================] - 0s 675us/step - loss:
3.2975e-04
Epoch 562/800
250/250 [==============================] - 0s 679us/step - loss:
3.7562e-04
Epoch 563/800
250/250 [==============================] - 0s 683us/step - loss:
3.4986e-04
Epoch 564/800
250/250 [==============================] - 0s 691us/step - loss:
3.3295e-04
Epoch 565/800
250/250 [==============================] - 0s 699us/step - loss:
3.9638e-04
Epoch 566/800
250/250 [==============================] - 0s 691us/step - loss:
3.4198e-04
Epoch 567/800
250/250 [==============================] - 0s 747us/step - loss:
3.5251e-04
Epoch 568/800
250/250 [==============================] - 0s 671us/step - loss:
3.8130e-04
Epoch 569/800
250/250 [==============================] - 0s 667us/step - loss:
3.6966e-04
Epoch 570/800
250/250 [==============================] - 0s 659us/step - loss:
3.0558e-04
Epoch 571/800
250/250 [==============================] - 0s 679us/step - loss:
3.8375e-04
Epoch 572/800
250/250 [==============================] - 0s 671us/step - loss:
3.2769e-04
Epoch 573/800
250/250 [==============================] - 0s 687us/step - loss:
3.7728e-04
```

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Epoch 574/800
250/250 [==============================] - 0s 687us/step - loss:
3.4232e-04
Epoch 575/800
250/250 [==============================] - 0s 675us/step - loss:
3.6564e-04
Epoch 576/800
250/250 [==============================] - 0s 655us/step - loss:
3.4164e-04
Epoch 577/800
250/250 [==============================] - 0s 651us/step - loss:
3.2381e-04
Epoch 578/800
250/250 [==============================] - 0s 655us/step - loss:
3.3913e-04
Epoch 579/800
250/250 [==============================] - 0s 663us/step - loss:
3.1593e-04
Epoch 580/800
250/250 [==============================] - 0s 679us/step - loss:
3.5438e-04
Epoch 581/800
250/250 [==============================] - 0s 711us/step - loss:
3.5642e-04
Epoch 582/800
250/250 [==============================] - 0s 675us/step - loss:
3.2814e-04
Epoch 583/800
250/250 [==============================] - 0s 671us/step - loss:
3.3542e-04
Epoch 584/800
250/250 [==============================] - 0s 667us/step - loss:
3.8328e-04
Epoch 585/800
250/250 [==============================] - 0s 687us/step - loss:
3.7158e-04
Epoch 586/800
250/250 [==============================] - 0s 683us/step - loss:
3.4684e-04
Epoch 587/800
250/250 [==============================] - 0s 675us/step - loss:
3.6080e-04
Epoch 588/800
250/250 [==============================] - 0s 663us/step - loss:
3.8065e-04
Epoch 589/800
250/250 [==============================] - 0s 659us/step - loss:
3.4455e-04
Epoch 590/800
250/250 [==============================] - 0s 659us/step - loss:
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3.4593e-04
Epoch 591/800
250/250 [==============================] - 0s 699us/step - loss:
3.3515e-04
Epoch 592/800
250/250 [==============================] - 0s 667us/step - loss:
3.7339e-04
Epoch 593/800
250/250 [==============================] - 0s 651us/step - loss:
3.3472e-04
Epoch 594/800
250/250 [==============================] - 0s 675us/step - loss:
3.4050e-04
Epoch 595/800
250/250 [==============================] - 0s 739us/step - loss:
3.5482e-04
Epoch 596/800
250/250 [==============================] - 0s 667us/step - loss:
3.5457e-04
Epoch 597/800
250/250 [==============================] - 0s 675us/step - loss:
3.4927e-04
Epoch 598/800
250/250 [==============================] - 0s 659us/step - loss:
3.4089e-04
Epoch 599/800
250/250 [==============================] - 0s 655us/step - loss:
3.2600e-04
Epoch 600/800
250/250 [==============================] - 0s 695us/step - loss:
3.2969e-04
Epoch 601/800
250/250 [==============================] - 0s 691us/step - loss:
3.1449e-04
Epoch 602/800
250/250 [==============================] - 0s 687us/step - loss:
4.1410e-04
Epoch 603/800
250/250 [==============================] - 0s 663us/step - loss:
3.4465e-04
Epoch 604/800
250/250 [==============================] - 0s 655us/step - loss:
2.9709e-04
Epoch 605/800
250/250 [==============================] - 0s 659us/step - loss:
3.5772e-04
Epoch 606/800
250/250 [==============================] - 0s 655us/step - loss:
3.2841e-04
Epoch 607/800
```

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250/250 [==============================] - 0s 671us/step - loss:
3.7072e-04
Epoch 608/800
250/250 [==============================] - 0s 663us/step - loss:
3.4621e-04
Epoch 609/800
250/250 [==============================] - 0s 719us/step - loss:
2.9877e-04
Epoch 610/800
250/250 [==============================] - 0s 655us/step - loss:
3.4713e-04
Epoch 611/800
250/250 [==============================] - 0s 655us/step - loss:
3.4177e-04
Epoch 612/800
250/250 [==============================] - 0s 671us/step - loss:
3.2950e-04
Epoch 613/800
250/250 [==============================] - 0s 671us/step - loss:
2.9760e-04
Epoch 614/800
250/250 [==============================] - 0s 663us/step - loss:
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Epoch 615/800
250/250 [==============================] - 0s 663us/step - loss:
3.2452e-04
Epoch 616/800
250/250 [==============================] - 0s 651us/step - loss:
3.4771e-04
Epoch 617/800
250/250 [==============================] - 0s 659us/step - loss:
3.4249e-04
Epoch 618/800
250/250 [==============================] - 0s 659us/step - loss:
2.9307e-04
Epoch 619/800
250/250 [==============================] - 0s 655us/step - loss:
3.2204e-04
Epoch 620/800
250/250 [==============================] - 0s 659us/step - loss:
3.4275e-04
Epoch 621/800
250/250 [==============================] - 0s 659us/step - loss:
3.0762e-04
Epoch 622/800
250/250 [==============================] - 0s 711us/step - loss:
3.4828e-04
Epoch 623/800
250/250 [==============================] - 0s 659us/step - loss:
3.3911e-04
```

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Epoch 624/800
250/250 [==============================] - 0s 667us/step - loss:
3.2204e-04
Epoch 625/800
250/250 [==============================] - 0s 659us/step - loss:
3.2818e-04
Epoch 626/800
250/250 [==============================] - 0s 655us/step - loss:
3.1692e-04
Epoch 627/800
250/250 [==============================] - 0s 659us/step - loss:
3.2328e-04
Epoch 628/800
250/250 [==============================] - 0s 655us/step - loss:
3.3145e-04
Epoch 629/800
250/250 [==============================] - 0s 663us/step - loss:
3.1252e-04
Epoch 630/800
250/250 [==============================] - 0s 659us/step - loss:
3.2510e-04
Epoch 631/800
250/250 [==============================] - 0s 659us/step - loss:
3.3427e-04
Epoch 632/800
250/250 [==============================] - 0s 659us/step - loss:
3.1990e-04
Epoch 633/800
250/250 [==============================] - 0s 671us/step - loss:
3.2227e-04
Epoch 634/800
250/250 [==============================] - 0s 711us/step - loss:
3.0645e-04
Epoch 635/800
250/250 [==============================] - 0s 659us/step - loss:
3.3391e-04
Epoch 636/800
250/250 [==============================] - 0s 663us/step - loss:
3.0678e-04
Epoch 637/800
250/250 [==============================] - 0s 663us/step - loss:
3.5189e-04
Epoch 638/800
250/250 [==============================] - 0s 663us/step - loss:
2.8370e-04
Epoch 639/800
250/250 [==============================] - 0s 659us/step - loss:
3.2240e-04
Epoch 640/800
250/250 [==============================] - 0s 651us/step - loss:
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```
3.5186e-04
Epoch 641/800
250/250 [==============================] - 0s 651us/step - loss:
3.2034e-04
Epoch 642/800
250/250 [==============================] - 0s 659us/step - loss:
3.3970e-04
Epoch 643/800
250/250 [==============================] - 0s 667us/step - loss:
2.9688e-04
Epoch 644/800
250/250 [==============================] - 0s 659us/step - loss:
3.4148e-04
Epoch 645/800
250/250 [==============================] - 0s 667us/step - loss:
3.0594e-04
Epoch 646/800
250/250 [==============================] - 0s 683us/step - loss:
3.0206e-04
Epoch 647/800
250/250 [==============================] - 0s 703us/step - loss:
3.0074e-04
Epoch 648/800
250/250 [==============================] - 0s 663us/step - loss:
3.1192e-04
Epoch 649/800
250/250 [==============================] - 0s 663us/step - loss:
3.0148e-04
Epoch 650/800
250/250 [==============================] - 0s 659us/step - loss:
2.9443e-04
Epoch 651/800
250/250 [==============================] - 0s 655us/step - loss:
2.9170e-04
Epoch 652/800
250/250 [==============================] - 0s 655us/step - loss:
3.5023e-04
Epoch 653/800
250/250 [==============================] - 0s 663us/step - loss:
3.0321e-04
Epoch 654/800
250/250 [==============================] - 0s 659us/step - loss:
3.1836e-04
Epoch 655/800
250/250 [==============================] - 0s 667us/step - loss:
2.8577e-04
Epoch 656/800
250/250 [==============================] - 0s 663us/step - loss:
2.7540e-04
Epoch 657/800
```

```
250/250 [==============================] - 0s 675us/step - loss:
2.7360e-04
Epoch 658/800
250/250 [==============================] - 0s 647us/step - loss:
2.8451e-04
Epoch 659/800
250/250 [==============================] - 0s 727us/step - loss:
3.0905e-04
Epoch 660/800
250/250 [==============================] - 0s 663us/step - loss:
3.1362e-04
Epoch 661/800
250/250 [==============================] - 0s 667us/step - loss:
3.2742e-04
Epoch 662/800
250/250 [==============================] - 0s 655us/step - loss:
2.7233e-04
Epoch 663/800
250/250 [==============================] - 0s 655us/step - loss:
3.0895e-04
Epoch 664/800
250/250 [==============================] - 0s 647us/step - loss:
3.2934e-04
Epoch 665/800
250/250 [==============================] - 0s 659us/step - loss:
2.8960e-04
Epoch 666/800
250/250 [==============================] - 0s 659us/step - loss:
2.7011e-04
Epoch 667/800
250/250 [==============================] - 0s 659us/step - loss:
3.0638e-04
Epoch 668/800
250/250 [==============================] - 0s 663us/step - loss:
3.0635e-04
Epoch 669/800
250/250 [==============================] - 0s 663us/step - loss:
2.7887e-04
Epoch 670/800
250/250 [==============================] - 0s 651us/step - loss:
3.0443e-04
Epoch 671/800
250/250 [==============================] - 0s 663us/step - loss:
2.9147e-04
Epoch 672/800
250/250 [==============================] - 0s 719us/step - loss:
2.7942e-04
Epoch 673/800
250/250 [==============================] - 0s 659us/step - loss:
3.3036e-04
```

```
Epoch 674/800
250/250 [==============================] - 0s 659us/step - loss:
2.7178e-04
Epoch 675/800
250/250 [==============================] - 0s 663us/step - loss:
2.7646e-04
Epoch 676/800
250/250 [==============================] - 0s 659us/step - loss:
3.2796e-04
Epoch 677/800
250/250 [==============================] - 0s 639us/step - loss:
2.9001e-04
Epoch 678/800
250/250 [==============================] - 0s 631us/step - loss:
2.9563e-04
Epoch 679/800
250/250 [==============================] - 0s 643us/step - loss:
3.2582e-04
Epoch 680/800
250/250 [==============================] - 0s 639us/step - loss:
2.9656e-04
Epoch 681/800
250/250 [==============================] - 0s 639us/step - loss:
2.9438e-04
Epoch 682/800
250/250 [==============================] - 0s 627us/step - loss:
2.8968e-04
Epoch 683/800
250/250 [==============================] - 0s 635us/step - loss:
2.8477e-04
Epoch 684/800
250/250 [==============================] - 0s 691us/step - loss:
2.9765e-04
Epoch 685/800
250/250 [==============================] - 0s 643us/step - loss:
2.9094e-04
Epoch 686/800
250/250 [==============================] - 0s 635us/step - loss:
2.9886e-04
Epoch 687/800
250/250 [==============================] - 0s 647us/step - loss:
2.9830e-04
Epoch 688/800
250/250 [==============================] - 0s 655us/step - loss:
2.9880e-04
Epoch 689/800
250/250 [==============================] - 0s 651us/step - loss:
3.1332e-04
Epoch 690/800
250/250 [==============================] - 0s 683us/step - loss:
```

```
3.2801e-04
Epoch 691/800
250/250 [==============================] - 0s 687us/step - loss:
2.8812e-04
Epoch 692/800
250/250 [==============================] - 0s 659us/step - loss:
3.1081e-04
Epoch 693/800
250/250 [==============================] - 0s 663us/step - loss:
2.6012e-04
Epoch 694/800
250/250 [==============================] - 0s 663us/step - loss:
2.8747e-04
Epoch 695/800
250/250 [==============================] - 0s 647us/step - loss:
2.9556e-04
Epoch 696/800
250/250 [==============================] - 0s 956us/step - loss:
2.8620e-04
Epoch 697/800
250/250 [==============================] - 0s 691us/step - loss:
3.1407e-04
Epoch 698/800
250/250 [==============================] - 0s 663us/step - loss:
2.8079e-04
Epoch 699/800
250/250 [==============================] - 0s 675us/step - loss:
2.7684e-04
Epoch 700/800
250/250 [==============================] - 0s 675us/step - loss:
2.9407e-04
Epoch 701/800
250/250 [==============================] - 0s 691us/step - loss:
3.3090e-04
Epoch 702/800
250/250 [==============================] - 0s 667us/step - loss:
3.1076e-04
Epoch 703/800
250/250 [==============================] - 0s 643us/step - loss:
2.7750e-04
Epoch 704/800
250/250 [==============================] - 0s 651us/step - loss:
2.6570e-04
Epoch 705/800
250/250 [==============================] - 0s 643us/step - loss:
2.7330e-04
Epoch 706/800
250/250 [==============================] - 0s 631us/step - loss:
3.1701e-04
Epoch 707/800
```

```
250/250 [==============================] - 0s 703us/step - loss:
2.9970e-04
Epoch 708/800
250/250 [==============================] - 0s 659us/step - loss:
3.3451e-04
Epoch 709/800
250/250 [==============================] - 0s 699us/step - loss:
3.2507e-04
Epoch 710/800
250/250 [==============================] - 0s 659us/step - loss:
3.0221e-04
Epoch 711/800
250/250 [==============================] - 0s 655us/step - loss:
3.2084e-04
Epoch 712/800
250/250 [==============================] - 0s 663us/step - loss:
2.9580e-04
Epoch 713/800
250/250 [==============================] - 0s 651us/step - loss:
2.9803e-04
Epoch 714/800
250/250 [==============================] - 0s 667us/step - loss:
3.3077e-04
Epoch 715/800
250/250 [==============================] - 0s 743us/step - loss:
2.6897e-04
Epoch 716/800
250/250 [==============================] - 0s 819us/step - loss:
2.9570e-04
Epoch 717/800
250/250 [==============================] - 0s 671us/step - loss:
2.8631e-04
Epoch 718/800
250/250 [==============================] - 0s 735us/step - loss:
3.2529e-04
Epoch 719/800
250/250 [==============================] - 0s 651us/step - loss:
2.5799e-04
Epoch 720/800
250/250 [==============================] - 0s 647us/step - loss:
3.2262e-04
Epoch 721/800
250/250 [==============================] - 0s 635us/step - loss:
2.9716e-04
Epoch 722/800
250/250 [==============================] - 0s 639us/step - loss:
3.0530e-04
Epoch 723/800
250/250 [==============================] - 0s 643us/step - loss:
2.6482e-04
```

```
Epoch 724/800
250/250 [==============================] - 0s 639us/step - loss:
2.8241e-04
Epoch 725/800
250/250 [==============================] - 0s 643us/step - loss:
3.0644e-04
Epoch 726/800
250/250 [==============================] - 0s 643us/step - loss:
3.0529e-04
Epoch 727/800
250/250 [==============================] - 0s 647us/step - loss:
2.9161e-04
Epoch 728/800
250/250 [==============================] - 0s 671us/step - loss:
2.9375e-04
Epoch 729/800
250/250 [==============================] - 0s 687us/step - loss:
3.2433e-04
Epoch 730/800
250/250 [==============================] - 0s 711us/step - loss:
2.9640e-04
Epoch 731/800
250/250 [==============================] - 0s 682us/step - loss:
2.8122e-04
Epoch 732/800
250/250 [==============================] - 0s 663us/step - loss:
2.9941e-04
Epoch 733/800
250/250 [==============================] - 0s 655us/step - loss:
2.6726e-04
Epoch 734/800
250/250 [==============================] - 0s 647us/step - loss:
3.2376e-04
Epoch 735/800
250/250 [==============================] - 0s 643us/step - loss:
2.9048e-04
Epoch 736/800
250/250 [==============================] - 0s 627us/step - loss:
2.9965e-04
Epoch 737/800
250/250 [==============================] - 0s 639us/step - loss:
3.2702e-04
Epoch 738/800
250/250 [==============================] - 0s 655us/step - loss:
2.7872e-04
Epoch 739/800
250/250 [==============================] - 0s 651us/step - loss:
2.7686e-04
Epoch 740/800
250/250 [==============================] - 0s 655us/step - loss:
```

```
2.3919e-04
Epoch 741/800
250/250 [==============================] - 0s 683us/step - loss:
3.1166e-04
Epoch 742/800
250/250 [==============================] - 0s 627us/step - loss:
2.4521e-04
Epoch 743/800
250/250 [==============================] - 0s 635us/step - loss:
2.9396e-04
Epoch 744/800
250/250 [==============================] - 0s 631us/step - loss:
2.7762e-04
Epoch 745/800
250/250 [==============================] - 0s 626us/step - loss:
2.4529e-04
Epoch 746/800
250/250 [==============================] - 0s 635us/step - loss:
3.1515e-04
Epoch 747/800
250/250 [==============================] - 0s 626us/step - loss:
2.8326e-04
Epoch 748/800
250/250 [==============================] - 0s 631us/step - loss:
2.6864e-04
Epoch 749/800
250/250 [==============================] - 0s 659us/step - loss:
2.8484e-04
Epoch 750/800
250/250 [==============================] - 0s 683us/step - loss:
2.6610e-04
Epoch 751/800
250/250 [==============================] - 0s 707us/step - loss:
2.9483e-04
Epoch 752/800
250/250 [==============================] - 0s 731us/step - loss:
2.6452e-04
Epoch 753/800
250/250 [==============================] - 0s 687us/step - loss:
3.1818e-04
Epoch 754/800
250/250 [==============================] - 0s 679us/step - loss:
2.9956e-04
Epoch 755/800
250/250 [==============================] - 0s 667us/step - loss:
3.0606e-04
Epoch 756/800
250/250 [==============================] - 0s 655us/step - loss:
2.9624e-04
Epoch 757/800
```

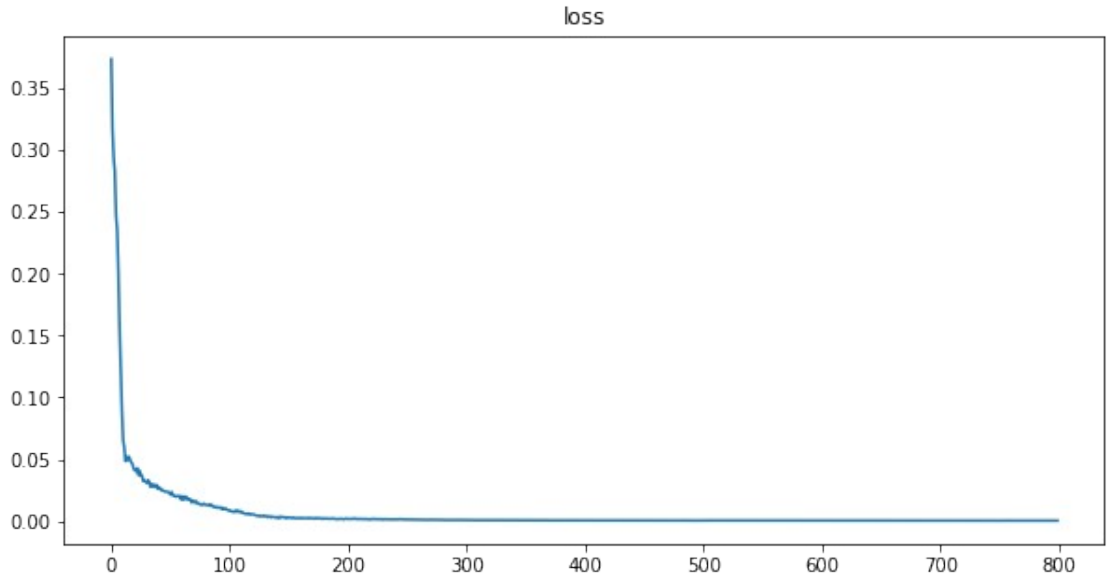
```
250/250 [==============================] - 0s 655us/step - loss:
2.8832e-04
Epoch 758/800
250/250 [==============================] - 0s 651us/step - loss:
2.9226e-04
Epoch 759/800
250/250 [==============================] - 0s 635us/step - loss:
3.1622e-04
Epoch 760/800
250/250 [==============================] - 0s 631us/step - loss:
2.8628e-04
Epoch 761/800
250/250 [==============================] - 0s 635us/step - loss:
2.9841e-04
Epoch 762/800
250/250 [==============================] - 0s 703us/step - loss:
2.7620e-04
Epoch 763/800
250/250 [==============================] - 0s 643us/step - loss:
3.0721e-04
Epoch 764/800
250/250 [==============================] - 0s 647us/step - loss:
2.9920e-04
Epoch 765/800
250/250 [==============================] - 0s 631us/step - loss:
2.8604e-04
Epoch 766/800
250/250 [==============================] - 0s 631us/step - loss:
3.0016e-04
Epoch 767/800
250/250 [==============================] - 0s 635us/step - loss:
2.6866e-04
Epoch 768/800
250/250 [==============================] - 0s 731us/step - loss:
2.7239e-04
Epoch 769/800
250/250 [==============================] - 0s 839us/step - loss:
3.0282e-04
Epoch 770/800
250/250 [==============================] - 0s 715us/step - loss:
2.7265e-04
Epoch 771/800
250/250 [==============================] - 0s 683us/step - loss:
2.8571e-04
Epoch 772/800
250/250 [==============================] - 0s 659us/step - loss:
2.5956e-04
Epoch 773/800
250/250 [==============================] - 0s 739us/step - loss:
2.6593e-04
```

```
Epoch 774/800
250/250 [==============================] - 0s 659us/step - loss:
2.6746e-04
Epoch 775/800
250/250 [==============================] - 0s 671us/step - loss:
3.0407e-04
Epoch 776/800
250/250 [==============================] - 0s 631us/step - loss:
2.9274e-04
Epoch 777/800
250/250 [==============================] - 0s 635us/step - loss:
2.5822e-04
Epoch 778/800
250/250 [==============================] - 0s 659us/step - loss:
2.6136e-04
Epoch 779/800
250/250 [==============================] - 0s 647us/step - loss:
2.8401e-04
Epoch 780/800
250/250 [==============================] - 0s 647us/step - loss:
2.8348e-04
Epoch 781/800
250/250 [==============================] - 0s 655us/step - loss:
2.9182e-04
Epoch 782/800
250/250 [==============================] - 0s 703us/step - loss:
2.7129e-04
Epoch 783/800
250/250 [==============================] - 0s 622us/step - loss:
2.7191e-04
Epoch 784/800
250/250 [==============================] - 0s 643us/step - loss:
3.3234e-04
Epoch 785/800
250/250 [==============================] - 0s 667us/step - loss:
2.8390e-04
Epoch 786/800
250/250 [==============================] - 0s 659us/step - loss:
2.5553e-04
Epoch 787/800
250/250 [==============================] - 0s 635us/step - loss:
3.0240e-04
Epoch 788/800
250/250 [==============================] - 0s 639us/step - loss:
2.7902e-04
Epoch 789/800
250/250 [==============================] - 0s 678us/step - loss:
2.5911e-04
Epoch 790/800
250/250 [==============================] - 0s 643us/step - loss:
```

```
2.9042e-04
Epoch 791/800
250/250 [==============================] - 0s 643us/step - loss:
2.8127e-04
Epoch 792/800
250/250 [==============================] - 0s 687us/step - loss:
3.0440e-04
Epoch 793/800
250/250 [==============================] - 0s 639us/step - loss:
3.0340e-04
Epoch 794/800
250/250 [==============================] - 0s 663us/step - loss:
2.5792e-04
Epoch 795/800
250/250 [==============================] - 0s 655us/step - loss:
2.6729e-04
Epoch 796/800
250/250 [==============================] - 0s 627us/step - loss:
2.9554e-04
Epoch 797/800
250/250 [==============================] - 0s 787us/step - loss:
2.8650e-04
Epoch 798/800
250/250 [==============================] - 0s 663us/step - loss:
2.6587e-04
Epoch 799/800
250/250 [==============================] - 0s 683us/step - loss:
2.5942e-04
Epoch 800/800
250/250 [==============================] - 0s 659us/step - loss:
2.7169e-04
```

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


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



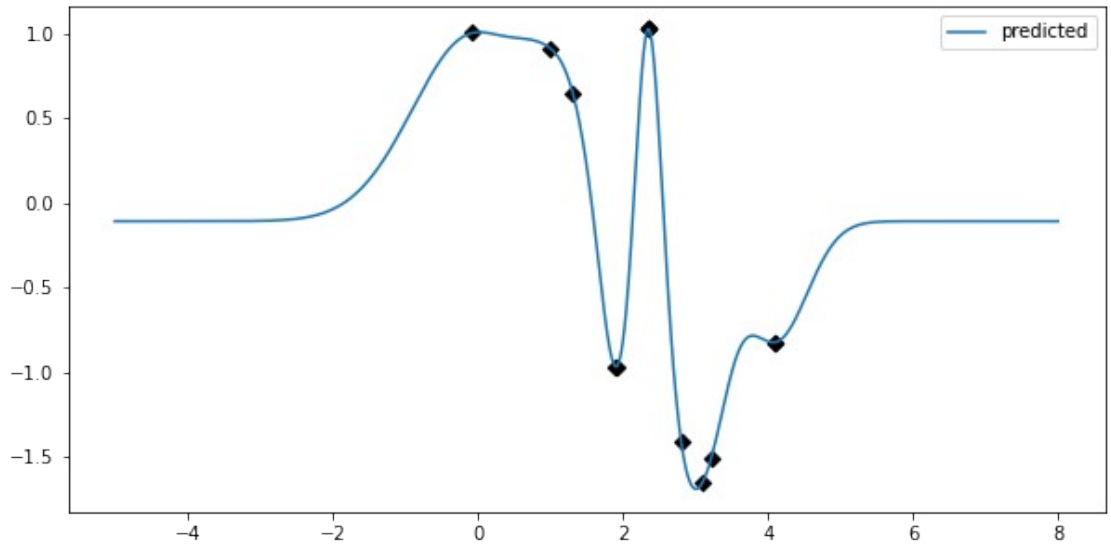

```
t2 = np.arange(-5, 8, 0.005)

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()
```

```
82/82 [==============================] - 0s 630us/step
1/1 [==============================] - 0s 14ms/step
```



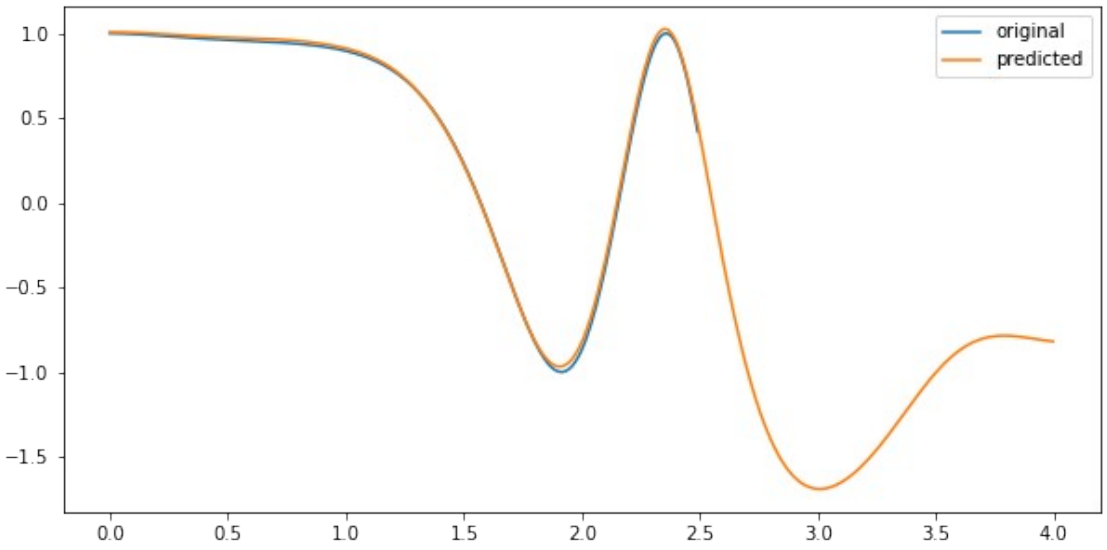
```
t2 = np.arange(0, 4.0, 0.005)

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()
```

```
25/25 [==============================] - 0s 708us/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.