Московский авиационный институт
(Национальный исследовательский университет)
Институт №8 «Информационные технологии и прикладная математика»

Кафедра вычислительной математики и программирования

Лабораторная работа №3
по курсу «Нейроинформатика»

Многослойные сети. Алгоритм обратного распространения ошибки

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Вариант: 17
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Рожлейс И. А.
Оценка:

Москва, 2022

Лабораторная №3

Многослойные сети. Алгоритм обратного распространения ошибки

Вариант № 17

Красоткин Семён (М80-408Б-19)

Цель работы

Исследование свойств многослойной нейронной сети прямого распространения и алгоритмов её обучения, применение сети в задачах классификации и аппроксимации функции.

Код

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

from sklearn.model_selection import train_test_split
```

Классификация

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


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


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


# Эллипс
a1 = 0.4
b1 = 0.15
alpha1 = np.pi / 6
x01 = 0.1
```

```python
y01 = -0.15

# Эллипс
a2 = 0.7
b2 = 0.5
alpha2 = np.pi / 3
x02 = 0
y02 = 0

# Парабола
p = 1
alpha3 = np.pi / 2
x03 = -0.8
y03 = 0

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

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

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

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

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

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

plt.plot(fig1x, fig1y, c = 'r')
plt.plot(fig2x, fig2y, c = 'g')
plt.plot(fig3x, fig3y, c = 'b')
plt.show()
```
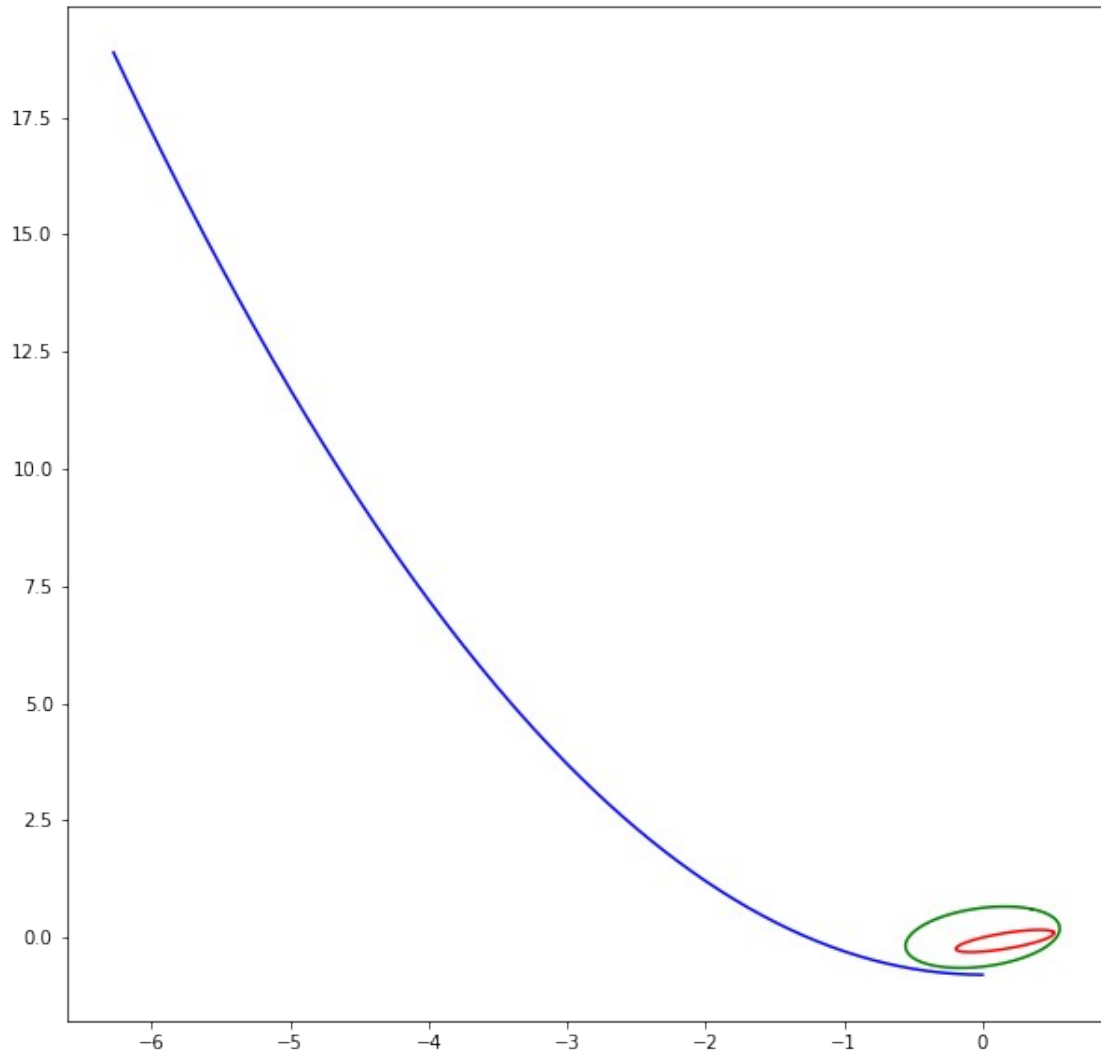
```python
datax = np.concatenate((fig1x, fig2x, fig3x), axis=0)
datay = np.concatenate((fig1y, fig2y, fig3y), axis=0)


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

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

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

data = data.transpose()

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

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

model.add(Dense(25, input_dim = 2, activation = "tanh",
kernel_initializer = keras.initializers.RandomNormal(stddev = 0.01),
bias_initializer = keras.initializers.Zeros()))
model.add(Dense(57, activation = "tanh"))
model.add(Dense(3, activation = "sigmoid"))

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

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

```
Epoch 1/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1555
Epoch 2/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1347
Epoch 3/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1310
Epoch 4/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1296
Epoch 5/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1280
Epoch 6/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1284
Epoch 7/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1275
Epoch 8/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1261
Epoch 9/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1250
Epoch 10/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1262
Epoch 11/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1244
Epoch 12/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1233
Epoch 13/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1233
Epoch 14/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1208
Epoch 15/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1200
Epoch 16/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1186
Epoch 17/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1165
Epoch 18/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1148
Epoch 19/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1117
```

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Epoch 20/200
604/604 [==============================] - 1s 2ms/step - loss: 0.1107
Epoch 21/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1080
Epoch 22/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1060
Epoch 23/200
604/604 [==============================] - 1s 1ms/step - loss: 0.1030
Epoch 24/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0991
Epoch 25/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0953
Epoch 26/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0899
Epoch 27/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0845
Epoch 28/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0791
Epoch 29/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0735
Epoch 30/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0690
Epoch 31/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0649
Epoch 32/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0614
Epoch 33/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0579
Epoch 34/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0556
Epoch 35/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0537
Epoch 36/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0517
Epoch 37/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0499
Epoch 38/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0479
Epoch 39/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0457
Epoch 40/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0442
Epoch 41/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0430
Epoch 42/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0414
Epoch 43/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0386
Epoch 44/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0384
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Epoch 45/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0358
Epoch 46/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0353
Epoch 47/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0344
Epoch 48/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0312
Epoch 49/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0308
Epoch 50/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0289
Epoch 51/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0280
Epoch 52/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0268
Epoch 53/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0255
Epoch 54/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0250
Epoch 55/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0239
Epoch 56/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0223
Epoch 57/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0215
Epoch 58/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0208
Epoch 59/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0201
Epoch 60/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0188
Epoch 61/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0187
Epoch 62/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0180
Epoch 63/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0175
Epoch 64/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0163
Epoch 65/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0158
Epoch 66/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0151
Epoch 67/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0144
Epoch 68/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0143
Epoch 69/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0139
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Epoch 70/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0134
Epoch 71/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0130
Epoch 72/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0134
Epoch 73/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0126
Epoch 74/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0126
Epoch 75/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0119
Epoch 76/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0116
Epoch 77/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0110
Epoch 78/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0108
Epoch 79/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0103
Epoch 80/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0103
Epoch 81/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0106
Epoch 82/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0102
Epoch 83/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0099
Epoch 84/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0097
Epoch 85/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0097
Epoch 86/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0094
Epoch 87/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0093
Epoch 88/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0086
Epoch 89/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0089
Epoch 90/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0088
Epoch 91/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0078
Epoch 92/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0080
Epoch 93/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0080
Epoch 94/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0078
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Epoch 95/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0084
Epoch 96/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0076
Epoch 97/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0075
Epoch 98/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0052
Epoch 99/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0081
Epoch 100/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0069
Epoch 101/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0075
Epoch 102/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0071
Epoch 103/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0071
Epoch 104/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0069
Epoch 105/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0067
Epoch 106/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0063
Epoch 107/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0065
Epoch 108/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0063
Epoch 109/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0068
Epoch 110/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0069
Epoch 111/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0056
Epoch 112/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0060
Epoch 113/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0055
Epoch 114/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0060
Epoch 115/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0059
Epoch 116/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0058
Epoch 117/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0059
Epoch 118/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0061
Epoch 119/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0048
```

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Epoch 120/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0058
Epoch 121/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0054
Epoch 122/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0057
Epoch 123/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0040
Epoch 124/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0049
Epoch 125/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0047
Epoch 126/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0047
Epoch 127/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0052
Epoch 128/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0052
Epoch 129/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0054
Epoch 130/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0050
Epoch 131/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0049
Epoch 132/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0040
Epoch 133/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0055
Epoch 134/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0053
Epoch 135/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0043
Epoch 136/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0051
Epoch 137/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0039
Epoch 138/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0040
Epoch 139/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0038
Epoch 140/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0042
Epoch 141/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0046
Epoch 142/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0033
Epoch 143/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0042
Epoch 144/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0037
```

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Epoch 145/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0042
Epoch 146/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0039
Epoch 147/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0040
Epoch 148/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0046
Epoch 149/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0047
Epoch 150/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0036
Epoch 151/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0039
Epoch 152/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0037
Epoch 153/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0046
Epoch 154/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0040
Epoch 155/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0033
Epoch 156/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0039
Epoch 157/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0039
Epoch 158/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0039
Epoch 159/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0040
Epoch 160/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0032
Epoch 161/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0041
Epoch 162/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0036
Epoch 163/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0038
Epoch 164/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0022
Epoch 165/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0028
Epoch 166/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0031
Epoch 167/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0034
Epoch 168/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0038
Epoch 169/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0035
```

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Epoch 170/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0036
Epoch 171/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0030
Epoch 172/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0029
Epoch 173/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0036
Epoch 174/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0036
Epoch 175/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0032
Epoch 176/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0032
Epoch 177/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0041
Epoch 178/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0031
Epoch 179/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0024
Epoch 180/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0025
Epoch 181/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0022
Epoch 182/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0029
Epoch 183/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0023
Epoch 184/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0029
Epoch 185/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0023
Epoch 186/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0022
Epoch 187/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0023
Epoch 188/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0016
Epoch 189/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0021
Epoch 190/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0032
Epoch 191/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0023
Epoch 192/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0018
Epoch 193/200
604/604 [==============================] - 1s 1ms/step - loss: 0.0029
Epoch 194/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0021
```

```
Epoch 195/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0028
Epoch 196/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0013
Epoch 197/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0020
Epoch 198/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0026
Epoch 199/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0020
Epoch 200/200
604/604 [==============================] - 1s 2ms/step - loss: 0.0027

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()
```
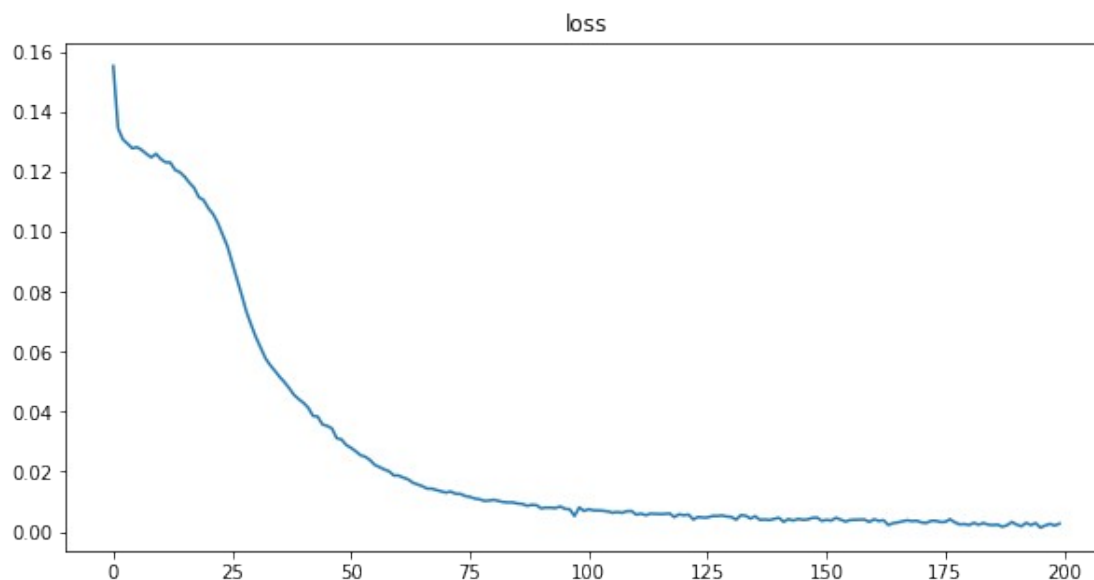


```
x = np.linspace(-18, 1, 200)
y = np.linspace(-1, 6, 200)

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

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

ax1.plot(fig1x, fig1y, c = 'r')
```

```python
ax1.plot(fig2x, fig2y, c = 'g')
ax1.plot(fig3x, fig3y, c = 'b')

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

xy = data.transpose()

pred = model.predict(data)


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

plt.show()
```

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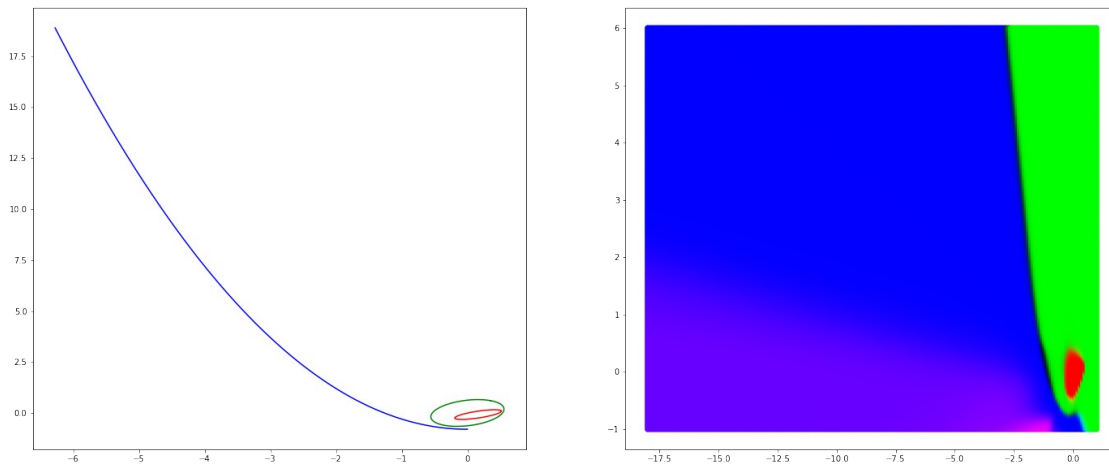

Аппроксимация
```python
f = lambda t: np.cos(-5*t**2 + 10*t - 5)
t = np.arange(0, 2.5, 0.01)
ft = f(t)

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

plt.plot(t, ft)
plt.show()
```
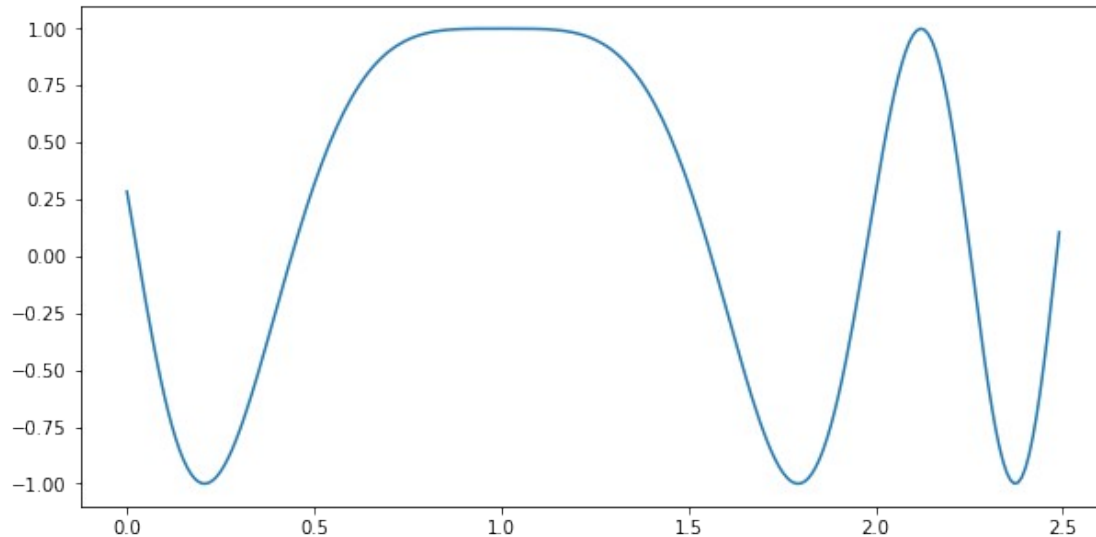
```
model = keras.models.Sequential()

model.add(Dense(20, input_dim = 1, activation = "tanh",
kernel_initializer = keras.initializers.RandomNormal(stddev = 0.01),
bias_initializer = keras.initializers.Zeros()))
model.add(Dense(100, activation = "tanh"))
model.add(Dense(40, activation = "tanh"))
model.add(Dense(1, activation = "linear"))

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

hist = model.fit(t, ft, batch_size = 1, epochs = 600, shuffle = True)

Epoch 1/600
250/250 [==============================] - 1s 2ms/step - loss: 0.5861
Epoch 2/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5759
Epoch 3/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5712
Epoch 4/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5730
Epoch 5/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5686
Epoch 6/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5577
Epoch 7/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5578
Epoch 8/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5606
Epoch 9/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5588
Epoch 10/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5637
```

```
Epoch 11/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5569
Epoch 12/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5426
Epoch 13/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5576
Epoch 14/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5605
Epoch 15/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5579
Epoch 16/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5459
Epoch 17/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5597
Epoch 18/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5559
Epoch 19/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5600
Epoch 20/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5575
Epoch 21/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5566
Epoch 22/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5519
Epoch 23/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5578
Epoch 24/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5563
Epoch 25/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5562
Epoch 26/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5531
Epoch 27/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5584
Epoch 28/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5452
Epoch 29/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5545
Epoch 30/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5526
Epoch 31/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5519
Epoch 32/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5557
Epoch 33/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5536
Epoch 34/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5535
Epoch 35/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5532
```

```
Epoch 36/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5473
Epoch 37/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5523
Epoch 38/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5502
Epoch 39/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5540
Epoch 40/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5501
Epoch 41/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5548
Epoch 42/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5517
Epoch 43/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5551
Epoch 44/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5521
Epoch 45/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5371
Epoch 46/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5502
Epoch 47/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5501
Epoch 48/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5517
Epoch 49/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5538
Epoch 50/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5511
Epoch 51/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5492
Epoch 52/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5524
Epoch 53/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5489
Epoch 54/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5413
Epoch 55/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5500
Epoch 56/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5571
Epoch 57/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5528
Epoch 58/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5488
Epoch 59/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5529
Epoch 60/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5542
```

```
Epoch 61/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5477
Epoch 62/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5524
Epoch 63/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5527
Epoch 64/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5516
Epoch 65/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5540
Epoch 66/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5487
Epoch 67/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5524
Epoch 68/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5528
Epoch 69/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5477
Epoch 70/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5524
Epoch 71/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5498
Epoch 72/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5485
Epoch 73/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5519
Epoch 74/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5504
Epoch 75/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5518
Epoch 76/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5524
Epoch 77/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5547
Epoch 78/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5534
Epoch 79/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5452
Epoch 80/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5543
Epoch 81/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5536
Epoch 82/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5516
Epoch 83/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5520
Epoch 84/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5537
Epoch 85/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5517
```

```
Epoch 86/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5475
Epoch 87/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5510
Epoch 88/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5494
Epoch 89/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5525
Epoch 90/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5526
Epoch 91/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5517
Epoch 92/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5488
Epoch 93/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5482
Epoch 94/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5530
Epoch 95/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5490
Epoch 96/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5441
Epoch 97/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5538
Epoch 98/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5528
Epoch 99/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5390
Epoch 100/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5520
Epoch 101/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5526
Epoch 102/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5488
Epoch 103/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5512
Epoch 104/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5520
Epoch 105/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5449
Epoch 106/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5492
Epoch 107/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5534
Epoch 108/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5501
Epoch 109/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5492
Epoch 110/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5534
```

```
Epoch 111/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5518
Epoch 112/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5520
Epoch 113/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5479
Epoch 114/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5506
Epoch 115/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5486
Epoch 116/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5528
Epoch 117/600
250/250 [==============================] - 1s 2ms/step - loss: 0.5489
Epoch 118/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5499
Epoch 119/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5525
Epoch 120/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5425
Epoch 121/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5559
Epoch 122/600
250/250 [==============================] - 1s 2ms/step - loss: 0.5494
Epoch 123/600
250/250 [==============================] - 1s 2ms/step - loss: 0.5503
Epoch 124/600
250/250 [==============================] - 1s 2ms/step - loss: 0.5521
Epoch 125/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5493
Epoch 126/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5541
Epoch 127/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5518
Epoch 128/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5507
Epoch 129/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5529
Epoch 130/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5464
Epoch 131/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5528
Epoch 132/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5533
Epoch 133/600
250/250 [==============================] - 1s 2ms/step - loss: 0.5486
Epoch 134/600
250/250 [==============================] - 1s 2ms/step - loss: 0.5513
Epoch 135/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5538
```

```
Epoch 136/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5496
Epoch 137/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5522
Epoch 138/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5538
Epoch 139/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5530
Epoch 140/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5499
Epoch 141/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5542
Epoch 142/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5516
Epoch 143/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5540
Epoch 144/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5528
Epoch 145/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5521
Epoch 146/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5502
Epoch 147/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5511
Epoch 148/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5516
Epoch 149/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5448
Epoch 150/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5516
Epoch 151/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5499
Epoch 152/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5506
Epoch 153/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5506
Epoch 154/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5496
Epoch 155/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5480
Epoch 156/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5435
Epoch 157/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5432
Epoch 158/600
250/250 [==============================] - 0s 2ms/step - loss: 0.5284
Epoch 159/600
250/250 [==============================] - 0s 1ms/step - loss: 0.5111
Epoch 160/600
250/250 [==============================] - 0s 1ms/step - loss: 0.4683
```

```
Epoch 161/600
250/250 [==============================] - 0s 2ms/step - loss: 0.3960
Epoch 162/600
250/250 [==============================] - 0s 2ms/step - loss: 0.3266
Epoch 163/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2612
Epoch 164/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2432
Epoch 165/600
250/250 [==============================] - 0s 1ms/step - loss: 0.2533
Epoch 166/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2366
Epoch 167/600
250/250 [==============================] - 0s 1ms/step - loss: 0.2507
Epoch 168/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2342
Epoch 169/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2409
Epoch 170/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2355
Epoch 171/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2425
Epoch 172/600
250/250 [==============================] - 0s 1ms/step - loss: 0.2280
Epoch 173/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2286
Epoch 174/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2263
Epoch 175/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2233
Epoch 176/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2316
Epoch 177/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2204
Epoch 178/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2093
Epoch 179/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2138
Epoch 180/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2139
Epoch 181/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2165
Epoch 182/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2081
Epoch 183/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2051
Epoch 184/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2084
Epoch 185/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2038
```

```
Epoch 186/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2010
Epoch 187/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2039
Epoch 188/600
250/250 [==============================] - 0s 1ms/step - loss: 0.2011
Epoch 189/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1996
Epoch 190/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1924
Epoch 191/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1945
Epoch 192/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1979
Epoch 193/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1920
Epoch 194/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1920
Epoch 195/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1897
Epoch 196/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1883
Epoch 197/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1868
Epoch 198/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1869
Epoch 199/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1798
Epoch 200/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1694
Epoch 201/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1806
Epoch 202/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1753
Epoch 203/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1753
Epoch 204/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1715
Epoch 205/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1633
Epoch 206/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1669
Epoch 207/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1644
Epoch 208/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1604
Epoch 209/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1613
Epoch 210/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1598
```

```
Epoch 211/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1447
Epoch 212/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1568
Epoch 213/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1475
Epoch 214/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1479
Epoch 215/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1469
Epoch 216/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1445
Epoch 217/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1422
Epoch 218/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1368
Epoch 219/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1371
Epoch 220/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1309
Epoch 221/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1367
Epoch 222/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1321
Epoch 223/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1337
Epoch 224/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1316
Epoch 225/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1266
Epoch 226/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1268
Epoch 227/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1355
Epoch 228/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1271
Epoch 229/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1182
Epoch 230/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1207
Epoch 231/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1114
Epoch 232/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1559
Epoch 233/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1130
Epoch 234/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1062
Epoch 235/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1098
```

```
Epoch 236/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1254
Epoch 237/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0884
Epoch 238/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1169
Epoch 239/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0962
Epoch 240/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0877
Epoch 241/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1108
Epoch 242/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1171
Epoch 243/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0887
Epoch 244/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0981
Epoch 245/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1200
Epoch 246/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0854
Epoch 247/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0884
Epoch 248/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1101
Epoch 249/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1070
Epoch 250/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0760
Epoch 251/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1051
Epoch 252/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0843
Epoch 253/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0976
Epoch 254/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1056
Epoch 255/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0860
Epoch 256/600
250/250 [==============================] - 0s 1ms/step - loss: 0.1044
Epoch 257/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1013
Epoch 258/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0594
Epoch 259/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0648
Epoch 260/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0837
```

```
Epoch 261/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0611
Epoch 262/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1273
Epoch 263/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0916
Epoch 264/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0822
Epoch 265/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0991
Epoch 266/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0922
Epoch 267/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0716
Epoch 268/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0686
Epoch 269/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0659
Epoch 270/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0654
Epoch 271/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0732
Epoch 272/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0721
Epoch 273/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0824
Epoch 274/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0739
Epoch 275/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0702
Epoch 276/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0538
Epoch 277/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0780
Epoch 278/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0575
Epoch 279/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0701
Epoch 280/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0498
Epoch 281/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0687
Epoch 282/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0646
Epoch 283/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0800
Epoch 284/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0573
Epoch 285/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0685
```

```
Epoch 286/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0699
Epoch 287/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0552
Epoch 288/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0580
Epoch 289/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0503
Epoch 290/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0516
Epoch 291/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0471
Epoch 292/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0539
Epoch 293/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0445
Epoch 294/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0514
Epoch 295/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0698
Epoch 296/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0571
Epoch 297/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0446
Epoch 298/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0539
Epoch 299/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0579
Epoch 300/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0668
Epoch 301/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0493
Epoch 302/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0485
Epoch 303/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0457
Epoch 304/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0438
Epoch 305/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0514
Epoch 306/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0627
Epoch 307/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0384
Epoch 308/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0471
Epoch 309/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0637
Epoch 310/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0397
```

```
Epoch 311/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0398
Epoch 312/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0515
Epoch 313/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0489
Epoch 314/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0376
Epoch 315/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0351
Epoch 316/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0360
Epoch 317/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0440
Epoch 318/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0484
Epoch 319/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0847
Epoch 320/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0379
Epoch 321/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0381
Epoch 322/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0461
Epoch 323/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0442
Epoch 324/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0444
Epoch 325/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0439
Epoch 326/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0370
Epoch 327/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0333
Epoch 328/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0444
Epoch 329/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0540
Epoch 330/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0378
Epoch 331/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0471
Epoch 332/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0488
Epoch 333/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0427
Epoch 334/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0342
Epoch 335/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0314
```

```
Epoch 336/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0306
Epoch 337/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0368
Epoch 338/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0429
Epoch 339/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0298
Epoch 340/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0299
Epoch 341/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0389
Epoch 342/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0308
Epoch 343/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0293
Epoch 344/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0323
Epoch 345/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0269
Epoch 346/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0706
Epoch 347/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0275
Epoch 348/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0276
Epoch 349/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0360
Epoch 350/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0399
Epoch 351/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0284
Epoch 352/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0249
Epoch 353/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0292
Epoch 354/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0264
Epoch 355/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0376
Epoch 356/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0252
Epoch 357/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0304
Epoch 358/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0257
Epoch 359/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0431
Epoch 360/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0410
```

```
Epoch 361/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0349
Epoch 362/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0234
Epoch 363/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0210
Epoch 364/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0254
Epoch 365/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0218
Epoch 366/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0226
Epoch 367/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0236
Epoch 368/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0231
Epoch 369/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0551
Epoch 370/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0338
Epoch 371/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0213
Epoch 372/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0308
Epoch 373/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0363
Epoch 374/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0191
Epoch 375/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0235
Epoch 376/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0220
Epoch 377/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0324
Epoch 378/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0385
Epoch 379/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0217
Epoch 380/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0212
Epoch 381/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0235
Epoch 382/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0186
Epoch 383/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0176
Epoch 384/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0184
Epoch 385/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0691
```

```
Epoch 386/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0279
Epoch 387/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0167
Epoch 388/600
250/250 [==============================] - 0s 1ms/step - loss: 0.0193
Epoch 389/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0189
Epoch 390/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0219
Epoch 391/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0218
Epoch 392/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0477
Epoch 393/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0142
Epoch 394/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0291
Epoch 395/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0182
Epoch 396/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0320
Epoch 397/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0211
Epoch 398/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0187
Epoch 399/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0158
Epoch 400/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0137
Epoch 401/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0140
Epoch 402/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0544
Epoch 403/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0330
Epoch 404/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0260
Epoch 405/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0217
Epoch 406/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0305
Epoch 407/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0172
Epoch 408/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0626
Epoch 409/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0365
Epoch 410/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0127
```

```
Epoch 411/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0134
Epoch 412/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0113
Epoch 413/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0101
Epoch 414/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0135
Epoch 415/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0147
Epoch 416/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0163
Epoch 417/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0186
Epoch 418/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0724
Epoch 419/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0197
Epoch 420/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0153
Epoch 421/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0414
Epoch 422/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0420
Epoch 423/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0159
Epoch 424/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0115
Epoch 425/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0180
Epoch 426/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0130
Epoch 427/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0143
Epoch 428/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0193
Epoch 429/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0110
Epoch 430/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0235
Epoch 431/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0113
Epoch 432/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0418
Epoch 433/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0214
Epoch 434/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0112
Epoch 435/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0315
```

```
Epoch 436/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0135
Epoch 437/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0226
Epoch 438/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0136
Epoch 439/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0147
Epoch 440/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0106
Epoch 441/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0383
Epoch 442/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0160
Epoch 443/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0129
Epoch 444/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0182
Epoch 445/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0134
Epoch 446/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0099
Epoch 447/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0373
Epoch 448/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0114
Epoch 449/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0161
Epoch 450/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0111
Epoch 451/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0115
Epoch 452/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0397
Epoch 453/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0134
Epoch 454/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0320
Epoch 455/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0096
Epoch 456/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0098
Epoch 457/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0109
Epoch 458/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0152
Epoch 459/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0102
Epoch 460/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0203
```

```
Epoch 461/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0101
Epoch 462/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0142
Epoch 463/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0125
Epoch 464/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0122
Epoch 465/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0146
Epoch 466/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0102
Epoch 467/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0099
Epoch 468/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0333
Epoch 469/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0157
Epoch 470/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0404
Epoch 471/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0090
Epoch 472/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0108
Epoch 473/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0128
Epoch 474/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0076
Epoch 475/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0108
Epoch 476/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0183
Epoch 477/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0274
Epoch 478/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0144
Epoch 479/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0222
Epoch 480/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0413
Epoch 481/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0107
Epoch 482/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0229
Epoch 483/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0408
Epoch 484/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0235
Epoch 485/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0147
```

```
Epoch 486/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0146
Epoch 487/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0104
Epoch 488/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0084
Epoch 489/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0242
Epoch 490/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0517
Epoch 491/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0431
Epoch 492/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0081
Epoch 493/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0100
Epoch 494/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0104
Epoch 495/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0249
Epoch 496/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0543
Epoch 497/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0118
Epoch 498/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0128
Epoch 499/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0247
Epoch 500/600
250/250 [==============================] - 1s 2ms/step - loss: 0.0109
Epoch 501/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0112
Epoch 502/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0127
Epoch 503/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0099
Epoch 504/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0157
Epoch 505/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0134
Epoch 506/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0147
Epoch 507/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0231
Epoch 508/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0090
Epoch 509/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0137
Epoch 510/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0125
```

```
Epoch 511/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0093
Epoch 512/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0118
Epoch 513/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0318
Epoch 514/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0091
Epoch 515/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0138
Epoch 516/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0078
Epoch 517/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0081
Epoch 518/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0116
Epoch 519/600
250/250 [==============================] - 1s 2ms/step - loss: 0.3061
Epoch 520/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2078
Epoch 521/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2069
Epoch 522/600
250/250 [==============================] - 0s 2ms/step - loss: 0.2050
Epoch 523/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1921
Epoch 524/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1711
Epoch 525/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1845
Epoch 526/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1753
Epoch 527/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1846
Epoch 528/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1804
Epoch 529/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1797
Epoch 530/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1745
Epoch 531/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1761
Epoch 532/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1748
Epoch 533/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1707
Epoch 534/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1727
Epoch 535/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1739
```

```
Epoch 536/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1732
Epoch 537/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1754
Epoch 538/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1774
Epoch 539/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1722
Epoch 540/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1674
Epoch 541/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1737
Epoch 542/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1714
Epoch 543/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1674
Epoch 544/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1736
Epoch 545/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1636
Epoch 546/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1687
Epoch 547/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1663
Epoch 548/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1553
Epoch 549/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1627
Epoch 550/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1635
Epoch 551/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1586
Epoch 552/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1661
Epoch 553/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1574
Epoch 554/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1499
Epoch 555/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1324
Epoch 556/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1472
Epoch 557/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1401
Epoch 558/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1304
Epoch 559/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1081
Epoch 560/600
250/250 [==============================] - 0s 2ms/step - loss: 0.1034
```

```
Epoch 561/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0999
Epoch 562/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0863
Epoch 563/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0606
Epoch 564/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0543
Epoch 565/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0458
Epoch 566/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0418
Epoch 567/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0298
Epoch 568/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0194
Epoch 569/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0198
Epoch 570/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0202
Epoch 571/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0158
Epoch 572/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0086
Epoch 573/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0086
Epoch 574/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0167
Epoch 575/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0113
Epoch 576/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0078
Epoch 577/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0196
Epoch 578/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0096
Epoch 579/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0078
Epoch 580/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0064
Epoch 581/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0186
Epoch 582/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0043
Epoch 583/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0146
Epoch 584/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0078
Epoch 585/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0038
```

```
Epoch 586/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0036
Epoch 587/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0142
Epoch 588/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0070
Epoch 589/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0057
Epoch 590/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0057
Epoch 591/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0065
Epoch 592/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0090
Epoch 593/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0059
Epoch 594/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0095
Epoch 595/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0069
Epoch 596/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0107
Epoch 597/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0078
Epoch 598/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0032
Epoch 599/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0052
Epoch 600/600
250/250 [==============================] - 0s 2ms/step - loss: 0.0043

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()
```
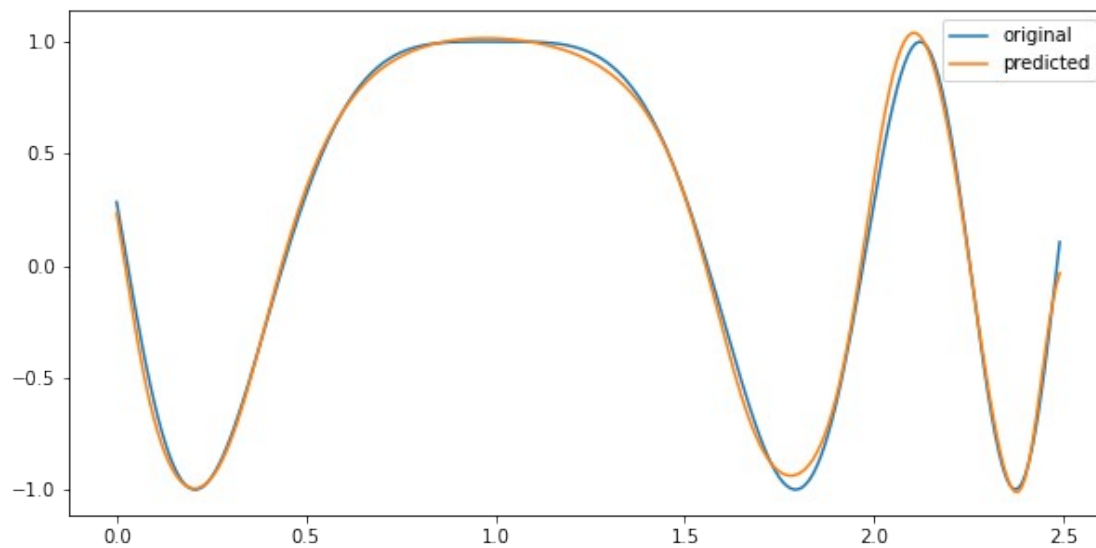
loss
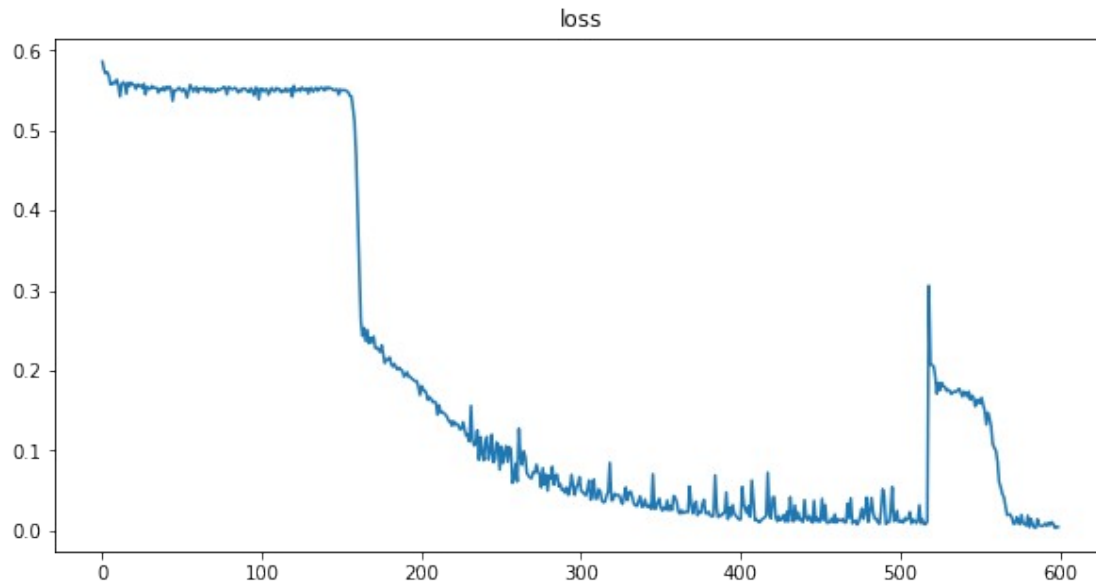
```
t2 = np.arange(0, 2.5, 0.01)

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()
```

8/8 [==============================] - 0s 3ms/step

Выводы

Ознакомился с многослойными нейронными сетями и их свойствами. Реализовал две многослойные модели для решения задач классификации и апроскимации.