lab03

May 2, 2024

0.0.1 People's Friendship University in Russia

Faculty of Science

Department of Mathematical Modeling and Artificial Intelligence

0.1 Labratory work №3 report

0.1.1 Meathods of machine learning

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0.2 Moscow 2024

0.2.1 Version №4

Test 3 – Option 4

1. Function of one variable f(x)= (x-3)*sqrt(x) on the interval [1, 3]
2. Order of derivative of a function of one variable 4
3. Function of two variables f(x,y) = xe^-xy in the area [0, 5] × [0, 5]
4. Order of the mixed derivative of a function of two variables
5. Regression quality indicator: maximum error (MaxErr)

[1]:
```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
tf.__version__
```

[1]:
```
'2.16.1'
```

0.3 1. 1 ( )

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$f(x) = (x-3)\sqrt{x}$ $[1, 3]$

[2]:
```
# define fucntion
def function(x):
    return tf.math.multiply((x - 3),tf.math.sqrt(x))
```

```
# input vector for x values
x_values = tf.Variable(np.linspace(1, 3, 100))

# tensor
y_values = function(x_values)

# get max and min fucntion values
max_value = tf.reduce_max(y_values)
min_value = tf.reduce_min(y_values)
print("Maximum value of the function:", max_value.numpy())
print("Minimum value of the function:", min_value.numpy())
```

```
Maximum value of the function: 0.0
Minimum value of the function: -2.0
```

0.4 2. , ,

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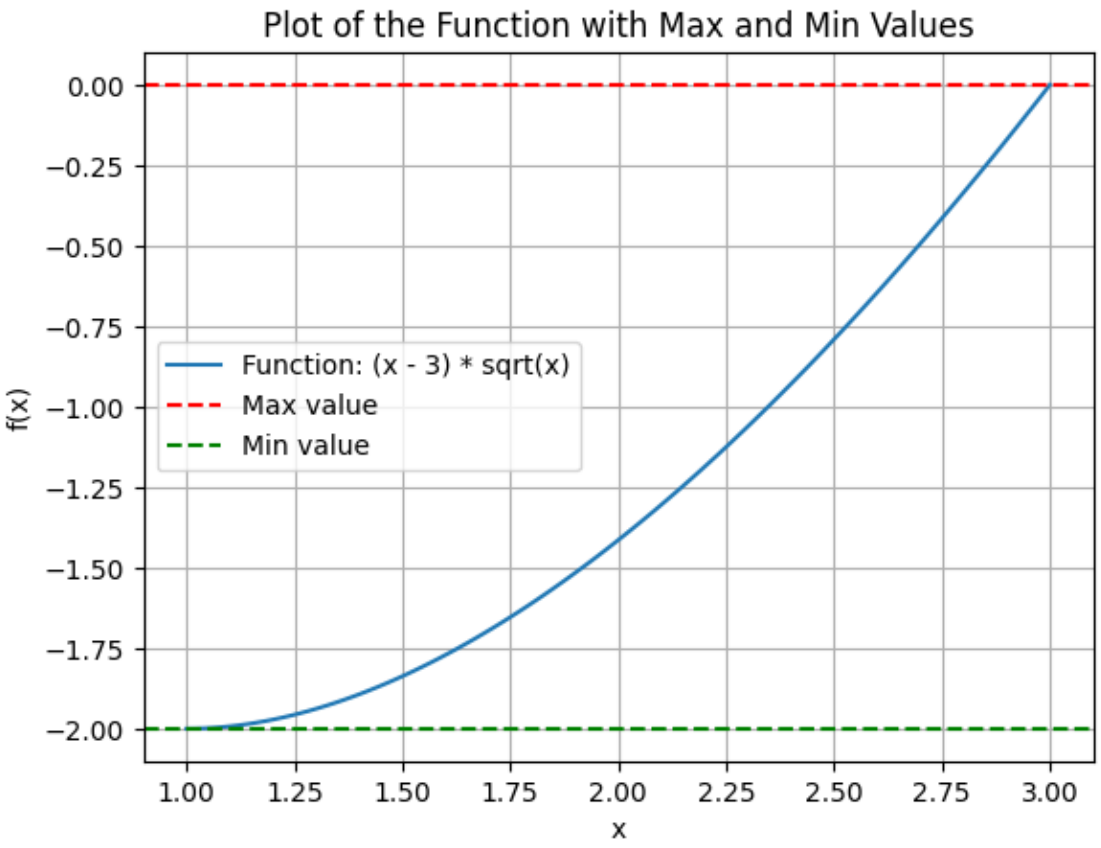
[3]:
```
# Plot the function
plt.plot(x_values, y_values, label='Function: (x - 3) * sqrt(x)')

# Plotting lines for maximum and minimum values
plt.axhline(y=max_value, color='r', linestyle='--', label='Max value')
plt.axhline(y=min_value, color='g', linestyle='--', label='Min value')

# labels and legend
plt.xlabel('x')
plt.ylabel('f(x)')
plt.title('Plot of the Function with Max and Min Values')
plt.legend()

# Show plot
plt.grid(True)
plt.show()
```



0.5 3. (4-), ,

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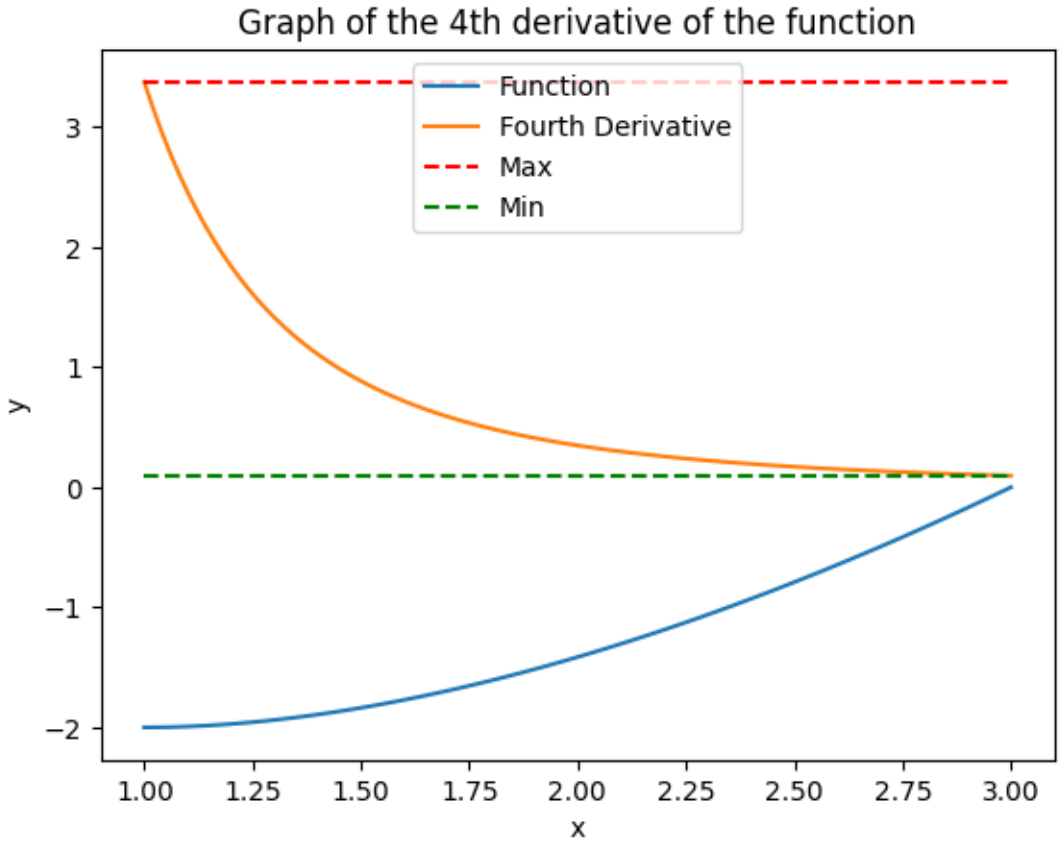
[4]:
```
# Define the fourth derivative function
def dervfunction(x):
    with tf.GradientTape() as s1:
        with tf.GradientTape() as s2:
            with tf.GradientTape() as s3:
                with tf.GradientTape() as s4:
                    y = function(x)
                    dy_dx = s4.gradient(y, x)
                    d2y_dx2 = s3.gradient(dy_dx, x)
                    d3y_dx3 = s2.gradient(d2y_dx2, x)
                    d4y_dx4 = s1.gradient(d3y_dx3, x)
    return d4y_dx4

# Calculate the fourth derivative
y_4 = dervfunction(x_values)
```

```python
# Calculate the maximum and minimum values of the fourth derivative
max_value = tf.reduce_max(y_4)
min_value = tf.reduce_min(y_4)

# Plotting
fig, ax = plt.subplots()
ax.plot(x_values, y_values, label="Function")
ax.plot(x_values, y_4.numpy(), label="Fourth Derivative")
ax.plot([1, 3], [max_value, max_value], 'r--', label='Max')
ax.plot([1, 3], [min_value, min_value], 'g--', label='Min')
ax.set_xlabel("x")
ax.set_ylabel("y")
ax.set_title("Graph of the 4th derivative of the function")
ax.legend()
plt.show()
print("Maximum value of the dervative:", max_value.numpy())
print("Minimum value of the function:", min_value.numpy())
```




```
Maximum value of the dervative: 3.375
Minimum value of the function: 0.09622504486493767
```

0.6 4. 2 ( )

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$f(x, y) = xe^{-xy} $ $[0, 5] \times [0, 5] $

[5]:
```
# define fucntion
def function(x, y):
    return tf.math.multiply(x, tf.math.exp(tf.math.multiply(-x, y)))

# input vector for x and y values
x_values_two = tf.Variable(np.linspace(1, 3, 100))
y_values_two = tf.Variable(np.linspace(1, 3, 100))

# Create meshgrid for x and y values
X, Y = np.meshgrid(x_values_two, y_values_two)


# Compute the function values for each (x, y) pair
Z_tensor = function(X, Y)

# Find the maximum and minimum values of the function
max_value = tf.reduce_max(Z_tensor)
min_value = tf.reduce_min(Z_tensor)

print("Maximum value of the function:", max_value.numpy())
print("Minimum value of the function:", min_value.numpy())
```

```
Maximum value of the function: 0.3678794411714423
Minimum value of the function: 0.0003702294122600387
```

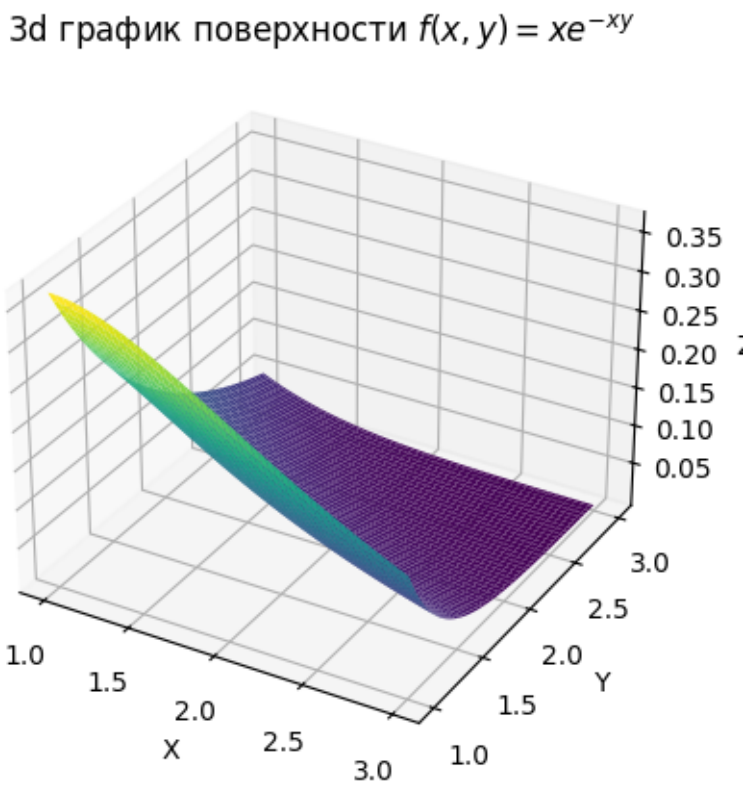
0.7 5. 3d , .

$f(x, y) = xe^{-xy} $

[6]:
```
# Plotting
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.plot_surface(X, Y, Z_tensor, cmap='viridis')

# Labeling axes and the plot
ax.set_xlabel('X')
ax.set_ylabel('Y')
ax.set_zlabel('Z')
ax.set_title('3d            $f(x, y) = xe^{-xy} $')

plt.show()
```

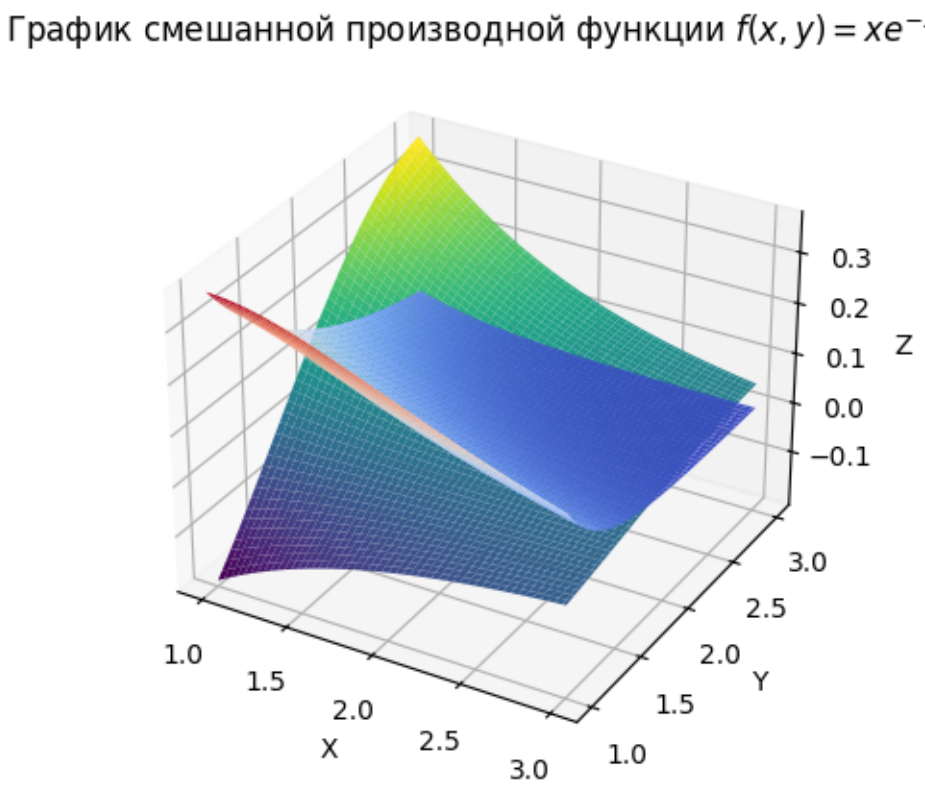


0.8 6. , , **3d** , .

[7]:
```
def functionMixed(x, y):
    with tf.GradientTape() as t4:
        t4.watch(y)
        with tf.GradientTape() as t3:
            t3.watch(x)
            with tf.GradientTape() as t2:
                t2.watch(x)
                with tf.GradientTape() as t1:
                    t1.watch(x)
                    t = tf.exp(-x) * tf.math.sin(y)
                g = t1.gradient(t, x)
            h = t2.gradient(g, x)
        k = t3.gradient(h, x)
    l = t4.gradient(k, y)
    return l
# Convert X and Y to TensorFlow tensors
X_tensor = tf.constant(X, dtype=tf.float32)
Y_tensor = tf.constant(Y, dtype=tf.float32)
```

```
# Compute the mixed partial derivative
Z_mixed = functionMixed(X_tensor, Y_tensor)

fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.plot_surface(X, Y, Z_tensor.numpy(), cmap='coolwarm')
ax.plot_surface(X, Y, Z_mixed.numpy(), cmap='viridis')
ax.set_xlabel('X')
ax.set_ylabel('Y')
ax.set_zlabel('Z')
ax.set_title('                        $f(x, y) = xe^{-xy} $')
plt.show()
```



0.9 7. TensorFlow, 1

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[8]:
```
#Let's create create a traing dataset from function in the first excersice
x_train = tf.constant(np.linspace(0, 2, 100), dtype=tf.float32)
y_train = tf.constant(tf.math.multiply((x_train - 3),tf.math.sqrt(x_train)),␣
↪dtype=tf.float32)
```

[9]:
```
# Define the range for scaling
x_min = tf.reduce_min(x_train)
x_max = tf.reduce_max(x_train)
y_min = tf.reduce_min(y_train)
y_max = tf.reduce_max(y_train)

# Perform Min-Max scaling
xs = (x_train - x_min) / (x_max - x_min)
ys = (y_train - y_min) / (y_max - y_min)
```

[10]:
```
print(tf.math.reduce_max(xs).numpy(), "\n", tf.math.reduce_min(xs).numpy(),␣
↪"\n",
      tf.math.reduce_max(ys).numpy(), "\n", tf.math.reduce_min(ys).numpy())
```

```
1.0
 0.0
 1.0
 0.0
```

[11]:
```
def loss(predicted_y, target_y):
  return tf.reduce_max(tf.abs(target_y - predicted_y))
```

[12]:
```
class Model(object):
  def __init__(self):
    #                `2.0`            `1.0`
    #                                      (`tf.random.normal`)
    self.w = tf.Variable(2.0)
    self.b = tf.Variable(1.0)

  def __call__(self, x):
    return self.w * x + self.b

model = Model()
```

[13]:
```
def train(model, inputs, outputs, learning_rate):
  with tf.GradientTape() as t:
```

```
    current_loss = loss(model(inputs), outputs)
  dw, db = t.gradient(current_loss, [model.w, model.b])
  model.w.assign_sub(learning_rate * dw)
  model.b.assign_sub(learning_rate * db)

  return current_loss
```

[14]:
```
model = Model()

#                  'w'   'b'
list_w, list_b = [], []
epochs = range(15)
losses = []
for epoch in epochs:
  list_w.append(model.w.numpy())
  list_b.append(model.b.numpy())
  current_loss = train(model, xs, ys, learning_rate=0.1)
  losses.append(current_loss)
  print('    %2d: w=%1.2f b=%1.2f,     =%2.5f' %
        (epoch, list_w[-1], list_b[-1], current_loss))
```

```
    0: w=2.00 b=1.00,     =2.70713
    1: w=1.90 b=0.90,     =2.50713
    2: w=1.80 b=0.80,     =2.30713
    3: w=1.70 b=0.70,     =2.10713
    4: w=1.60 b=0.60,     =1.90713
    5: w=1.50 b=0.50,     =1.70713
    6: w=1.40 b=0.40,     =1.50713
    7: w=1.30 b=0.30,     =1.30713
    8: w=1.20 b=0.20,     =1.10713
    9: w=1.10 b=0.10,     =0.90713
   10: w=1.00 b=-0.00,     =1.00000
   11: w=1.00 b=0.10,     =0.90000
   12: w=1.00 b=0.20,     =0.90827
   13: w=0.90 b=0.10,     =0.90000
   14: w=0.90 b=0.20,     =0.81867
```

0.10 8.

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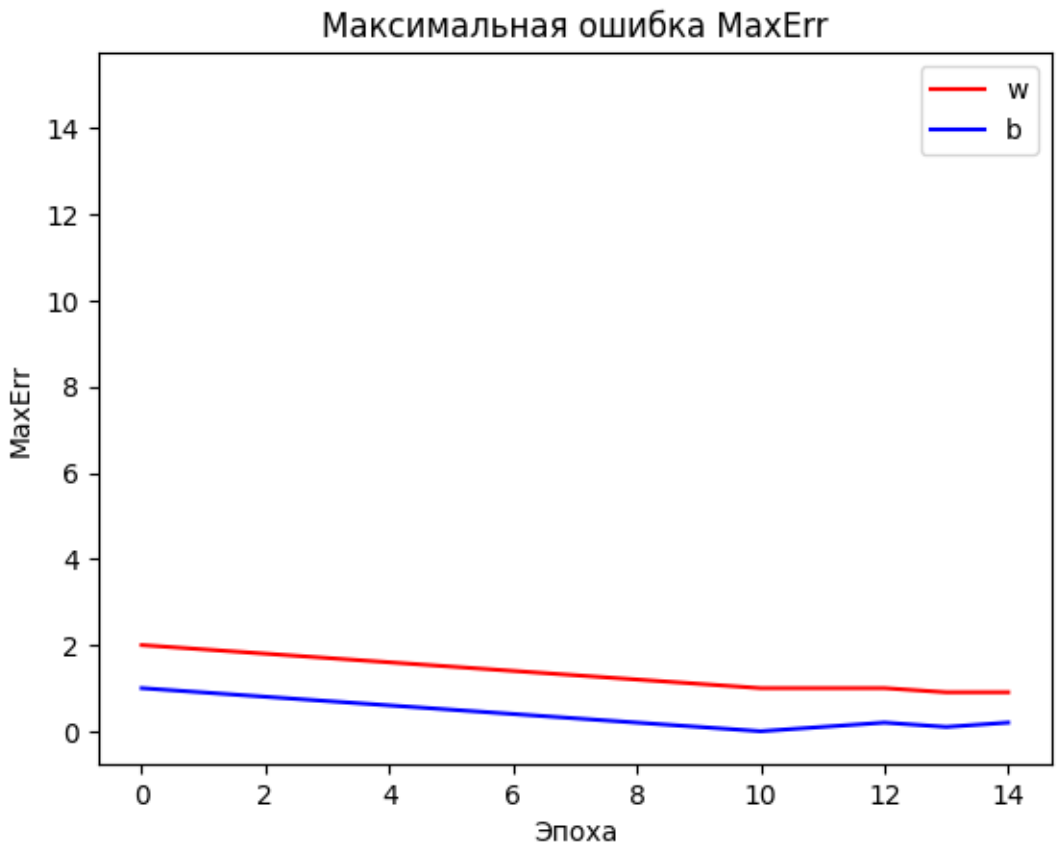
tf.math.

[15]:
```
plt.plot(epochs, list_w, 'r', epochs, list_b, 'b')
plt.plot(len(epochs), 'r--', len(epochs), 'b--')
plt.legend(['w', 'b'])
plt.title('            MaxErr')
plt.xlabel('   ')
plt.ylabel('MaxErr')
plt.show()
```



0.11 9. ( ) ,

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[16]:
```
y_pred = model(xs)
plt.figure(figsize=(16, 8))
plt.scatter(xs, ys, label='       ', color='g')
plt.plot(xs, y_pred, label='         ', color='b')
plt.xlabel('             ')
plt.ylabel('           ')
plt.title('                    ')
plt.legend()
plt.show()
```

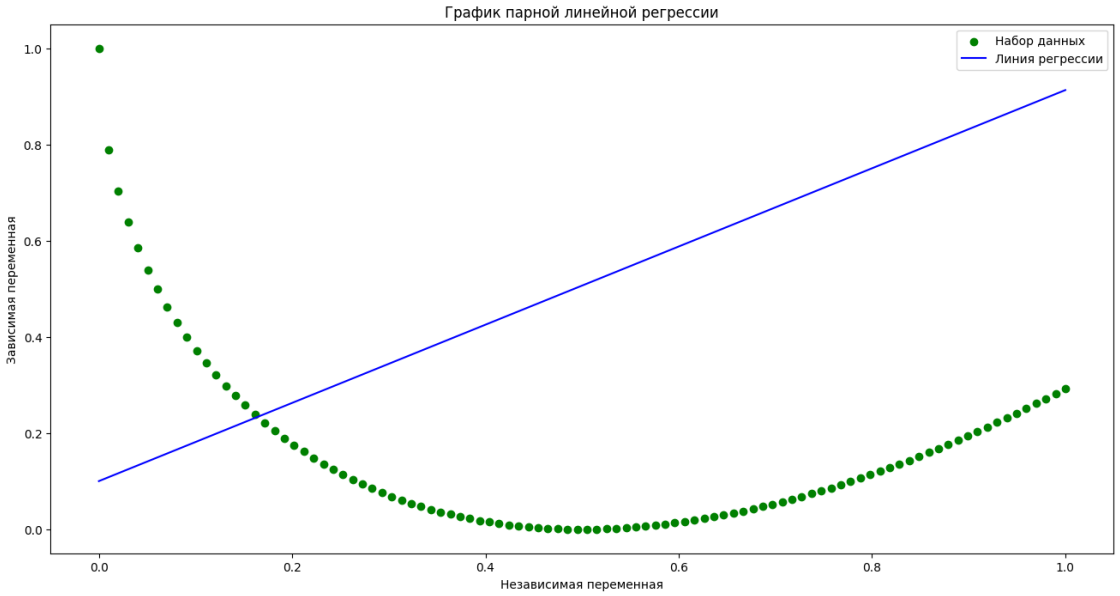
График парной линейной регрессии
Набор данных
Линия регрессии
Зависимая переменная
Независимая переменная
0.0
0.2
0.4
0.6
0.8
1.0

[ ]: