k818aumz5

February 4, 2023

The Vanishing Gradient Problem :

The problem: As more layers using certain activation functions are added to neural networks, the gradients of the loss function approaches zero, making the network hard to train.

Why: Certain activation functions, like the sigmoid function, squishes a large input space into a small input space between 0 and 1. Therefore, a large change in the input of the sigmoid function will cause a small change in the output. Hence, the derivative becomes small.

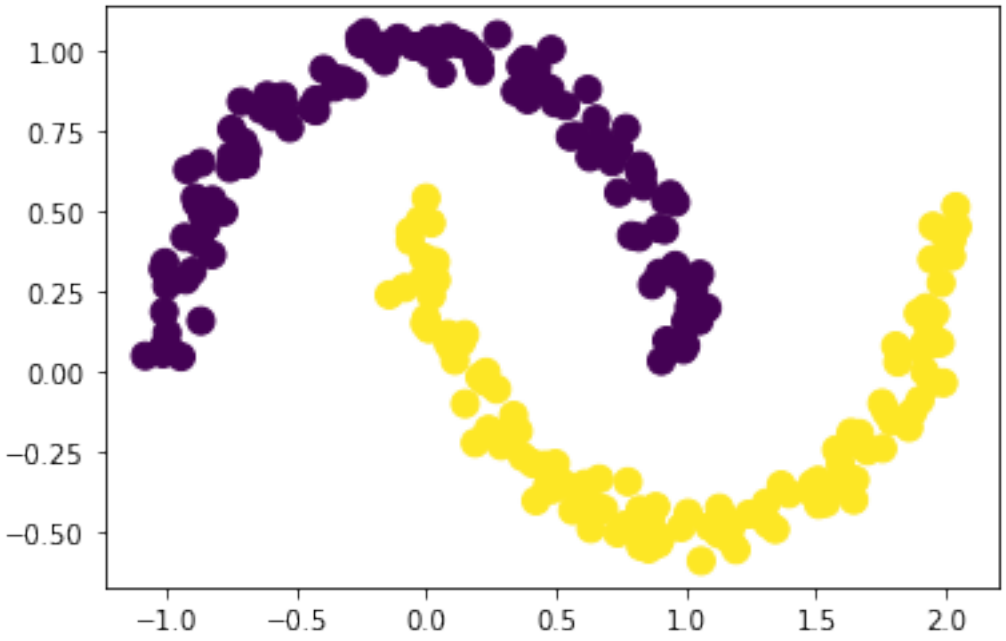
Solutions:

The simplest solution is to use other activation functions, such as ReLU, which doesn't cause a small derivative.

[29]:
```
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import tensorflow as tf
import keras
from sklearn.datasets import make_moons
from sklearn.model_selection import train_test_split
from keras.layers import Dense
from keras.models import Sequential
```

[2]:
```
X,y = make_moons(n_samples=250, noise=0.05, random_state=42)
```

[3]:
```
plt.scatter(X[:,0],X[:,1], c=y, s=100)
plt.show()
```



[4]:
```
model = Sequential()

model.add(Dense(10,activation='sigmoid',input_dim=2))
model.add(Dense(10,activation='sigmoid'))
model.add(Dense(10,activation='sigmoid'))
model.add(Dense(1, activation='sigmoid'))
```

[5]:
```
model.compile(loss='binary_crossentropy',optimizer='adam',metrics=['accuracy'])
```

[6]:
```
model.get_weights()[0]
```

[6]:
```
array([[ 0.18404245,  0.2700578 , -0.1796683 ,  0.4289047 , -0.49278128,
        -0.16220212, -0.5465988 ,  0.25976235,  0.09992492,  0.28631818],
       [-0.49214402,  0.52247757,  0.10643345,  0.4220243 ,  0.01249403,
        -0.41913083,  0.400917  , -0.03765839,  0.11924303,  0.10320246]],
      dtype=float32)
```

[7]:
```
old_weights = model.get_weights()[0]
```

[8]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.20,␣
↪random_state=42)
```

[9]:
```
model.fit(X_train, y_train, epochs = 100)
```

```
Epoch 1/100
7/7 [==============================] - 1s 4ms/step - loss: 0.7124 - accuracy:
```

```
0.5100
Epoch 2/100
7/7 [==============================] - 0s 5ms/step - loss: 0.7048 - accuracy:
0.5100
Epoch 3/100
7/7 [==============================] - 0s 4ms/step - loss: 0.7003 - accuracy:
0.5100
Epoch 4/100
7/7 [==============================] - 0s 4ms/step - loss: 0.6963 - accuracy:
0.5100
Epoch 5/100
7/7 [==============================] - 0s 4ms/step - loss: 0.6934 - accuracy:
0.5100
Epoch 6/100
7/7 [==============================] - 0s 4ms/step - loss: 0.6914 - accuracy:
0.5100
Epoch 7/100
7/7 [==============================] - 0s 3ms/step - loss: 0.6911 - accuracy:
0.5100
Epoch 8/100
7/7 [==============================] - 0s 4ms/step - loss: 0.6904 - accuracy:
0.5100
Epoch 9/100
7/7 [==============================] - 0s 4ms/step - loss: 0.6902 - accuracy:
0.5100
Epoch 10/100
7/7 [==============================] - 0s 3ms/step - loss: 0.6896 - accuracy:
0.5100
Epoch 11/100
7/7 [==============================] - 0s 4ms/step - loss: 0.6893 - accuracy:
0.5150
Epoch 12/100
7/7 [==============================] - 0s 6ms/step - loss: 0.6889 - accuracy:
0.6750
Epoch 13/100
7/7 [==============================] - 0s 16ms/step - loss: 0.6884 - accuracy:
0.7100
Epoch 14/100
7/7 [==============================] - 0s 8ms/step - loss: 0.6882 - accuracy:
0.7100
Epoch 15/100
7/7 [==============================] - 0s 23ms/step - loss: 0.6877 - accuracy:
0.7300
Epoch 16/100
7/7 [==============================] - 0s 16ms/step - loss: 0.6874 - accuracy:
0.7150
Epoch 17/100
7/7 [==============================] - 0s 12ms/step - loss: 0.6869 - accuracy:
```

```
0.7000
Epoch 18/100
7/7 [==============================] - 0s 15ms/step - loss: 0.6864 - accuracy:
0.7200
Epoch 19/100
7/7 [==============================] - 0s 7ms/step - loss: 0.6863 - accuracy:
0.7250
Epoch 20/100
7/7 [==============================] - 0s 8ms/step - loss: 0.6850 - accuracy:
0.7300
Epoch 21/100
7/7 [==============================] - 0s 8ms/step - loss: 0.6844 - accuracy:
0.7350
Epoch 22/100
7/7 [==============================] - 0s 36ms/step - loss: 0.6837 - accuracy:
0.7500
Epoch 23/100
7/7 [==============================] - 0s 11ms/step - loss: 0.6828 - accuracy:
0.7450
Epoch 24/100
7/7 [==============================] - 0s 15ms/step - loss: 0.6821 - accuracy:
0.7400
Epoch 25/100
7/7 [==============================] - 0s 12ms/step - loss: 0.6815 - accuracy:
0.6750
Epoch 26/100
7/7 [==============================] - 0s 14ms/step - loss: 0.6806 - accuracy:
0.5500
Epoch 27/100
7/7 [==============================] - 0s 14ms/step - loss: 0.6800 - accuracy:
0.6750
Epoch 28/100
7/7 [==============================] - 0s 8ms/step - loss: 0.6790 - accuracy:
0.7300
Epoch 29/100
7/7 [==============================] - 0s 15ms/step - loss: 0.6780 - accuracy:
0.7400
Epoch 30/100
7/7 [==============================] - 0s 6ms/step - loss: 0.6769 - accuracy:
0.7600
Epoch 31/100
7/7 [==============================] - 0s 8ms/step - loss: 0.6759 - accuracy:
0.7600
Epoch 32/100
7/7 [==============================] - 0s 32ms/step - loss: 0.6747 - accuracy:
0.7700
Epoch 33/100
7/7 [==============================] - 0s 17ms/step - loss: 0.6738 - accuracy:
```

```
0.7750
Epoch 34/100
7/7 [==============================] - 0s 4ms/step - loss: 0.6725 - accuracy:
0.7800
Epoch 35/100
7/7 [==============================] - 0s 4ms/step - loss: 0.6709 - accuracy:
0.7900
Epoch 36/100
7/7 [==============================] - 0s 8ms/step - loss: 0.6696 - accuracy:
0.7750
Epoch 37/100
7/7 [==============================] - 0s 6ms/step - loss: 0.6681 - accuracy:
0.7700
Epoch 38/100
7/7 [==============================] - 0s 7ms/step - loss: 0.6665 - accuracy:
0.7700
Epoch 39/100
7/7 [==============================] - 0s 18ms/step - loss: 0.6647 - accuracy:
0.7650
Epoch 40/100
7/7 [==============================] - 0s 6ms/step - loss: 0.6631 - accuracy:
0.7700
Epoch 41/100
7/7 [==============================] - 0s 15ms/step - loss: 0.6612 - accuracy:
0.7700
Epoch 42/100
7/7 [==============================] - 0s 28ms/step - loss: 0.6593 - accuracy:
0.7750
Epoch 43/100
7/7 [==============================] - 0s 12ms/step - loss: 0.6573 - accuracy:
0.7700
Epoch 44/100
7/7 [==============================] - 0s 12ms/step - loss: 0.6553 - accuracy:
0.7800
Epoch 45/100
7/7 [==============================] - 0s 12ms/step - loss: 0.6531 - accuracy:
0.7700
Epoch 46/100
7/7 [==============================] - 0s 6ms/step - loss: 0.6505 - accuracy:
0.7700
Epoch 47/100
7/7 [==============================] - 0s 21ms/step - loss: 0.6480 - accuracy:
0.7750
Epoch 48/100
7/7 [==============================] - 0s 13ms/step - loss: 0.6454 - accuracy:
0.7700
Epoch 49/100
7/7 [==============================] - 0s 16ms/step - loss: 0.6425 - accuracy:
```

```
0.7700
Epoch 50/100
7/7 [==============================] - 0s 18ms/step - loss: 0.6401 - accuracy:
0.7850
Epoch 51/100
7/7 [==============================] - 0s 12ms/step - loss: 0.6370 - accuracy:
0.7700
Epoch 52/100
7/7 [==============================] - 0s 5ms/step - loss: 0.6341 - accuracy:
0.7700
Epoch 53/100
7/7 [==============================] - 0s 5ms/step - loss: 0.6309 - accuracy:
0.7800
Epoch 54/100
7/7 [==============================] - 0s 10ms/step - loss: 0.6277 - accuracy:
0.7850
Epoch 55/100
7/7 [==============================] - 0s 8ms/step - loss: 0.6243 - accuracy:
0.7850
Epoch 56/100
7/7 [==============================] - 0s 5ms/step - loss: 0.6204 - accuracy:
0.7900
Epoch 57/100
7/7 [==============================] - 0s 10ms/step - loss: 0.6167 - accuracy:
0.7900
Epoch 58/100
7/7 [==============================] - 0s 13ms/step - loss: 0.6127 - accuracy:
0.7900
Epoch 59/100
7/7 [==============================] - 0s 6ms/step - loss: 0.6085 - accuracy:
0.7900
Epoch 60/100
7/7 [==============================] - 0s 14ms/step - loss: 0.6042 - accuracy:
0.7900
Epoch 61/100
7/7 [==============================] - 0s 26ms/step - loss: 0.5997 - accuracy:
0.7850
Epoch 62/100
7/7 [==============================] - 0s 13ms/step - loss: 0.5951 - accuracy:
0.7850
Epoch 63/100
7/7 [==============================] - 0s 13ms/step - loss: 0.5904 - accuracy:
0.7850
Epoch 64/100
7/7 [==============================] - 0s 15ms/step - loss: 0.5856 - accuracy:
0.7850
Epoch 65/100
7/7 [==============================] - 0s 12ms/step - loss: 0.5808 - accuracy:
```

```
0.7900
Epoch 66/100
7/7 [==============================] - 0s 8ms/step - loss: 0.5755 - accuracy:
0.7900
Epoch 67/100
7/7 [==============================] - 0s 6ms/step - loss: 0.5704 - accuracy:
0.8000
Epoch 68/100
7/7 [==============================] - 0s 8ms/step - loss: 0.5647 - accuracy:
0.8000
Epoch 69/100
7/7 [==============================] - 0s 11ms/step - loss: 0.5592 - accuracy:
0.7900
Epoch 70/100
7/7 [==============================] - 0s 10ms/step - loss: 0.5541 - accuracy:
0.7900
Epoch 71/100
7/7 [==============================] - 0s 16ms/step - loss: 0.5485 - accuracy:
0.7900
Epoch 72/100
7/7 [==============================] - 0s 12ms/step - loss: 0.5429 - accuracy:
0.7900
Epoch 73/100
7/7 [==============================] - 0s 13ms/step - loss: 0.5372 - accuracy:
0.7900
Epoch 74/100
7/7 [==============================] - 0s 5ms/step - loss: 0.5317 - accuracy:
0.7900
Epoch 75/100
7/7 [==============================] - 0s 10ms/step - loss: 0.5267 - accuracy:
0.7900
Epoch 76/100
7/7 [==============================] - 0s 12ms/step - loss: 0.5210 - accuracy:
0.7950
Epoch 77/100
7/7 [==============================] - 0s 12ms/step - loss: 0.5154 - accuracy:
0.7900
Epoch 78/100
7/7 [==============================] - 0s 12ms/step - loss: 0.5096 - accuracy:
0.7900
Epoch 79/100
7/7 [==============================] - 0s 8ms/step - loss: 0.5043 - accuracy:
0.7950
Epoch 80/100
7/7 [==============================] - 0s 12ms/step - loss: 0.4991 - accuracy:
0.8050
Epoch 81/100
7/7 [==============================] - 0s 8ms/step - loss: 0.4941 - accuracy:
```

```
0.8050
Epoch 82/100
7/7 [==============================] - 0s 8ms/step - loss: 0.4890 - accuracy:
0.8100
Epoch 83/100
7/7 [==============================] - 0s 22ms/step - loss: 0.4840 - accuracy:
0.8100
Epoch 84/100
7/7 [==============================] - 0s 15ms/step - loss: 0.4792 - accuracy:
0.8100
Epoch 85/100
7/7 [==============================] - 0s 35ms/step - loss: 0.4742 - accuracy:
0.8100
Epoch 86/100
7/7 [==============================] - 0s 11ms/step - loss: 0.4694 - accuracy:
0.8100
Epoch 87/100
7/7 [==============================] - 0s 5ms/step - loss: 0.4651 - accuracy:
0.8100
Epoch 88/100
7/7 [==============================] - 0s 5ms/step - loss: 0.4608 - accuracy:
0.8100
Epoch 89/100
7/7 [==============================] - 0s 11ms/step - loss: 0.4561 - accuracy:
0.8100
Epoch 90/100
7/7 [==============================] - 0s 12ms/step - loss: 0.4520 - accuracy:
0.8100
Epoch 91/100
7/7 [==============================] - 0s 4ms/step - loss: 0.4483 - accuracy:
0.8100
Epoch 92/100
7/7 [==============================] - 0s 5ms/step - loss: 0.4438 - accuracy:
0.8100
Epoch 93/100
7/7 [==============================] - 0s 12ms/step - loss: 0.4397 - accuracy:
0.8100
Epoch 94/100
7/7 [==============================] - 0s 6ms/step - loss: 0.4360 - accuracy:
0.8100
Epoch 95/100
7/7 [==============================] - 0s 6ms/step - loss: 0.4326 - accuracy:
0.8100
Epoch 96/100
7/7 [==============================] - 0s 4ms/step - loss: 0.4293 - accuracy:
0.8100
Epoch 97/100
7/7 [==============================] - 0s 4ms/step - loss: 0.4258 - accuracy:
```

```
0.8100
Epoch 98/100
7/7 [==============================] - 0s 4ms/step - loss: 0.4226 - accuracy:
0.8100
Epoch 99/100
7/7 [==============================] - 0s 4ms/step - loss: 0.4196 - accuracy:
0.8100
Epoch 100/100
7/7 [==============================] - 0s 4ms/step - loss: 0.4164 - accuracy:
0.8100
```

[9]:
```
<keras.callbacks.History at 0x7f511b305550>
```

[10]:
```
new_weights = model.get_weights()[0]
```

[11]:
```
model.optimizer.get_config()["learning_rate"]
```

[11]:
```
0.001
```

[12]:
```
gradient = (old_weights - new_weights)/ 0.001
percent_change = abs(100*(old_weights - new_weights)/ old_weights)
```

[13]:
```
gradient
```

[13]:
```
array([[ -680.3453 ,   283.82428,  -310.81702,  -561.9538 ,   569.8005 ,
         -715.84015,   541.0472 ,   590.6196 ,  -606.09546,  -568.54803],
       [ 1103.66   ,  -634.56476,   462.43475,   954.51483, -1085.3569 ,
         1065.5938 , -1082.2494 ,  -917.213  ,   968.9136 ,   960.5847 ]],
      dtype=float32)
```

[14]:
```
percent_change
```

[14]:
```
array([[ 369.6676  ,  105.09761 ,  172.99492 ,  131.02068 ,  115.62949 ,
         441.32602 ,   98.984344,  227.36925 ,  606.5509  ,  198.57213 ],
       [ 224.25552 ,  121.453026,  434.48254 ,  226.17532 , 8687.007   ,
         254.23897 ,  269.9435  , 2435.6138  ,  812.5537  ,  930.77704 ]],
      dtype=float32)
```

[15]:
```
old_weights
```

[15]:
```
array([[ 0.18404245,  0.2700578 , -0.1796683 ,  0.4289047 , -0.49278128,
        -0.16220212, -0.5465988 ,  0.25976235,  0.09992492,  0.28631818],
       [-0.49214402,  0.52247757,  0.10643345,  0.4220243 ,  0.01249403,
        -0.41913083,  0.400917  , -0.03765839,  0.11924303,  0.10320246]],
      dtype=float32)
```

[16]:
```
new_weights
```

[16]:
```
array([[ 0.86438775, -0.0137665 ,  0.13114873,  0.99085855, -1.0625818 ,
         0.55363804, -1.087646  , -0.33085737,  0.7060204 ,  0.85486627],
       [-1.5958041 ,  1.1570424 , -0.35600132, -0.53249055,  1.0978509 ,
        -1.4847246 ,  1.4831663 ,  0.8795547 , -0.8496706 , -0.8573823 ]],
      dtype=float32)
```

[17]:
```
model = Sequential()

model.add(Dense(10,activation='relu',input_dim=2))
model.add(Dense(10,activation='relu'))
model.add(Dense(10,activation='relu'))
model.add(Dense(10,activation='relu'))
model.add(Dense(10,activation='relu'))
model.add(Dense(10,activation='relu'))
model.add(Dense(10,activation='relu'))
model.add(Dense(10,activation='relu'))
model.add(Dense(10,activation='relu'))
model.add(Dense(10,activation='relu'))
model.add(Dense(10,activation='relu'))
model.add(Dense(1, activation='sigmoid'))
```

[18]:
```
model.compile(loss='binary_crossentropy',optimizer='adam',metrics=['accuracy'])
```

[19]:
```
old_weights = model.get_weights()[0]
```

[20]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.20,␣
↪random_state=42)
```

[21]:
```
model.fit(X_train, y_train, epochs = 100)
```

```
Epoch 1/100
7/7 [==============================] - 2s 7ms/step - loss: 0.6924 - accuracy:
0.5100
Epoch 2/100
7/7 [==============================] - 0s 8ms/step - loss: 0.6900 - accuracy:
0.5400
Epoch 3/100
7/7 [==============================] - 0s 8ms/step - loss: 0.6868 - accuracy:
0.7550
Epoch 4/100
7/7 [==============================] - 0s 6ms/step - loss: 0.6821 - accuracy:
0.7500
Epoch 5/100
7/7 [==============================] - 0s 5ms/step - loss: 0.6733 - accuracy:
0.8400
Epoch 6/100
7/7 [==============================] - 0s 8ms/step - loss: 0.6630 - accuracy:
```

```
0.8550
Epoch 7/100
7/7 [==============================] - 0s 6ms/step - loss: 0.6493 - accuracy:
0.8800
Epoch 8/100
7/7 [==============================] - 0s 7ms/step - loss: 0.6328 - accuracy:
0.8800
Epoch 9/100
7/7 [==============================] - 0s 11ms/step - loss: 0.6081 - accuracy:
0.8600
Epoch 10/100
7/7 [==============================] - 0s 10ms/step - loss: 0.5760 - accuracy:
0.8550
Epoch 11/100
7/7 [==============================] - 0s 11ms/step - loss: 0.5340 - accuracy:
0.8750
Epoch 12/100
7/7 [==============================] - 0s 7ms/step - loss: 0.4852 - accuracy:
0.8550
Epoch 13/100
7/7 [==============================] - 0s 6ms/step - loss: 0.4291 - accuracy:
0.8850
Epoch 14/100
7/7 [==============================] - 0s 8ms/step - loss: 0.3809 - accuracy:
0.8850
Epoch 15/100
7/7 [==============================] - 0s 7ms/step - loss: 0.3254 - accuracy:
0.9000
Epoch 16/100
7/7 [==============================] - 0s 6ms/step - loss: 0.2887 - accuracy:
0.8950
Epoch 17/100
7/7 [==============================] - 0s 7ms/step - loss: 0.2610 - accuracy:
0.9050
Epoch 18/100
7/7 [==============================] - 0s 8ms/step - loss: 0.2421 - accuracy:
0.8950
Epoch 19/100
7/7 [==============================] - 0s 11ms/step - loss: 0.2210 - accuracy:
0.9150
Epoch 20/100
7/7 [==============================] - 0s 7ms/step - loss: 0.2147 - accuracy:
0.9100
Epoch 21/100
7/7 [==============================] - 0s 7ms/step - loss: 0.2125 - accuracy:
0.9200
Epoch 22/100
7/7 [==============================] - 0s 8ms/step - loss: 0.2068 - accuracy:
```

```
0.9100
Epoch 23/100
7/7 [==============================] - 0s 10ms/step - loss: 0.1945 - accuracy:
0.9200
Epoch 24/100
7/7 [==============================] - 0s 8ms/step - loss: 0.2087 - accuracy:
0.9050
Epoch 25/100
7/7 [==============================] - 0s 7ms/step - loss: 0.1919 - accuracy:
0.9250
Epoch 26/100
7/7 [==============================] - 0s 5ms/step - loss: 0.1832 - accuracy:
0.9150
Epoch 27/100
7/7 [==============================] - 0s 12ms/step - loss: 0.1753 - accuracy:
0.9200
Epoch 28/100
7/7 [==============================] - 0s 12ms/step - loss: 0.1704 - accuracy:
0.9250
Epoch 29/100
7/7 [==============================] - 0s 6ms/step - loss: 0.1671 - accuracy:
0.9300
Epoch 30/100
7/7 [==============================] - 0s 6ms/step - loss: 0.1686 - accuracy:
0.9300
Epoch 31/100
7/7 [==============================] - 0s 11ms/step - loss: 0.1571 - accuracy:
0.9350
Epoch 32/100
7/7 [==============================] - 0s 6ms/step - loss: 0.1781 - accuracy:
0.9250
Epoch 33/100
7/7 [==============================] - 0s 7ms/step - loss: 0.1775 - accuracy:
0.9300
Epoch 34/100
7/7 [==============================] - 0s 5ms/step - loss: 0.1585 - accuracy:
0.9250
Epoch 35/100
7/7 [==============================] - 0s 5ms/step - loss: 0.1606 - accuracy:
0.9250
Epoch 36/100
7/7 [==============================] - 0s 7ms/step - loss: 0.1717 - accuracy:
0.9300
Epoch 37/100
7/7 [==============================] - 0s 4ms/step - loss: 0.1467 - accuracy:
0.9500
Epoch 38/100
7/7 [==============================] - 0s 6ms/step - loss: 0.1732 - accuracy:
```

```
0.9250
Epoch 39/100
7/7 [==============================] - 0s 11ms/step - loss: 0.1507 - accuracy:
0.9350
Epoch 40/100
7/7 [==============================] - 0s 7ms/step - loss: 0.1385 - accuracy:
0.9500
Epoch 41/100
7/7 [==============================] - 0s 6ms/step - loss: 0.1456 - accuracy:
0.9250
Epoch 42/100
7/7 [==============================] - 0s 7ms/step - loss: 0.1265 - accuracy:
0.9500
Epoch 43/100
7/7 [==============================] - 0s 8ms/step - loss: 0.1128 - accuracy:
0.9600
Epoch 44/100
7/7 [==============================] - 0s 8ms/step - loss: 0.1145 - accuracy:
0.9500
Epoch 45/100
7/7 [==============================] - 0s 6ms/step - loss: 0.1055 - accuracy:
0.9600
Epoch 46/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0999 - accuracy:
0.9550
Epoch 47/100
7/7 [==============================] - 0s 5ms/step - loss: 0.0935 - accuracy:
0.9650
Epoch 48/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0948 - accuracy:
0.9650
Epoch 49/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0855 - accuracy:
0.9650
Epoch 50/100
7/7 [==============================] - 0s 10ms/step - loss: 0.0895 - accuracy:
0.9650
Epoch 51/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0725 - accuracy:
0.9900
Epoch 52/100
7/7 [==============================] - 0s 10ms/step - loss: 0.0805 - accuracy:
0.9650
Epoch 53/100
7/7 [==============================] - 0s 7ms/step - loss: 0.0933 - accuracy:
0.9600
Epoch 54/100
7/7 [==============================] - 0s 7ms/step - loss: 0.0663 - accuracy:
```

```
0.9750
Epoch 55/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0693 - accuracy:
0.9700
Epoch 56/100
7/7 [==============================] - 0s 8ms/step - loss: 0.0601 - accuracy:
0.9800
Epoch 57/100
7/7 [==============================] - 0s 5ms/step - loss: 0.0529 - accuracy:
0.9900
Epoch 58/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0441 - accuracy:
0.9900
Epoch 59/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0420 - accuracy:
0.9900
Epoch 60/100
7/7 [==============================] - 0s 8ms/step - loss: 0.0380 - accuracy:
0.9950
Epoch 61/100
7/7 [==============================] - 0s 7ms/step - loss: 0.0423 - accuracy:
0.9850
Epoch 62/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0454 - accuracy:
0.9850
Epoch 63/100
7/7 [==============================] - 0s 7ms/step - loss: 0.0313 - accuracy:
0.9950
Epoch 64/100
7/7 [==============================] - 0s 11ms/step - loss: 0.0312 - accuracy:
1.0000
Epoch 65/100
7/7 [==============================] - 0s 10ms/step - loss: 0.0253 - accuracy:
0.9950
Epoch 66/100
7/7 [==============================] - 0s 12ms/step - loss: 0.0237 - accuracy:
1.0000
Epoch 67/100
7/7 [==============================] - 0s 10ms/step - loss: 0.0226 - accuracy:
0.9950
Epoch 68/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0203 - accuracy:
1.0000
Epoch 69/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0181 - accuracy:
1.0000
Epoch 70/100
7/7 [==============================] - 0s 7ms/step - loss: 0.0166 - accuracy:
```

```
1.0000
Epoch 71/100
7/7 [==============================] - 0s 7ms/step - loss: 0.0157 - accuracy:
1.0000
Epoch 72/100
7/7 [==============================] - 0s 5ms/step - loss: 0.0152 - accuracy:
1.0000
Epoch 73/100
7/7 [==============================] - 0s 7ms/step - loss: 0.0135 - accuracy:
1.0000
Epoch 74/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0130 - accuracy:
1.0000
Epoch 75/100
7/7 [==============================] - 0s 8ms/step - loss: 0.0121 - accuracy:
1.0000
Epoch 76/100
7/7 [==============================] - 0s 7ms/step - loss: 0.0116 - accuracy:
1.0000
Epoch 77/100
7/7 [==============================] - 0s 12ms/step - loss: 0.0108 - accuracy:
1.0000
Epoch 78/100
7/7 [==============================] - 0s 8ms/step - loss: 0.0096 - accuracy:
1.0000
Epoch 79/100
7/7 [==============================] - 0s 5ms/step - loss: 0.0099 - accuracy:
1.0000
Epoch 80/100
7/7 [==============================] - 0s 8ms/step - loss: 0.0088 - accuracy:
1.0000
Epoch 81/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0082 - accuracy:
1.0000
Epoch 82/100
7/7 [==============================] - 0s 5ms/step - loss: 0.0078 - accuracy:
1.0000
Epoch 83/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0072 - accuracy:
1.0000
Epoch 84/100
7/7 [==============================] - 0s 8ms/step - loss: 0.0066 - accuracy:
1.0000
Epoch 85/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0063 - accuracy:
1.0000
Epoch 86/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0060 - accuracy:
```

```
1.0000
Epoch 87/100
7/7 [==============================] - 0s 10ms/step - loss: 0.0056 - accuracy:
1.0000
Epoch 88/100
7/7 [==============================] - 0s 5ms/step - loss: 0.0054 - accuracy:
1.0000
Epoch 89/100
7/7 [==============================] - 0s 7ms/step - loss: 0.0052 - accuracy:
1.0000
Epoch 90/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0050 - accuracy:
1.0000
Epoch 91/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0048 - accuracy:
1.0000
Epoch 92/100
7/7 [==============================] - 0s 5ms/step - loss: 0.0046 - accuracy:
1.0000
Epoch 93/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0043 - accuracy:
1.0000
Epoch 94/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0041 - accuracy:
1.0000
Epoch 95/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0039 - accuracy:
1.0000
Epoch 96/100
7/7 [==============================] - 0s 8ms/step - loss: 0.0039 - accuracy:
1.0000
Epoch 97/100
7/7 [==============================] - 0s 7ms/step - loss: 0.0036 - accuracy:
1.0000
Epoch 98/100
7/7 [==============================] - 0s 9ms/step - loss: 0.0036 - accuracy:
1.0000
Epoch 99/100
7/7 [==============================] - 0s 8ms/step - loss: 0.0034 - accuracy:
1.0000
Epoch 100/100
7/7 [==============================] - 0s 6ms/step - loss: 0.0032 - accuracy:
1.0000
```

[21]: `<keras.callbacks.History at 0x7f511b25de20>`

[22]:
```
new_weights = model.get_weights()[0]
```

[23]:
```
model.optimizer.get_config()["learning_rate"]
```

[23]:
```
0.001
```

[24]:
```
gradient = (old_weights - new_weights)/ 0.001
percent_change = abs(100*(old_weights - new_weights)/ old_weights)
```

[25]:
```
gradient
```

[25]:
```
array([[ 238.1037  ,    8.366286,  -25.899588,  -39.772747,   -4.219502,
          146.7252  ,   11.92063 ,  -25.667309,  -32.940685,   34.258266],
        [ -29.849901,   24.193523,   75.90496 ,   62.46665 , -164.69519 ,
         -209.34384 ,   33.327938,  -13.049423,   90.38502 ,  -11.896818]],
      dtype=float32)
```

[26]:
```
percent_change
```

[26]:
```
array([[ 55.869396 ,   1.5076709,   4.005221 ,   8.081712 ,   0.9096341,
         169.42677  ,   1.9219062,   3.7337885,   6.117841 ,  30.70192  ],
        [ 22.507624 ,   3.7737753,  12.581471 ,  17.776312 ,  24.384586 ,
          35.327286 ,  46.407158 ,   1.8619287,  19.620298 ,   3.2026446]],
      dtype=float32)
```

[27]:
```
old_weights
```

[27]:
```
array([[-0.42617914,  0.55491465,  0.6466457 ,  0.49213272,  0.46386808,
          0.08660096,  0.6202504 ,  0.6874334 ,  0.5384365 ,  0.11158347],
        [ 0.13262129,  0.64109606,  0.60330755, -0.3514039 ,  0.675407  ,
         -0.592584  ,  0.07181638,  0.7008552 , -0.46067095,  0.3714686 ]],
      dtype=float32)
```

[28]:
```
new_weights
```

[28]:
```
array([[-0.66428286,  0.54654837,  0.6725453 ,  0.5319055 ,  0.46808758,
         -0.06012425,  0.6083298 ,  0.71310073,  0.57137716,  0.0773252 ],
        [ 0.16247119,  0.61690253,  0.5274026 , -0.41387054,  0.8401022 ,
         -0.38324016,  0.03848844,  0.7139046 , -0.55105597,  0.38336542]],
      dtype=float32)
```

Solution :

1:Reduce model complexity(if your model contains large hidden layers use few hidden layer(shallow network) but it is not recommmended for solving complex problem

2:Use Relu activation function

[28]:
```
```