Get to Know Tensorflow

October 2, 2020

1 WELCOME to this guided project "Get to Know TensorFlow" on Coursera Labs!

This project course is part of "Tensorflow for AI" Series of project courses on Coursera. We will go through 4 parts to implement our project: **Task 1:** Introduction and overview of the whole project (non-technical task). **Task 2:** Install and Import TensorFlow and Practice Simple Examples. **Task 3:** Create TensorFlow Pipeline. **Task 4:** Define, Compile and Train a Neural Network. **Task 5:** Solve Simple Exercises.

[1]:
```
print("Let's learn \n Tensorflow! ")
```

```
Let's learn
 Tensorflow!
```

1.0.1 Task 1: Introduction and overview of the whole project (non-technical task)

In this project, you will get a soft introduction to what Machine Learning and Deep Learning are, and how they offer you a new programming paradigm, giving you a new set of tools to open new scenarios. All you need to know is some basic programming skills, and you'll pick the rest up as you go along. . . .

Definition of Tensorflow TensorFlow is the second machine learning framework that Google created and used to design, build, and train deep learning models. You can use the TensorFlow library do to numerical computations, which in itself doesn't seem all too special, but these computations are done with data flow graphs. In these graphs, nodes represent mathematical operations, while the edges represent the data, which usually are multidimensional data arrays or tensors, that are communicated between these edges. Tensorflow is an open-source machine learning library developed by Google. One of its applications is to develop deep neural networks.

Currently, the most famous deep learning library in the world is Google's TensorFlow. Google product uses machine learning in all of its products to improve the search engine, translation, image captioning or recommendations. TensorFlow was first made public in late 2015, while the first stable version appeared in 2017. It is open source under Apache Open Source license. You can use it, modify it and redistribute the modified version for a fee without paying anything to Google.

It is called Tensorflow because it takes input as a multi-dimensional array, also known as tensors. You can construct a sort of flowchart of operations (called a Graph) that you want to perform on that input. The input goes in at one end, and then it flows through this system of multiple

operations and comes out the other end as output. This is why it is called TensorFlow because the tensor goes in it flows through a list of operations, and then it comes out the other side. |

1.0.2 Task 2: Install and Import TensorFlow and Practice Simple Examples

Let's first install TensorFlow

[5]:
```
# !pip install tensorflow==2.0.0-alpha0
```

And now let's start with our imports to use TensorFlow easily:

1. **numpy** helps us to represent our data as lists easily and quickly.
2. **keras** is the framework for defining a neural network as a set of Sequential layers.

[6]:
```
import tensorflow as tf
import numpy as np
from tensorflow import keras
```

Start with simple TensorFlow Examples

Example 1 Let's now practice the elementary workflow of Tensorflow with a simple example. Let 's create a computational graph that multiplies two numbers together.

During the example, we will multiply X_1 and X_2 together. Tensorflow will create a node to connect the operation. In our example, it is called multiply. When the graph is determined, Tensorflow computational engines will multiply together X_1 and X_2.

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Finally, we will run a TensorFlow session that will run the computational graph with the values of X_1 and X_2 and print the result of the multiplication.

Let 's define the X_1 and X_2 input nodes. When we create a node in Tensorflow, we have to choose what kind of node to create. The X1 and X2 nodes will be a placeholder node. The placeholder assigns a new value each time we make a calculation. We will create them as a TF dot placeholder node.

[7]:
```
### Step 1: Define the Variable
X_1 = tf.placeholder(tf.float32, name = "X_1")
X_2 = tf.placeholder(tf.float32, name = "X_2")
```

When we create a placeholder node, we have to pass in the data type will be adding numbers here so we can use a floating-point data type, let's use tf.float32. We also need to give this node a name. This name will show up when we look at the graphical visualizations of our model. Let's name this node X_1 by passing in a parameter called name with a value of X_1 and now let's define X_2 the same way. X_2.

[ ]:
```
### Step 2: Define the Computation
multiply = tf.multiply(X_1, X_2, name = "multiplication")
```

Now we can define the node that does the multiplication operation. In Tensorflow we can do that by creating a tf.multiply node.

We will pass in the X_1 and X_2 nodes to the multiplication node. It tells tensorflow to link those nodes in the computational graph, so we are asking it to pull the values from x and y and multiply the result. Let's also give the multiplication node the name multiply. It is the entire definition for our simple computational graph.

[ ]:
```
### Step 3: Execute the operation
X_1 = tf.placeholder(tf.float32, name = "X_1")
X_2 = tf.placeholder(tf.float32, name = "X_2")

multiply = tf.multiply(X_1, X_2, name = "multiplication")

with tf.Session() as session:
    result = session.run(multiply, feed_dict={X_1:[1,2,3], X_2:[4,5,6]})
    print(result)
```

To execute operations in the graph, we have to create a session. In Tensorflow, it is done by tf.Session(). Now that we have a session we can ask the session to run operations on our computational graph by calling session. To run the computation, we need to use run.

When the addition operation runs, it is going to see that it needs to grab the values of the X_1 and X_2 nodes, so we also need to feed in values for X_1 and X_2. We can do that by supplying a parameter called feed_dict. We pass the value 1,2,3 for X_1 and 4,5,6 for X_2.

We print the results with print(result). We should see 4, 10 and 18 for 1x4, 2x5 and 3x6

Example 2 Let's initialize two variables that are actually constants. Pass an array of four numbers to the constant() function.

Note that you could potentially also pass in an integer, but that more often than not, you'll find yourself working with arrays. As you saw in the introduction, tensors are all about arrays! So make sure that you pass in an array :) Next, you can use multiply() to multiply your two variables. Store the result in the result variable. Lastly, print out the result with the help of the print() function.

[9]:
```
# Initialize two constants
x1 = tf.constant([1,2,3,4])
x2 = tf.constant([5,6,7,8])

# Multiply
result = tf.multiply(x1, x2, name="multiplication_2")

# Print the result
print(result)
```

```
tf.Tensor([ 5 12 21 32], shape=(4,), dtype=int32)
```

Example 3

In this exercise, we will build a basic neural network with TensorFlow that predicts the price of a house using a simple formula. Now imagine if house pricing was as easy as a house costs 30k + 30k per swimming pool, so that a house with one swimming pool in costs 60k, a house with 2 swimming pools costs 90k etc.

You will create a neural network that learns this pattern or relationship so that it would predict a villa with 7 swimming pools as costing close to 240k etc.

Hint: Your neural network may work better if you scale the house price down. You don't have to give the answer 250…it might be better to create something that predicts the number 2.4, and then your answer is in the 'hundreds of thousands' etc.

[10]:
```
from tensorflow import keras

model = tf.keras.Sequential([keras.layers.Dense(units=1, input_shape=[1])])
model.compile(optimizer='sgd', loss='mean_squared_error')

xs = np.array([1.0, 2.0, 3.0, 4.0, 5.0, 6.0], dtype=float)
ys = np.array([0.6, 0.9, 1.2, 1.5, 1.8, 2.1], dtype=float)

model.fit(xs, ys, epochs=1000)

print(model.predict([7.0]))
```

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Epoch 1/1000
6/6 [==============================] - 0s 9ms/sample - loss: 21.0308
Epoch 2/1000
6/6 [==============================] - 0s 166us/sample - loss: 19.7114
Epoch 3/1000
6/6 [==============================] - 0s 166us/sample - loss: 18.4751
Epoch 4/1000
6/6 [==============================] - 0s 166us/sample - loss: 17.3165
Epoch 5/1000
6/6 [==============================] - 0s 166us/sample - loss: 16.2307
Epoch 6/1000
6/6 [==============================] - 0s 166us/sample - loss: 15.2133
Epoch 7/1000
6/6 [==============================] - 0s 0s/sample - loss: 14.2599
Epoch 8/1000
6/6 [==============================] - 0s 166us/sample - loss: 13.3665
Epoch 9/1000
6/6 [==============================] - 0s 166us/sample - loss: 12.5293
Epoch 10/1000
6/6 [==============================] - 0s 166us/sample - loss: 11.7448
Epoch 11/1000
6/6 [==============================] - 0s 332us/sample - loss: 11.0096
Epoch 12/1000
6/6 [==============================] - 0s 333us/sample - loss: 10.3207
Epoch 13/1000
6/6 [==============================] - 0s 166us/sample - loss: 9.6751
Epoch 14/1000
6/6 [==============================] - 0s 166us/sample - loss: 9.0701
Epoch 15/1000
6/6 [==============================] - 0s 166us/sample - loss: 8.5032
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Epoch 16/1000
6/6 [==============================] - 0s 166us/sample - loss: 7.9719
Epoch 17/1000
6/6 [==============================] - 0s 166us/sample - loss: 7.4741
Epoch 18/1000
6/6 [==============================] - 0s 0s/sample - loss: 7.0076
Epoch 19/1000
6/6 [==============================] - 0s 166us/sample - loss: 6.5704
Epoch 20/1000
6/6 [==============================] - 0s 166us/sample - loss: 6.1607
Epoch 21/1000
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Epoch 22/1000
6/6 [==============================] - 0s 166us/sample - loss: 5.4171
Epoch 23/1000
6/6 [==============================] - 0s 166us/sample - loss: 5.0800
Epoch 24/1000
6/6 [==============================] - 0s 166us/sample - loss: 4.7641
Epoch 25/1000
6/6 [==============================] - 0s 0s/sample - loss: 4.4680
Epoch 26/1000
6/6 [==============================] - 0s 166us/sample - loss: 4.1906
Epoch 27/1000
6/6 [==============================] - 0s 166us/sample - loss: 3.9307
Epoch 28/1000
6/6 [==============================] - 0s 166us/sample - loss: 3.6871
Epoch 29/1000
6/6 [==============================] - 0s 166us/sample - loss: 3.4588
Epoch 30/1000
6/6 [==============================] - 0s 0s/sample - loss: 3.2449
Epoch 31/1000
6/6 [==============================] - 0s 166us/sample - loss: 3.0444
Epoch 32/1000
6/6 [==============================] - 0s 332us/sample - loss: 2.8565
Epoch 33/1000
6/6 [==============================] - 0s 166us/sample - loss: 2.6805
Epoch 34/1000
6/6 [==============================] - 0s 166us/sample - loss: 2.5155
Epoch 35/1000
6/6 [==============================] - 0s 166us/sample - loss: 2.3609
Epoch 36/1000
6/6 [==============================] - 0s 166us/sample - loss: 2.2161
Epoch 37/1000
6/6 [==============================] - 0s 166us/sample - loss: 2.0803
Epoch 38/1000
6/6 [==============================] - 0s 0s/sample - loss: 1.9531
Epoch 39/1000
6/6 [==============================] - 0s 166us/sample - loss: 1.8339
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Epoch 40/1000
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Epoch 41/1000
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Epoch 42/1000
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Epoch 43/1000
6/6 [==============================] - 0s 166us/sample - loss: 1.4274
Epoch 44/1000
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Epoch 45/1000
6/6 [==============================] - 0s 0s/sample - loss: 1.2605
Epoch 46/1000
6/6 [==============================] - 0s 166us/sample - loss: 1.1848
Epoch 47/1000
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Epoch 50/1000
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Epoch 51/1000
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Epoch 56/1000
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Epoch 58/1000
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Epoch 59/1000
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Epoch 60/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.5114
Epoch 61/1000
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Epoch 62/1000
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Epoch 63/1000
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Epoch 64/1000
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Epoch 206/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0521
Epoch 207/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0521
```

```
Epoch 208/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0520
Epoch 209/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0520
Epoch 210/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0519
Epoch 211/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0519
Epoch 212/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0519
Epoch 213/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0518
Epoch 214/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0518
Epoch 215/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0517
Epoch 216/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0517
Epoch 217/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0517
Epoch 218/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0516
Epoch 219/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0516
Epoch 220/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0515
Epoch 221/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0515
Epoch 222/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0515
Epoch 223/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0514
Epoch 224/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0514
Epoch 225/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0513
Epoch 226/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0513
Epoch 227/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0513
Epoch 228/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0512
Epoch 229/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0512
Epoch 230/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0512
Epoch 231/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0511
```

```
Epoch 232/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0511
Epoch 233/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0510
Epoch 234/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0510
Epoch 235/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0510
Epoch 236/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0509
Epoch 237/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0509
Epoch 238/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0509
Epoch 239/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0508
Epoch 240/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0508
Epoch 241/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0507
Epoch 242/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0507
Epoch 243/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0507
Epoch 244/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0506
Epoch 245/1000
6/6 [==============================] - 0s 216us/sample - loss: 0.0506
Epoch 246/1000
6/6 [==============================] - 0s 116us/sample - loss: 0.0506
Epoch 247/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0505
Epoch 248/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0505
Epoch 249/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0504
Epoch 250/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0504
Epoch 251/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0504
Epoch 252/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0503
Epoch 253/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0503
Epoch 254/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0503
Epoch 255/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0502
```

```
Epoch 256/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0502
Epoch 257/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0502
Epoch 258/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0501
Epoch 259/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0501
Epoch 260/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0500
Epoch 261/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0500
Epoch 262/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0500
Epoch 263/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0499
Epoch 264/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0499
Epoch 265/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0499
Epoch 266/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0498
Epoch 267/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0498
Epoch 268/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0498
Epoch 269/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0497
Epoch 270/1000
6/6 [==============================] - 0s 499us/sample - loss: 0.0497
Epoch 271/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0496
Epoch 272/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0496
Epoch 273/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0496
Epoch 274/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0495
Epoch 275/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0495
Epoch 276/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0495
Epoch 277/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0494
Epoch 278/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0494
Epoch 279/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0494
```

```
Epoch 280/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0493
Epoch 281/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0493
Epoch 282/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0492
Epoch 283/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0492
Epoch 284/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0492
Epoch 285/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0491
Epoch 286/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0491
Epoch 287/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0491
Epoch 288/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0490
Epoch 289/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0490
Epoch 290/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0490
Epoch 291/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0489
Epoch 292/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0489
Epoch 293/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0489
Epoch 294/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0488
Epoch 295/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0488
Epoch 296/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0487
Epoch 297/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0487
Epoch 298/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0487
Epoch 299/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0486
Epoch 300/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0486
Epoch 301/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0486
Epoch 302/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0485
Epoch 303/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0485
```

```
Epoch 304/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0485
Epoch 305/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0484
Epoch 306/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0484
Epoch 307/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0484
Epoch 308/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0483
Epoch 309/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0483
Epoch 310/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0483
Epoch 311/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0482
Epoch 312/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0482
Epoch 313/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0481
Epoch 314/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0481
Epoch 315/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0481
Epoch 316/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0480
Epoch 317/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0480
Epoch 318/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0480
Epoch 319/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0479
Epoch 320/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0479
Epoch 321/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0479
Epoch 322/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0478
Epoch 323/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0478
Epoch 324/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0478
Epoch 325/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0477
Epoch 326/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0477
Epoch 327/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0477
```

```
Epoch 328/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0476
Epoch 329/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0476
Epoch 330/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0476
Epoch 331/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0475
Epoch 332/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0475
Epoch 333/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0474
Epoch 334/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0474
Epoch 335/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0474
Epoch 336/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0473
Epoch 337/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0473
Epoch 338/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0473
Epoch 339/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0472
Epoch 340/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0472
Epoch 341/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0472
Epoch 342/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0471
Epoch 343/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0471
Epoch 344/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0471
Epoch 345/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0470
Epoch 346/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0470
Epoch 347/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0470
Epoch 348/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0469
Epoch 349/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0469
Epoch 350/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0469
Epoch 351/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0468
```

```
Epoch 352/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0468
Epoch 353/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0468
Epoch 354/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0467
Epoch 355/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0467
Epoch 356/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0467
Epoch 357/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0466
Epoch 358/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0466
Epoch 359/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0466
Epoch 360/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0465
Epoch 361/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0465
Epoch 362/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0465
Epoch 363/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0464
Epoch 364/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0464
Epoch 365/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0464
Epoch 366/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0463
Epoch 367/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0463
Epoch 368/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0462
Epoch 369/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0462
Epoch 370/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0462
Epoch 371/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0461
Epoch 372/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0461
Epoch 373/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0461
Epoch 374/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0460
Epoch 375/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0460
```

```
Epoch 376/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0460
Epoch 377/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0459
Epoch 378/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0459
Epoch 379/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0459
Epoch 380/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0458
Epoch 381/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0458
Epoch 382/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0458
Epoch 383/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0457
Epoch 384/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0457
Epoch 385/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0457
Epoch 386/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0456
Epoch 387/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0456
Epoch 388/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0456
Epoch 389/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0455
Epoch 390/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0455
Epoch 391/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0455
Epoch 392/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0454
Epoch 393/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0454
Epoch 394/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0454
Epoch 395/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0453
Epoch 396/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0453
Epoch 397/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0453
Epoch 398/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0452
Epoch 399/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0452
```

```
Epoch 400/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0452
Epoch 401/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0451
Epoch 402/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0451
Epoch 403/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0451
Epoch 404/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0451
Epoch 405/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0450
Epoch 406/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0450
Epoch 407/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0450
Epoch 408/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0449
Epoch 409/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0449
Epoch 410/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0449
Epoch 411/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0448
Epoch 412/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0448
Epoch 413/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0448
Epoch 414/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0447
Epoch 415/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0447
Epoch 416/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0447
Epoch 417/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0446
Epoch 418/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0446
Epoch 419/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0446
Epoch 420/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0445
Epoch 421/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0445
Epoch 422/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0445
Epoch 423/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0444
```

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Epoch 424/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0444
Epoch 425/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0444
Epoch 426/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0443
Epoch 427/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0443
Epoch 428/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0443
Epoch 429/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0442
Epoch 430/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0442
Epoch 431/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0442
Epoch 432/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0441
Epoch 433/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0441
Epoch 434/1000
6/6 [==============================] - 0s 162us/sample - loss: 0.0441
Epoch 435/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0440
Epoch 436/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0440
Epoch 437/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0440
Epoch 438/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0439
Epoch 439/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0439
Epoch 440/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0439
Epoch 441/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0438
Epoch 442/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0438
Epoch 443/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0438
Epoch 444/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0438
Epoch 445/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0437
Epoch 446/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0437
Epoch 447/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0437
```

```
Epoch 448/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0436
Epoch 449/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0436
Epoch 450/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0436
Epoch 451/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0435
Epoch 452/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0435
Epoch 453/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0435
Epoch 454/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0434
Epoch 455/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0434
Epoch 456/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0434
Epoch 457/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0433
Epoch 458/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0433
Epoch 459/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0433
Epoch 460/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0432
Epoch 461/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0432
Epoch 462/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0432
Epoch 463/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0432
Epoch 464/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0431
Epoch 465/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0431
Epoch 466/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0431
Epoch 467/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0430
Epoch 468/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0430
Epoch 469/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0430
Epoch 470/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0429
Epoch 471/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0429
```

```
Epoch 472/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0429
Epoch 473/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0428
Epoch 474/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0428
Epoch 475/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0428
Epoch 476/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0427
Epoch 477/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0427
Epoch 478/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0427
Epoch 479/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0426
Epoch 480/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0426
Epoch 481/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0426
Epoch 482/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0426
Epoch 483/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0425
Epoch 484/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0425
Epoch 485/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0425
Epoch 486/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0424
Epoch 487/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0424
Epoch 488/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0424
Epoch 489/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0423
Epoch 490/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0423
Epoch 491/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0423
Epoch 492/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0422
Epoch 493/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0422
Epoch 494/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0422
Epoch 495/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0422
```

```
Epoch 496/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0421
Epoch 497/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0421
Epoch 498/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0421
Epoch 499/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0420
Epoch 500/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0420
Epoch 501/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0420
Epoch 502/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0419
Epoch 503/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0419
Epoch 504/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0419
Epoch 505/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0418
Epoch 506/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0418
Epoch 507/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0418
Epoch 508/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0418
Epoch 509/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0417
Epoch 510/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0417
Epoch 511/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0417
Epoch 512/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0416
Epoch 513/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0416
Epoch 514/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0416
Epoch 515/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0415
Epoch 516/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0415
Epoch 517/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0415
Epoch 518/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0415
Epoch 519/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0414
```

```
Epoch 520/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0414
Epoch 521/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0414
Epoch 522/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0413
Epoch 523/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0413
Epoch 524/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0413
Epoch 525/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0412
Epoch 526/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0412
Epoch 527/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0412
Epoch 528/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0412
Epoch 529/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0411
Epoch 530/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0411
Epoch 531/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0411
Epoch 532/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0410
Epoch 533/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0410
Epoch 534/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0410
Epoch 535/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0409
Epoch 536/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0409
Epoch 537/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0409
Epoch 538/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0409
Epoch 539/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0408
Epoch 540/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0408
Epoch 541/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0408
Epoch 542/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0407
Epoch 543/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0407
```

```
Epoch 544/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0407
Epoch 545/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0406
Epoch 546/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0406
Epoch 547/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0406
Epoch 548/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0406
Epoch 549/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0405
Epoch 550/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0405
Epoch 551/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0405
Epoch 552/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0404
Epoch 553/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0404
Epoch 554/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0404
Epoch 555/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0403
Epoch 556/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0403
Epoch 557/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0403
Epoch 558/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0403
Epoch 559/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0402
Epoch 560/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0402
Epoch 561/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0402
Epoch 562/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0401
Epoch 563/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0401
Epoch 564/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0401
Epoch 565/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0401
Epoch 566/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0400
Epoch 567/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0400
```

```
Epoch 568/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0400
Epoch 569/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0399
Epoch 570/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0399
Epoch 571/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0399
Epoch 572/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0399
Epoch 573/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0398
Epoch 574/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0398
Epoch 575/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0398
Epoch 576/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0397
Epoch 577/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0397
Epoch 578/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0397
Epoch 579/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0396
Epoch 580/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0396
Epoch 581/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0396
Epoch 582/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0396
Epoch 583/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0395
Epoch 584/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0395
Epoch 585/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0395
Epoch 586/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0394
Epoch 587/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0394
Epoch 588/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0394
Epoch 589/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0394
Epoch 590/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0393
Epoch 591/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0393
```

```
Epoch 592/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0393
Epoch 593/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0392
Epoch 594/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0392
Epoch 595/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0392
Epoch 596/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0392
Epoch 597/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0391
Epoch 598/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0391
Epoch 599/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0391
Epoch 600/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0390
Epoch 601/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0390
Epoch 602/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0390
Epoch 603/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0390
Epoch 604/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0389
Epoch 605/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0389
Epoch 606/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0389
Epoch 607/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0388
Epoch 608/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0388
Epoch 609/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0388
Epoch 610/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0388
Epoch 611/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0387
Epoch 612/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0387
Epoch 613/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0387
Epoch 614/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0386
Epoch 615/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0386
```

```
Epoch 616/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0386
Epoch 617/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0386
Epoch 618/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0385
Epoch 619/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0385
Epoch 620/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0385
Epoch 621/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0385
Epoch 622/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0384
Epoch 623/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0384
Epoch 624/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0384
Epoch 625/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0383
Epoch 626/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0383
Epoch 627/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0383
Epoch 628/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0383
Epoch 629/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0382
Epoch 630/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0382
Epoch 631/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0382
Epoch 632/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0381
Epoch 633/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0381
Epoch 634/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0381
Epoch 635/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0381
Epoch 636/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0380
Epoch 637/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0380
Epoch 638/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0380
Epoch 639/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0379
```

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Epoch 640/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0379
Epoch 641/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0379
Epoch 642/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0379
Epoch 643/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0378
Epoch 644/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0378
Epoch 645/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0378
Epoch 646/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0378
Epoch 647/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0377
Epoch 648/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0377
Epoch 649/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0377
Epoch 650/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0376
Epoch 651/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0376
Epoch 652/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0376
Epoch 653/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0376
Epoch 654/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0375
Epoch 655/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0375
Epoch 656/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0375
Epoch 657/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0375
Epoch 658/1000
6/6 [==============================] - 0s 253us/sample - loss: 0.0374
Epoch 659/1000
6/6 [==============================] - 0s 164us/sample - loss: 0.0374
Epoch 660/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0374
Epoch 661/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0373
Epoch 662/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0373
Epoch 663/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0373
```

```
Epoch 664/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0373
Epoch 665/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0372
Epoch 666/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0372
Epoch 667/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0372
Epoch 668/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0372
Epoch 669/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0371
Epoch 670/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0371
Epoch 671/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0371
Epoch 672/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0370
Epoch 673/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0370
Epoch 674/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0370
Epoch 675/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0370
Epoch 676/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0369
Epoch 677/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0369
Epoch 678/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0369
Epoch 679/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0369
Epoch 680/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0368
Epoch 681/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0368
Epoch 682/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0368
Epoch 683/1000
6/6 [==============================] - 0s 333us/sample - loss: 0.0367
Epoch 684/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0367
Epoch 685/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0367
Epoch 686/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0367
Epoch 687/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0366
```

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Epoch 688/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0366
Epoch 689/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0366
Epoch 690/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0366
Epoch 691/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0365
Epoch 692/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0365
Epoch 693/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0365
Epoch 694/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0365
Epoch 695/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0364
Epoch 696/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0364
Epoch 697/1000
6/6 [==============================] - 0s 499us/sample - loss: 0.0364
Epoch 698/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0363
Epoch 699/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0363
Epoch 700/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0363
Epoch 701/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0363
Epoch 702/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0362
Epoch 703/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0362
Epoch 704/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0362
Epoch 705/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0362
Epoch 706/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0361
Epoch 707/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0361
Epoch 708/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0361
Epoch 709/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0361
Epoch 710/1000
6/6 [==============================] - 0s 333us/sample - loss: 0.0360
Epoch 711/1000
6/6 [==============================] - 0s 333us/sample - loss: 0.0360
```

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Epoch 712/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0360
Epoch 713/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0360
Epoch 714/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0359
Epoch 715/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0359
Epoch 716/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0359
Epoch 717/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0358
Epoch 718/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0358
Epoch 719/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0358
Epoch 720/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0358
Epoch 721/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0357
Epoch 722/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0357
Epoch 723/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0357
Epoch 724/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0357
Epoch 725/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0356
Epoch 726/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0356
Epoch 727/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0356
Epoch 728/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0356
Epoch 729/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0355
Epoch 730/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0355
Epoch 731/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0355
Epoch 732/1000
6/6 [==============================] - 0s 499us/sample - loss: 0.0355
Epoch 733/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0354
Epoch 734/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0354
Epoch 735/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0354
```

```
Epoch 736/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0354
Epoch 737/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0353
Epoch 738/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0353
Epoch 739/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0353
Epoch 740/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0353
Epoch 741/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0352
Epoch 742/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0352
Epoch 743/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0352
Epoch 744/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0351
Epoch 745/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0351
Epoch 746/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0351
Epoch 747/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0351
Epoch 748/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0350
Epoch 749/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0350
Epoch 750/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0350
Epoch 751/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0350
Epoch 752/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0349
Epoch 753/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0349
Epoch 754/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0349
Epoch 755/1000
6/6 [==============================] - 0s 333us/sample - loss: 0.0349
Epoch 756/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0348
Epoch 757/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0348
Epoch 758/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0348
Epoch 759/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0348
```

```
Epoch 760/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0347
Epoch 761/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0347
Epoch 762/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0347
Epoch 763/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0347
Epoch 764/1000
6/6 [==============================] - 0s 190us/sample - loss: 0.0346
Epoch 765/1000
6/6 [==============================] - 0s 142us/sample - loss: 0.0346
Epoch 766/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0346
Epoch 767/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0346
Epoch 768/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0345
Epoch 769/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0345
Epoch 770/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0345
Epoch 771/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0345
Epoch 772/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0344
Epoch 773/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0344
Epoch 774/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0344
Epoch 775/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0344
Epoch 776/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0343
Epoch 777/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0343
Epoch 778/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0343
Epoch 779/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0343
Epoch 780/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0342
Epoch 781/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0342
Epoch 782/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0342
Epoch 783/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0342
```

```
Epoch 784/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0341
Epoch 785/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0341
Epoch 786/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0341
Epoch 787/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0341
Epoch 788/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0340
Epoch 789/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0340
Epoch 790/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0340
Epoch 791/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0340
Epoch 792/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0339
Epoch 793/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0339
Epoch 794/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0339
Epoch 795/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0339
Epoch 796/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0338
Epoch 797/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0338
Epoch 798/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0338
Epoch 799/1000
6/6 [==============================] - 0s 101us/sample - loss: 0.0338
Epoch 800/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0337
Epoch 801/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0337
Epoch 802/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0337
Epoch 803/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0337
Epoch 804/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0336
Epoch 805/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0336
Epoch 806/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0336
Epoch 807/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0336
```

```
Epoch 808/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0335
Epoch 809/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0335
Epoch 810/1000
6/6 [==============================] - 0s 184us/sample - loss: 0.0335
Epoch 811/1000
6/6 [==============================] - 0s 148us/sample - loss: 0.0335
Epoch 812/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0334
Epoch 813/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0334
Epoch 814/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0334
Epoch 815/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0334
Epoch 816/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0333
Epoch 817/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0333
Epoch 818/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0333
Epoch 819/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0333
Epoch 820/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0333
Epoch 821/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0332
Epoch 822/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0332
Epoch 823/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0332
Epoch 824/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0332
Epoch 825/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0331
Epoch 826/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0331
Epoch 827/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0331
Epoch 828/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0331
Epoch 829/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0330
Epoch 830/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0330
Epoch 831/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0330
```

```
Epoch 832/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0330
Epoch 833/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0329
Epoch 834/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0329
Epoch 835/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0329
Epoch 836/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0329
Epoch 837/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0328
Epoch 838/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0328
Epoch 839/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0328
Epoch 840/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0328
Epoch 841/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0327
Epoch 842/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0327
Epoch 843/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0327
Epoch 844/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0327
Epoch 845/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0326
Epoch 846/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0326
Epoch 847/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0326
Epoch 848/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0326
Epoch 849/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0326
Epoch 850/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0325
Epoch 851/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0325
Epoch 852/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0325
Epoch 853/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0325
Epoch 854/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0324
Epoch 855/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0324
```

```
Epoch 856/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0324
Epoch 857/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0324
Epoch 858/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0323
Epoch 859/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0323
Epoch 860/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0323
Epoch 861/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0323
Epoch 862/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0322
Epoch 863/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0322
Epoch 864/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0322
Epoch 865/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0322
Epoch 866/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0322
Epoch 867/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0321
Epoch 868/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0321
Epoch 869/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0321
Epoch 870/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0321
Epoch 871/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0320
Epoch 872/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0320
Epoch 873/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0320
Epoch 874/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0320
Epoch 875/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0319
Epoch 876/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0319
Epoch 877/1000
6/6 [==============================] - 0s 332us/sample - loss: 0.0319
Epoch 878/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0319
Epoch 879/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0318
```

```
Epoch 880/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0318
Epoch 881/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0318
Epoch 882/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0318
Epoch 883/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0318
Epoch 884/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0317
Epoch 885/1000
6/6 [==============================] - 0s 164us/sample - loss: 0.0317
Epoch 886/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0317
Epoch 887/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0317
Epoch 888/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0316
Epoch 889/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0316
Epoch 890/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0316
Epoch 891/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0316
Epoch 892/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0315
Epoch 893/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0315
Epoch 894/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0315
Epoch 895/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0315
Epoch 896/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0315
Epoch 897/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0314
Epoch 898/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0314
Epoch 899/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0314
Epoch 900/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0314
Epoch 901/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0313
Epoch 902/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0313
Epoch 903/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0313
```

```
Epoch 904/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0313
Epoch 905/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0313
Epoch 906/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0312
Epoch 907/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0312
Epoch 908/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0312
Epoch 909/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0312
Epoch 910/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0311
Epoch 911/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0311
Epoch 912/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0311
Epoch 913/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0311
Epoch 914/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0310
Epoch 915/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0310
Epoch 916/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0310
Epoch 917/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0310
Epoch 918/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0310
Epoch 919/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0309
Epoch 920/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0309
Epoch 921/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0309
Epoch 922/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0309
Epoch 923/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0308
Epoch 924/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0308
Epoch 925/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0308
Epoch 926/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0308
Epoch 927/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0308
```

```
Epoch 928/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0307
Epoch 929/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0307
Epoch 930/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0307
Epoch 931/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0307
Epoch 932/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0306
Epoch 933/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0306
Epoch 934/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0306
Epoch 935/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0306
Epoch 936/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0306
Epoch 937/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0305
Epoch 938/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0305
Epoch 939/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0305
Epoch 940/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0305
Epoch 941/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0304
Epoch 942/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0304
Epoch 943/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0304
Epoch 944/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0304
Epoch 945/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0304
Epoch 946/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0303
Epoch 947/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0303
Epoch 948/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0303
Epoch 949/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0303
Epoch 950/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0302
Epoch 951/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0302
```

```
Epoch 952/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0302
Epoch 953/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0302
Epoch 954/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0302
Epoch 955/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0301
Epoch 956/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0301
Epoch 957/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0301
Epoch 958/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0301
Epoch 959/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0300
Epoch 960/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0300
Epoch 961/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0300
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6/6 [==============================] - 0s 166us/sample - loss: 0.0300
Epoch 963/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0300
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6/6 [==============================] - 0s 166us/sample - loss: 0.0299
Epoch 965/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0299
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Epoch 967/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0299
Epoch 968/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0298
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6/6 [==============================] - 0s 166us/sample - loss: 0.0297
Epoch 975/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0297
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```
Epoch 976/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0297
Epoch 977/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0297
Epoch 978/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0296
Epoch 979/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0296
Epoch 980/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0296
Epoch 981/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0296
Epoch 982/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0295
Epoch 983/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0295
Epoch 984/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0295
Epoch 985/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0295
Epoch 986/1000
6/6 [==============================] - 0s 0s/sample - loss: 0.0295
Epoch 987/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0294
Epoch 988/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0294
Epoch 989/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0294
Epoch 990/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0294
Epoch 991/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0293
Epoch 992/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0293
Epoch 993/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0293
Epoch 994/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0293
Epoch 995/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0293
Epoch 996/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0292
Epoch 997/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0292
Epoch 998/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0292
Epoch 999/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0292
```

```
Epoch 1000/1000
6/6 [==============================] - 0s 166us/sample - loss: 0.0292
[[2.6471088]]
```

1.0.3 Task 3: Create TensorFlow Pipeline

Let's Create a TensorFlow Pipeline in 5 Simple Steps

Step 1: Create the data First of all, let's use numpy library to generate two random values.

[11]:
```
import numpy as np
x_input = np.random.sample((1,2))
print(x_input)
```

```
[[0.14723435 0.61966029]]
```

Step 2: Create the placeholder Like in the previous example, we create a placeholder with the name X. We need to specify the shape of the tensor explicitly. In case, we will load an array with only two values. We can write the shape as shape=[1,2]

[ ]:
```
# using a placeholder
x = tf.placeholder(tf.float32, shape=[1,2], name = "x")
```

Step 3: Define the dataset method next, we need to define the Dataset where we can populate the value of the placeholder x. We need to use the method tf.data.Dataset.from_tensor_slices

[ ]:
```
dataset = tf.data.Dataset.from_tensor_slices(x)
```

Step 4: Create the pipeline In step four, we need to initialize the pipeline where the data will flow. We need to create an iterator with make_initializable_iterator. We name it iterator. Then we need to call this iterator to feed the next batch of data, get_next. We name this step get_next. Note that in our example, there is only one batch of data with only two values.

[ ]:
```
iterator = dataset.make_initializable_iterator()
get_next = iterator.get_next()
```

Step 5: Execute the operation The last step is similar to the previous example. We initiate a session, and we run the operation iterator. We feed the feed_dict with the value generated by numpy. These two value will populate the placeholder x. Then we run get_next to print the result.

[ ]:
```
with tf.Session() as sess:
    # feeding the placeholder with data
    sess.run(iterator.initializer, feed_dict={ x: x_input })
    print(sess.run(get_next)) # output [ 0.52374458  0.71968478]
```

1.0.4 Task 4: Define, Compile and Train a Neural Network

Let's create the simplest neural network. It has 1 layer, and that layer has 1 neuron, and the input shape to it is just 1 value.

[ ]:
```
model = tf.keras.Sequential([keras.layers.Dense(units=1, input_shape=[1])])
```

Now we compile our Neural Network, so we have to specify 2 functions, a loss and an optimizer.

1. The LOSS function measures the guessed answers against the known correct answers and measures how well or how badly it did.
2. The OPTIMIZER function makes another guess. Based on how the loss function went, it will try to minimize the loss.

It will repeat this for the number of EPOCHS which you will see shortly. But first, here's how we tell it to use 'MEAN SQUARED ERROR' for the loss and 'STOCHASTIC GRADIENT DESCENT' for the optimizer.

[ ]:
```
model.compile(optimizer='sgd', loss='mean_squared_error')
```

Providing the Data Next, we are taking some data : 6 xs and 6 ys. You can see that the relationship between these is that y=4x+1, so where x = -1, y=-3 etc. etc.

We are using **Numpy** library by specifying the values as an np.array[]

[ ]:
```
xs = np.array([-2.0,  -1.0, 0.0, 1.0, 2.0, 3.0], dtype=float)
ys = np.array([-2.0, 0.0, 6.0, 10.0, 14.0, 18.0], dtype=float)
```

Training the Neural Network The neural network learns the relationship between the Xs and Ys in the model.fit call. Making a guess, measuring how good or bad it is (aka the loss), using the optimizer to make another guess etc. It will do it for the number of epochs you specify. You'll see the loss on the right hand side, after running the code.

[ ]:
```
model.fit(xs, ys, epochs=500)
```

You can use the **model.predict** method to have it figure out the Y for a previously unknown X. So, for example, if X = 50 :

[ ]:
```
print(model.predict([50.0]))
```

1.0.5 Task 4: Solve Simple Exercises

Exercise 1 Which library is the framework for defining a neural network as a set of Sequential layers?

1. Numpy
2. Keras
3. Matplotlib

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Answer 1 The correct answer is (2)

Keras is the framework for defining a neural network as a set of Sequential layers. It is a neural network library while TensorFlow is the open-source library for a number of various tasks in machine learning

Exercise 2 Why we specify a LOSS and an OPTIMIZER functions?

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Answer 2 To compile our Neural Network, we have to specify 2 functions, a loss and an optimizer. The LOSS function measures the guessed answers against the known correct answers and measures how well or how badly it did. The OPTIMIZER function makes another guess. Based on how the loss function went, it will try to minimize the loss.

There is not a single loss function that works for all kind of data. For example: Mean Square Error, Mean Absolute Error, Huber Loss, Log-Cosh Loss, Quantile Loss

Exercise 3 What changes in the code below you should perform to increase the number of neurons in this simple Neural Network?

[ ]:
```
model = tf.keras.Sequential([keras.layers.Dense(units=1, input_shape=[1])])
```

1. Increasing the input_shape.
2. Creating another Dense Layer.
3. Increasing the units.

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Answer 3 The correct answer is (3)

Each unit goes for one single neuron in the neural network.

1.1 Bonus: Extra Exercise!

In this tutorial, we'll create a simple neural network classifier in TensorFlow. The key advantage of this model over the Linear Classifier trained in the previous tutorial is that it can separate data

which is NOT linearly separable. We will implement this model for classifying images of handwritten digits from the so-called MNIST data-set.

We assume that you have the basic knowledge over the concept and you are just interested in the Tensorflow implementation of the Neural Nets.

The structure of the neural network that we're going to implement is as follows. We're using images of handw-ritten digits of the MNIST data which has 10 classes (i.e. digits from 0 to 9). The implemented network has 2 hidden layers: the first one with 200 hidden units (neurons) and the second one (also known as classifier layer) with 10 (number of classes) neurons.

[ ]:
```
# imports
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt

img_h = img_w = 28              # MNIST images are 28x28
img_size_flat = img_h * img_w  # 28x28=784, the total number of pixels
n_classes = 10                  # Number of classes, one class per digit

def load_data(mode='train'):
    """
    Function to (download and) load the MNIST data
    :param mode: train or test
    :return: images and the corresponding labels
    """
    from tensorflow.examples.tutorials.mnist import input_data
    mnist = input_data.read_data_sets("MNIST_data/", one_hot=True)
    if mode == 'train':
        x_train, y_train, x_valid, y_valid = mnist.train.images, mnist.train.
 ↪labels, \
                                             mnist.validation.images, mnist.
 ↪validation.labels
        return x_train, y_train, x_valid, y_valid
    elif mode == 'test':
        x_test, y_test = mnist.test.images, mnist.test.labels
    return x_test, y_test

def randomize(x, y):
    """ Randomizes the order of data samples and their corresponding labels"""
    permutation = np.random.permutation(y.shape[0])
    shuffled_x = x[permutation, :]
    shuffled_y = y[permutation]
    return shuffled_x, shuffled_y

def get_next_batch(x, y, start, end):
```

```
    x_batch = x[start:end]
    y_batch = y[start:end]
    return x_batch, y_batch
```

[ ]:
```
# Load MNIST data
x_train, y_train, x_valid, y_valid = load_data(mode='train')
print("Size of:")
print("- Training-set:\t\t{}".format(len(y_train)))
print("- Validation-set:\t{}".format(len(y_valid)))
```

[ ]:
```
# To get a better sense of the data, let's checkout the shapes of the loaded␣
 ↪arrays.
print('x_train:\t{}'.format(x_train.shape))
print('y_train:\t{}'.format(y_train.shape))
print('x_train:\t{}'.format(x_valid.shape))
print('y_valid:\t{}'.format(y_valid.shape))
```

[ ]:
```
y_valid[:5, :]
```

[ ]:
```
# Hyper-parameters
epochs = 10              # Total number of training epochs
batch_size = 100         # Training batch size
display_freq = 100       # Frequency of displaying the training results
learning_rate = 0.001    # The optimization initial learning rate

h1 = 200                 # number of nodes in the 1st hidden layer
```

[ ]:
```
# weight and bais wrappers
def weight_variable(name, shape):
    """
    Create a weight variable with appropriate initialization
    :param name: weight name
    :param shape: weight shape
    :return: initialized weight variable
    """
    initer = tf.truncated_normal_initializer(stddev=0.01)
    return tf.get_variable('W_' + name,
                           dtype=tf.float32,
                           shape=shape,
                           initializer=initer)

def bias_variable(name, shape):
    """
    Create a bias variable with appropriate initialization
    :param name: bias variable name
    :param shape: bias variable shape
    :return: initialized bias variable
    """
```

```
    initial = tf.constant(0., shape=shape, dtype=tf.float32)
    return tf.get_variable('b_' + name,
                           dtype=tf.float32,
                           initializer=initial)
```

[ ]:
```
def fc_layer(x, num_units, name, use_relu=True):
    """
    Create a fully-connected layer
    :param x: input from previous layer
    :param num_units: number of hidden units in the fully-connected layer
    :param name: layer name
    :param use_relu: boolean to add ReLU non-linearity (or not)
    :return: The output array
    """
    in_dim = x.get_shape()[1]
    W = weight_variable(name, shape=[in_dim, num_units])
    b = bias_variable(name, [num_units])
    layer = tf.matmul(x, W)
    layer += b
    if use_relu:
        layer = tf.nn.relu(layer)
    return layer
```

[ ]:
```
# Create the graph for the linear model
# Placeholders for inputs (x) and outputs(y)
x = tf.placeholder(tf.float32, shape=[None, img_size_flat], name='X')
y = tf.placeholder(tf.float32, shape=[None, n_classes], name='Y')
```

[ ]:
```
# Create a fully-connected layer with h1 nodes as hidden layer
fc1 = fc_layer(x, h1, 'FC1', use_relu=True)
# Create a fully-connected layer with n_classes nodes as output layer
output_logits = fc_layer(fc1, n_classes, 'OUT', use_relu=False)
```

[ ]:
```
# Define the loss function, optimizer, and accuracy
loss = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(labels=y,␣
 ↪logits=output_logits), name='loss')
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate, name='Adam-op').
 ↪minimize(loss)
correct_prediction = tf.equal(tf.argmax(output_logits, 1), tf.argmax(y, 1),␣
 ↪name='correct_pred')
accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32),␣
 ↪name='accuracy')

# Network predictions
cls_prediction = tf.argmax(output_logits, axis=1, name='predictions')
```

[ ]:
```
# Create the op for initializing all variables
init = tf.global_variables_initializer()
```

[ ]:
```
# Create an interactive session (to keep the session in the other cells)
sess = tf.InteractiveSession()
# Initialize all variables
sess.run(init)
# Number of training iterations in each epoch
num_tr_iter = int(len(y_train) / batch_size)
for epoch in range(epochs):
    print('Training epoch: {}'.format(epoch + 1))
    # Randomly shuffle the training data at the beginning of each epoch
    x_train, y_train = randomize(x_train, y_train)
    for iteration in range(num_tr_iter):
        start = iteration * batch_size
        end = (iteration + 1) * batch_size
        x_batch, y_batch = get_next_batch(x_train, y_train, start, end)

        # Run optimization op (backprop)
        feed_dict_batch = {x: x_batch, y: y_batch}
        sess.run(optimizer, feed_dict=feed_dict_batch)

        if iteration % display_freq == 0:
            # Calculate and display the batch loss and accuracy
            loss_batch, acc_batch = sess.run([loss, accuracy],
                                             feed_dict=feed_dict_batch)

            print("iter {0:3d}:\t Loss={1:.2f},\tTraining Accuracy={2:.01%}".
                  format(iteration, loss_batch, acc_batch))

    # Run validation after every epoch
    feed_dict_valid = {x: x_valid[:1000], y: y_valid[:1000]}
    loss_valid, acc_valid = sess.run([loss, accuracy],␣
↪feed_dict=feed_dict_valid)
    print('---------------------------------------------------------')
    print("Epoch: {0}, validation loss: {1:.2f}, validation accuracy: {2:.01%}".
          format(epoch + 1, loss_valid, acc_valid))
    print('---------------------------------------------------------')
```

[ ]:
```
# Test the network after training
# Accuracy
x_test, y_test = load_data(mode='test')
feed_dict_test = {x: x_test[:1000], y: y_test[:1000]}
loss_test, acc_test = sess.run([loss, accuracy], feed_dict=feed_dict_test)
print('---------------------------------------------------------')
print("Test loss: {0:.2f}, test accuracy: {1:.01%}".format(loss_test, acc_test))
print('---------------------------------------------------------')
```

[ ]:
```
def plot_images(images, cls_true, cls_pred=None, title=None):
    """
    Create figure with 3x3 sub-plots.
```

```
    :param images: array of images to be plotted, (9, img_h*img_w)
    :param cls_true: corresponding true labels (9,)
    :param cls_pred: corresponding true labels (9,)
    """
    fig, axes = plt.subplots(3, 3, figsize=(9, 9))
    fig.subplots_adjust(hspace=0.3, wspace=0.3)
    for i, ax in enumerate(axes.flat):
        # Plot image.
        ax.imshow(images[i].reshape(28, 28), cmap='binary')

        # Show true and predicted classes.
        if cls_pred is None:
            ax_title = "True: {0}".format(cls_true[i])
        else:
            ax_title = "True: {0}, Pred: {1}".format(cls_true[i], cls_pred[i])

        ax.set_title(ax_title)

        # Remove ticks from the plot.
        ax.set_xticks([])
        ax.set_yticks([])

    if title:
        plt.suptitle(title, size=20)
    plt.show(block=False)

def plot_example_errors(images, cls_true, cls_pred, title=None):
    """
    Function for plotting examples of images that have been mis-classified
    :param images: array of all images, (#imgs, img_h*img_w)
    :param cls_true: corresponding true labels, (#imgs,)
    :param cls_pred: corresponding predicted labels, (#imgs,)
    """
    # Negate the boolean array.
    incorrect = np.logical_not(np.equal(cls_pred, cls_true))

    # Get the images from the test-set that have been
    # incorrectly classified.
    incorrect_images = images[incorrect]

    # Get the true and predicted classes for those images.
    cls_pred = cls_pred[incorrect]
    cls_true = cls_true[incorrect]

    # Plot the first 9 images.
    plot_images(images=incorrect_images[0:9],
                cls_true=cls_true[0:9],
```

```
                cls_pred=cls_pred[0:9],
                title=title)
```

[ ]:
```
# Plot some of the correct and misclassified examples
cls_pred = sess.run(cls_prediction, feed_dict=feed_dict_test)
cls_true = np.argmax(y_test[:1000], axis=1)
plot_images(x_test, cls_true, cls_pred, title='Correct Examples')
plot_example_errors(x_test[:1000], cls_true, cls_pred, title='Misclassified␣
 ↪Examples')
plt.show()
```

1.2 Congratulations!

Back To Tasks Page.