The Hello World of Deep Learning with Neural Networks

Like every first app you should start with something super simple that shows the overall scaffolding for how your code works.

In the case of creating neural networks, the sample I like to use is one where it learns the relationship between two numbers. So, for example, if you were writing code for a function like this, you already know the 'rules' —

```
float hw_function(float x){
    float y = (2 * x) - 1;
    return y;
}
```

So how would you train a neural network to do the equivalent task? Using data! By feeding it with a set of Xs, and a set of Ys, it should be able to figure out the relationship between them.

This is obviously a very different paradigm than what you might be used to, so let's step through it piece by piece.

Imports

Let's start with our imports. Here we are importing TensorFlow and calling it tf for ease of use.

We then import a library called numpy, which helps us to represent our data as lists easily and quickly.

The framework for defining a neural network as a set of Sequential layers is called keras, so we import that too.

```
import tensorflow as tf
import numpy as np
from tensorflow import keras
```

Define and Compile the Neural Network

Next we will create the simplest possible 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])])
#Dense is to create a layer of neurons
#1 unit -> 1 neuron
#shape of our input is 1, the input shape attribute is specified only for the first layer (cu
```

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

If you've seen lots of math for machine learning, here's where it's usually used, but in this case it's nicely encapsulated in functions for you. But what happens here — let's explain...

We know that in our function, the relationship between the numbers is y=2x-1.

When the computer is trying to 'learn' that, it makes a guess...maybe y=10x+10. The LOSS function measures the guessed answers against the known correct answers and measures how well or how badly it did.

It then uses the OPTIMIZER function to make another guess. Based on how the loss function went, it will try to minimize the loss. At that point maybe it will come up with somehting like y=5x+5, which, while still pretty bad, is closer to the correct result (i.e. the loss is lower)

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. You don't need to understand the math for these yet, but you can see that they work! :)

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d appropriate loss and optimizer functions for different

```
model.compile(optimizer='sgd', loss='mean_squared_error')
#use stochastic gradient descent - which is at times bad. (Remember from deep learning course
#mean_squared_error for loss function.
```

Providing the Data

Next up we'll feed in some data. In this case we are taking 6 xs and 6ys. You can see that the relationship between these is that y=2x-1, so where x = -1, y=-3 etc. etc.

A python library called 'Numpy' provides lots of array type data structures that are a defacto standard way of doing it. We declare that we want to use these by specifying the values as an np.array[]

```
xs = np.array([-1.0,  0.0, 1.0, 2.0, 3.0, 4.0], dtype=float)
ys = np.array([-3.0, -1.0, 1.0, 3.0, 5.0, 7.0], dtype=float)
```

Training the Neural Network

The process of training the neural network, where it 'learns' the relationship between the Xs and Ys is in the **model.fit** call. This is where it will go through the loop we spoke about above, making a guess, measuring how good or bad it is (aka the loss), using the opimizer to make another guess etc. It will do it for the number of epochs you specify. When you run this code, you'll see the loss on the right hand side.

```
model.fit(xs, ys, epochs=500)
#xs are our inputs, ys are our outputs, that we feed into our model to train itself.
#for each epoch (each iteration)
#model guesses a mapping between x and y (10x + 10)
#error of the guess is computed compared to the actual mapping between that particular x and
#the model then guesses again, another mapping (5x + 5)
#this process iterates for 500 times
```

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```
Epoch 1/500
1/1 [==============================] - 0s 2ms/step - loss: 13.8945
Epoch 2/500
1/1 [==============================] - 0s 2ms/step - loss: 11.1656
Epoch 3/500
1/1 [==============================] - 0s 1ms/step - loss: 9.0138
Epoch 4/500
1/1 [==============================] - 0s 2ms/step - loss: 7.3161
Epoch 5/500
1/1 [==============================] - 0s 3ms/step - loss: 5.9759
Epoch 6/500
1/1 [==============================] - 0s 2ms/step - loss: 4.9170
Epoch 7/500
1/1 [==============================] - 0s 5ms/step - loss: 4.0794
Epoch 8/500
1/1 [==============================] - 0s 1ms/step - loss: 3.4161
Epoch 9/500
1/1 [==============================] - 0s 4ms/step - loss: 2.8900
Epoch 10/500
1/1 [==============================] - 0s 3ms/step - loss: 2.4720
Epoch 11/500
1/1 [==============================] - 0s 1ms/step - loss: 2.1390
Epoch 12/500
1/1 [==============================] - 0s 3ms/step - loss: 1.8730
Epoch 13/500
1/1 [==============================] - 0s 2ms/step - loss: 1.6599
Epoch 14/500
1/1 [==============================] - 0s 3ms/step - loss: 1.4884
Epoch 15/500
1/1 [==============================] - 0s 3ms/step - loss: 1.3497
Epoch 16/500
1/1 [==============================] - 0s 2ms/step - loss: 1.2369
Epoch 17/500
1/1 [==============================] - 0s 3ms/step - loss: 1.1446
Epoch 18/500
1/1 [==============================] - 0s 3ms/step - loss: 1.0684
Epoch 19/500
1/1 [==============================] - 0s 3ms/step - loss: 1.0050
Epoch 20/500
1/1 [==============================] - 0s 2ms/step - loss: 0.9518
Epoch 21/500
1/1 [==============================] - 0s 2ms/step - loss: 0.9066
Epoch 22/500
1/1 [==============================] - 0s 2ms/step - loss: 0.8678
Epoch 23/500
1/1 [==============================] - 0s 2ms/step - loss: 0.8341
Epoch 24/500
1/1 [==============================] - 0s 2ms/step - loss: 0.8045
Epoch 25/500
1/1 [==============================] - 0s 2ms/step - loss: 0.7781
Epoch 26/500
1/1 [==============================] - 0s 3ms/step - loss: 0.7544
Epoch 27/500
1/1 [==============================] - 0s 2ms/step - loss: 0.7329
Epoch 28/500
1/1 [==============================] - 0s 3ms/step - loss: 0.7130
Epoch 29/500
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1/1 [==============================] - 0s 2ms/step - loss: 0.6946
Epoch 30/500
1/1 [==============================] - 0s 2ms/step - loss: 0.6774
Epoch 31/500
1/1 [==============================] - 0s 3ms/step - loss: 0.6611
Epoch 32/500
1/1 [==============================] - 0s 2ms/step - loss: 0.6457
Epoch 33/500
1/1 [==============================] - 0s 2ms/step - loss: 0.6310
Epoch 34/500
1/1 [==============================] - 0s 9ms/step - loss: 0.6169
Epoch 35/500
1/1 [==============================] - 0s 3ms/step - loss: 0.6034
Epoch 36/500
1/1 [==============================] - 0s 2ms/step - loss: 0.5903
Epoch 37/500
1/1 [==============================] - 0s 2ms/step - loss: 0.5776
Epoch 38/500
1/1 [==============================] - 0s 2ms/step - loss: 0.5653
Epoch 39/500
1/1 [==============================] - 0s 2ms/step - loss: 0.5533
Epoch 40/500
1/1 [==============================] - 0s 3ms/step - loss: 0.5417
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Epoch 42/500
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Epoch 43/500
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Epoch 44/500
1/1 [==============================] - 0s 2ms/step - loss: 0.4980
Epoch 45/500
1/1 [==============================] - 0s 2ms/step - loss: 0.4876
Epoch 46/500
1/1 [==============================] - 0s 3ms/step - loss: 0.4776
Epoch 47/500
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                                    ] - 0s 2ms/step - loss: 0.4581
Epoch 49/500
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Epoch 50/500
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Epoch 51/500
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Epoch 52/500
1/1 [==============================] - 0s 2ms/step - loss: 0.4215
Epoch 53/500
1/1 [==============================] - 0s 3ms/step - loss: 0.4128
Epoch 54/500
1/1 [==============================] - 0s 3ms/step - loss: 0.4043
Epoch 55/500
1/1 [==============================] - 0s 3ms/step - loss: 0.3960
Epoch 56/500
1/1 [==============================] - 0s 2ms/step - loss: 0.3879
Epoch 57/500
1/1 [==============================] - 0s 2ms/step - loss: 0.3799
Epoch 58/500
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1/1 [==============================] - 0s 2ms/step - loss: 0.3721
Epoch 59/500
1/1 [==============================] - 0s 2ms/step - loss: 0.3644
Epoch 60/500
1/1 [==============================] - 0s 2ms/step - loss: 0.3570
Epoch 61/500
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Epoch 62/500
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Epoch 63/500
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Epoch 64/500
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Epoch 68/500
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Epoch 85/500
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Epoch 86/500
1/1 [==============================] - 0s 1ms/step - loss: 0.2081
Epoch 87/500
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Epoch 87/500
1/1 [==============================] - 0s 1ms/step - loss: 0.2038
Epoch 88/500
1/1 [==============================] - 0s 2ms/step - loss: 0.1996
Epoch 89/500
1/1 [==============================] - 0s 1ms/step - loss: 0.1955
Epoch 90/500
1/1 [==============================] - 0s 1ms/step - loss: 0.1915
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Epoch 92/500
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Epoch 93/500
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Epoch 94/500
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Epoch 95/500
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Epoch 104/500
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Epoch 115/500
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Epoch 116/500
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Epoch 133/500
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1/1 [==============================] - 0s 1ms/step - loss: 0.0421
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Epoch 169/500
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Epoch 173/500
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Epoch 229/500
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Epoch 230/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0105
Epoch 231/500
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1/1 [==============================] - 0s 1ms/step - loss: 0.0103
Epoch 232/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0101
Epoch 233/500
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Epoch 234/500
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Epoch 238/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0089
Epoch 239/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0087
Epoch 240/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0085
Epoch 241/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0083
Epoch 242/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0082
Epoch 243/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0080
Epoch 244/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0078
Epoch 245/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0077
Epoch 246/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0075
Epoch 247/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0074
Epoch 248/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0072
Epoch 249/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0071
Epoch 250/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0069
Epoch 251/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0068
Epoch 252/500
1/1 [==============================] - 0s 3ms/step - loss: 0.0066
Epoch 253/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0065
Epoch 254/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0064
Epoch 255/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0062
Epoch 256/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0061
Epoch 257/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0060
Epoch 258/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0059
Epoch 259/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0057
Epoch 260/500
```

```
Epoch 260/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0056
Epoch 261/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0055
Epoch 262/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0054
Epoch 263/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0053
Epoch 264/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0052
Epoch 265/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0051
Epoch 266/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0050
Epoch 267/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0049
Epoch 268/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0048
Epoch 269/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0047
Epoch 270/500
1/1 [==============================] - 0s 8ms/step - loss: 0.0046
Epoch 271/500
1/1 [==============================] - 0s 3ms/step - loss: 0.0045
Epoch 272/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0044
Epoch 273/500
1/1 [==============================] - 0s 3ms/step - loss: 0.0043
Epoch 274/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0042
Epoch 275/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0041
Epoch 276/500
1/1 [==============================] - 0s 3ms/step - loss: 0.0040
Epoch 277/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0040
```

Saved successfully!

```
==============] - 0s 1ms/step - loss: 0.0039
1/1 [==============================] - 0s 2ms/step - loss: 0.0038
Epoch 280/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0037
Epoch 281/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0036
Epoch 282/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0036
Epoch 283/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0035
Epoch 284/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0034
Epoch 285/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0033
Epoch 286/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0033
Epoch 287/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0032
Epoch 288/500
1/1 [==============================] - 0s 3ms/step - loss: 0.0031
```

```
Epoch 289/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0031
Epoch 290/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0030
Epoch 291/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0030
Epoch 292/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0029
Epoch 293/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0028
Epoch 294/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0028
Epoch 295/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0027
Epoch 296/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0027
Epoch 297/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0026
Epoch 298/500
1/1 [==============================] - 0s 3ms/step - loss: 0.0026
Epoch 299/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0025
Epoch 300/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0025
Epoch 301/500
1/1 [==============================] - 0s 9ms/step - loss: 0.0024
Epoch 302/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0024
Epoch 303/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0023
Epoch 304/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0023
Epoch 305/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0022
Epoch 306/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0022
```

Saved successfully!

```
1/1 [==============================] - 0s 1ms/step - loss: 0.0021
Epoch 309/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0020
Epoch 310/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0020
Epoch 311/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0020
Epoch 312/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0019
Epoch 313/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0019
Epoch 314/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0018
Epoch 315/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0018
Epoch 316/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0018
Epoch 317/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0017
```

```
Epoch 318/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0017
Epoch 319/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0017
Epoch 320/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0016
Epoch 321/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0016
Epoch 322/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0016
Epoch 323/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0015
Epoch 324/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0015
Epoch 325/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0015
Epoch 326/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0014
Epoch 327/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0014
Epoch 328/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0014
Epoch 329/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0013
Epoch 330/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0013
Epoch 331/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0013
Epoch 332/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0013
Epoch 333/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0012
Epoch 334/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0012
Epoch 335/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0012
Epoch 336/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0012
Epoch 337/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0011
Epoch 338/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0011
Epoch 339/500
1/1 [==============================] - 0s 1ms/step - loss: 0.0011
Epoch 340/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0011
Epoch 341/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0010
Epoch 342/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0010
Epoch 343/500
1/1 [==============================] - 0s 2ms/step - loss: 0.0010
Epoch 344/500
1/1 [==============================] - 0s 1ms/step - loss: 9.8345e-04
Epoch 345/500
1/1 [==============================] - 0s 1ms/step - loss: 9.6324e-04
Epoch 346/500
```

Saved successfully!

```
1/1 [==============================] - 0s 1ms/step - loss: 9.4346e-04
Epoch 347/500
1/1 [==============================] - 0s 2ms/step - loss: 9.2408e-04
Epoch 348/500
1/1 [==============================] - 0s 2ms/step - loss: 9.0510e-04
Epoch 349/500
1/1 [==============================] - 0s 1ms/step - loss: 8.8650e-04
Epoch 350/500
1/1 [==============================] - 0s 1ms/step - loss: 8.6830e-04
Epoch 351/500
1/1 [==============================] - 0s 2ms/step - loss: 8.5046e-04
Epoch 352/500
1/1 [==============================] - 0s 1ms/step - loss: 8.3299e-04
Epoch 353/500
1/1 [==============================] - 0s 2ms/step - loss: 8.1588e-04
Epoch 354/500
1/1 [==============================] - 0s 2ms/step - loss: 7.9912e-04
Epoch 355/500
1/1 [==============================] - 0s 2ms/step - loss: 7.8271e-04
Epoch 356/500
1/1 [==============================] - 0s 2ms/step - loss: 7.6663e-04
Epoch 357/500
1/1 [==============================] - 0s 2ms/step - loss: 7.5088e-04
Epoch 358/500
1/1 [==============================] - 0s 2ms/step - loss: 7.3546e-04
Epoch 359/500
1/1 [==============================] - 0s 2ms/step - loss: 7.2035e-04
Epoch 360/500
1/1 [==============================] - 0s 2ms/step - loss: 7.0555e-04
Epoch 361/500
1/1 [==============================] - 0s 2ms/step - loss: 6.9107e-04
Epoch 362/500
1/1 [==============================] - 0s 1ms/step - loss: 6.7687e-04
Epoch 363/500
1/1 [==============================] - 0s 1ms/step - loss: 6.6297e-04
Epoch 364/500
1/1 [==============================] - 0s 1ms/step - loss: 6.4935e-04
Epoch 365/500
1/1 [==============================] - 0s 5ms/step - loss: 6.3601e-04
Epoch 366/500
1/1 [==============================] - 0s 2ms/step - loss: 6.2295e-04
Epoch 367/500
1/1 [==============================] - 0s 2ms/step - loss: 6.1015e-04
Epoch 368/500
1/1 [==============================] - 0s 2ms/step - loss: 5.9762e-04
Epoch 369/500
1/1 [==============================] - 0s 2ms/step - loss: 5.8534e-04
Epoch 370/500
1/1 [==============================] - 0s 2ms/step - loss: 5.7332e-04
Epoch 371/500
1/1 [==============================] - 0s 2ms/step - loss: 5.6154e-04
Epoch 372/500
1/1 [==============================] - 0s 1ms/step - loss: 5.5001e-04
Epoch 373/500
1/1 [==============================] - 0s 1ms/step - loss: 5.3871e-04
Epoch 374/500
1/1 [==============================] - 0s 2ms/step - loss: 5.2764e-04
Epoch 375/500
```

Saved successfully!

```
1/1 [==============================] - 0s 1ms/step - loss: 5.1680e-04
Epoch 376/500
1/1 [==============================] - 0s 2ms/step - loss: 5.0619e-04
Epoch 377/500
1/1 [==============================] - 0s 1ms/step - loss: 4.9579e-04
Epoch 378/500
1/1 [==============================] - 0s 2ms/step - loss: 4.8561e-04
Epoch 379/500
1/1 [==============================] - 0s 2ms/step - loss: 4.7563e-04
Epoch 380/500
1/1 [==============================] - 0s 2ms/step - loss: 4.6586e-04
Epoch 381/500
1/1 [==============================] - 0s 1ms/step - loss: 4.5629e-04
Epoch 382/500
1/1 [==============================] - 0s 1ms/step - loss: 4.4692e-04
Epoch 383/500
1/1 [==============================] - 0s 1ms/step - loss: 4.3774e-04
Epoch 384/500
1/1 [==============================] - 0s 2ms/step - loss: 4.2875e-04
Epoch 385/500
1/1 [==============================] - 0s 2ms/step - loss: 4.1995e-04
Epoch 386/500
1/1 [==============================] - 0s 2ms/step - loss: 4.1132e-04
Epoch 387/500
1/1 [==============================] - 0s 2ms/step - loss: 4.0287e-04
Epoch 388/500
1/1 [==============================] - 0s 2ms/step - loss: 3.9459e-04
Epoch 389/500
1/1 [==============================] - 0s 2ms/step - loss: 3.8649e-04
Epoch 390/500
1/1 [==============================] - 0s 3ms/step - loss: 3.7855e-04
Epoch 391/500
1/1 [==============================] - 0s 2ms/step - loss: 3.7078e-04
Epoch 392/500
1/1 [==============================] - 0s 2ms/step - loss: 3.6316e-04
Epoch 393/500
1/1 [==============================] - 0s 2ms/step - loss: 3.5570e-04
1/1 [==============================] - 0s 1ms/step - loss: 3.4839e-04
Epoch 395/500
1/1 [==============================] - 0s 2ms/step - loss: 3.4124e-04
Epoch 396/500
1/1 [==============================] - 0s 2ms/step - loss: 3.3423e-04
Epoch 397/500
1/1 [==============================] - 0s 2ms/step - loss: 3.2736e-04
Epoch 398/500
1/1 [==============================] - 0s 2ms/step - loss: 3.2064e-04
Epoch 399/500
1/1 [==============================] - 0s 1ms/step - loss: 3.1405e-04
Epoch 400/500
1/1 [==============================] - 0s 1ms/step - loss: 3.0760e-04
Epoch 401/500
1/1 [==============================] - 0s 2ms/step - loss: 3.0128e-04
Epoch 402/500
1/1 [==============================] - 0s 2ms/step - loss: 2.9510e-04
Epoch 403/500
1/1 [==============================] - 0s 2ms/step - loss: 2.8903e-04
Epoch 404/500
```

Saved successfully!

```
1/1 [==============================] - 0s 2ms/step - loss: 2.8310e-04
Epoch 405/500
1/1 [==============================] - 0s 2ms/step - loss: 2.7728e-04
Epoch 406/500
1/1 [==============================] - 0s 2ms/step - loss: 2.7159e-04
Epoch 407/500
1/1 [==============================] - 0s 2ms/step - loss: 2.6601e-04
Epoch 408/500
1/1 [==============================] - 0s 1ms/step - loss: 2.6055e-04
Epoch 409/500
1/1 [==============================] - 0s 2ms/step - loss: 2.5519e-04
Epoch 410/500
1/1 [==============================] - 0s 3ms/step - loss: 2.4995e-04
Epoch 411/500
1/1 [==============================] - 0s 2ms/step - loss: 2.4482e-04
Epoch 412/500
1/1 [==============================] - 0s 2ms/step - loss: 2.3979e-04
Epoch 413/500
1/1 [==============================] - 0s 2ms/step - loss: 2.3486e-04
Epoch 414/500
1/1 [==============================] - 0s 2ms/step - loss: 2.3004e-04
Epoch 415/500
1/1 [==============================] - 0s 1ms/step - loss: 2.2532e-04
Epoch 416/500
1/1 [==============================] - 0s 2ms/step - loss: 2.2069e-04
Epoch 417/500
1/1 [==============================] - 0s 2ms/step - loss: 2.1615e-04
Epoch 418/500
1/1 [==============================] - 0s 2ms/step - loss: 2.1171e-04
Epoch 419/500
1/1 [==============================] - 0s 2ms/step - loss: 2.0737e-04
Epoch 420/500
1/1 [==============================] - 0s 3ms/step - loss: 2.0311e-04
Epoch 421/500
1/1 [==============================] - 0s 2ms/step - loss: 1.9894e-04
```

Saved successfully!

```
1/1 [==============================] - 0s 2ms/step - loss: 1.9485e-04
1/1 [==============================] - 0s 2ms/step - loss: 1.9085e-04
Epoch 424/500
1/1 [==============================] - 0s 2ms/step - loss: 1.8693e-04
Epoch 425/500
1/1 [==============================] - 0s 2ms/step - loss: 1.8309e-04
Epoch 426/500
1/1 [==============================] - 0s 2ms/step - loss: 1.7933e-04
Epoch 427/500
1/1 [==============================] - 0s 1ms/step - loss: 1.7564e-04
Epoch 428/500
1/1 [==============================] - 0s 2ms/step - loss: 1.7203e-04
Epoch 429/500
1/1 [==============================] - 0s 2ms/step - loss: 1.6850e-04
Epoch 430/500
1/1 [==============================] - 0s 2ms/step - loss: 1.6504e-04
Epoch 431/500
1/1 [==============================] - 0s 2ms/step - loss: 1.6165e-04
Epoch 432/500
1/1 [==============================] - 0s 2ms/step - loss: 1.5833e-04
```

```
Epoch 433/500
1/1 [==============================] - 0s 2ms/step - loss: 1.5508e-04
Epoch 434/500
1/1 [==============================] - 0s 2ms/step - loss: 1.5189e-04
Epoch 435/500
1/1 [==============================] - 0s 1ms/step - loss: 1.4877e-04
Epoch 436/500
1/1 [==============================] - 0s 2ms/step - loss: 1.4572e-04
Epoch 437/500
1/1 [==============================] - 0s 2ms/step - loss: 1.4272e-04
Epoch 438/500
1/1 [==============================] - 0s 2ms/step - loss: 1.3979e-04
Epoch 439/500
1/1 [==============================] - 0s 2ms/step - loss: 1.3692e-04
Epoch 440/500
1/1 [==============================] - 0s 2ms/step - loss: 1.3411e-04
Epoch 441/500
1/1 [==============================] - 0s 2ms/step - loss: 1.3135e-04
Epoch 442/500
1/1 [==============================] - 0s 2ms/step - loss: 1.2865e-04
Epoch 443/500
1/1 [==============================] - 0s 2ms/step - loss: 1.2601e-04
Epoch 444/500
1/1 [==============================] - 0s 2ms/step - loss: 1.2342e-04
Epoch 445/500
1/1 [==============================] - 0s 2ms/step - loss: 1.2089e-04
Epoch 446/500
1/1 [==============================] - 0s 2ms/step - loss: 1.1840e-04
Epoch 447/500
1/1 [==============================] - 0s 2ms/step - loss: 1.1597e-04
Epoch 448/500
1/1 [==============================] - 0s 2ms/step - loss: 1.1359e-04
Epoch 449/500
1/1 [==============================] - 0s 2ms/step - loss: 1.1126e-04
Epoch 450/500
1/1 [==============================] - 0s 3ms/step - loss: 1.0897e-04
Saved successfully!
                                      ====] - 0s 2ms/step - loss: 1.0673e-04
1/1 [==============================] - 0s 2ms/step - loss: 1.0454e-04
Epoch 453/500
1/1 [==============================] - 0s 1ms/step - loss: 1.0239e-04
Epoch 454/500
1/1 [==============================] - 0s 1ms/step - loss: 1.0029e-04
Epoch 455/500
1/1 [==============================] - 0s 1ms/step - loss: 9.8229e-05
Epoch 456/500
1/1 [==============================] - 0s 1ms/step - loss: 9.6211e-05
Epoch 457/500
1/1 [==============================] - 0s 2ms/step - loss: 9.4235e-05
Epoch 458/500
1/1 [==============================] - 0s 1ms/step - loss: 9.2300e-05
Epoch 459/500
1/1 [==============================] - 0s 1ms/step - loss: 9.0404e-05
Epoch 460/500
1/1 [==============================] - 0s 1ms/step - loss: 8.8548e-05
Epoch 461/500
1/1 [==============================] - 0s 3ms/step - loss: 8.6729e-05
```

```
Epoch 462/500
1/1 [==============================] - 0s 1ms/step - loss: 8.4948e-05
Epoch 463/500
1/1 [==============================] - 0s 2ms/step - loss: 8.3201e-05
Epoch 464/500
1/1 [==============================] - 0s 1ms/step - loss: 8.1492e-05
Epoch 465/500
1/1 [==============================] - 0s 2ms/step - loss: 7.9820e-05
Epoch 466/500
1/1 [==============================] - 0s 1ms/step - loss: 7.8180e-05
Epoch 467/500
1/1 [==============================] - 0s 1ms/step - loss: 7.6573e-05
Epoch 468/500
1/1 [==============================] - 0s 1ms/step - loss: 7.5000e-05
Epoch 469/500
1/1 [==============================] - 0s 1ms/step - loss: 7.3459e-05
Epoch 470/500
1/1 [==============================] - 0s 1ms/step - loss: 7.1951e-05
Epoch 471/500
1/1 [==============================] - 0s 1ms/step - loss: 7.0474e-05
Epoch 472/500
1/1 [==============================] - 0s 1ms/step - loss: 6.9026e-05
Epoch 473/500
1/1 [==============================] - 0s 1ms/step - loss: 6.7608e-05
Epoch 474/500
1/1 [==============================] - 0s 2ms/step - loss: 6.6220e-05
Epoch 475/500
1/1 [==============================] - 0s 1ms/step - loss: 6.4860e-05
Epoch 476/500
1/1 [==============================] - 0s 1ms/step - loss: 6.3527e-05
Epoch 477/500
1/1 [==============================] - 0s 2ms/step - loss: 6.2222e-05
Epoch 478/500
1/1 [==============================] - 0s 2ms/step - loss: 6.0944e-05
Epoch 479/500
1/1 [==============================] - 0s 1ms/step - loss: 5.9691e-05
```

Saved successfully!

```
1/1 [==============================] - 0s 2ms/step - loss: 5.8465e-05
Epoch 481/500
1/1 [==============================] - 0s 1ms/step - loss: 5.7265e-05
Epoch 482/500
1/1 [==============================] - 0s 2ms/step - loss: 5.6089e-05
Epoch 483/500
1/1 [==============================] - 0s 2ms/step - loss: 5.4936e-05
Epoch 484/500
1/1 [==============================] - 0s 2ms/step - loss: 5.3808e-05
Epoch 485/500
1/1 [==============================] - 0s 1ms/step - loss: 5.2703e-05
Epoch 486/500
1/1 [==============================] - 0s 2ms/step - loss: 5.1621e-05
```

Ok, now you have a model that has been trained to learn the relationship between X and Y. You can use the **model.predict** method to have it figure out the Y for a previously unknown X. So, for example, if X = 10, what do you think Y will be? Take a guess before you run this code:

```
1/1 [==============================] - 0s 2ms/step - loss: 4.8505e-05
```

```
print(model.predict([10.0]))
```

```
[[18.981874]]
Epoch 492/500
```

You might have thought 19, right? But it ended up being a little under. Why do you think that is?

Remember that neural networks deal with probabilities, so given the data that we fed the NN with, it calculated that there is a very high probability that the relationship between X and Y is Y=2X-1, but with only 6 data points we can't know for sure. As a result, the result for 10 is very close to 19, but not necessarily 19.

As you work with neural networks, you'll see this pattern recurring. You will almost always deal with probabilities, not certainties, and will do a little bit of coding to figure out what the result is based on the probabilities, particularly when it comes to classification.

```
Epoch 499/500
1/1 [==============================] - 0s 2ms/step - loss: 3.9414e-05
Epoch 500/500
1/1 [==============================] - 0s 2ms/step - loss: 3.8604e-05
<tensorflow.python.keras.callbacks.History at 0x7febf1f29550>
```