00-Keras-Basics

October 19, 2022

For more information, visit us at www.pieriandata.com

1 Keras Basics

[23]:
```
# You can safely ignore any warnings on importing this
import keras
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
```

1.1 Simple y=mx+b+noise data

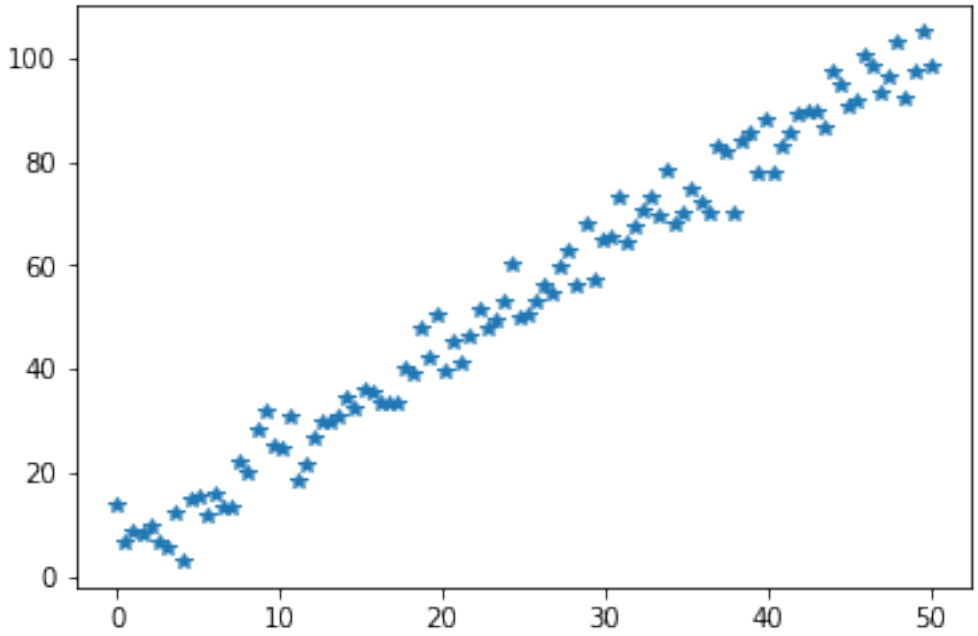
[47]:
```
m = 2
b = 3
x = np.linspace(0,50,100)

# 101 is an arbitrary choice to make sure your random values are same as mine!
np.random.seed(101)
noise = np.random.normal(loc=0.0,scale=4.0,size=len(x))
```

[48]:
```
y = 2*x + b + noise
```

[49]:
```
plt.plot(x,y,'*')
```

[49]:
```
[<matplotlib.lines.Line2D at 0x1a3acb34a8>]
```



1.2 Creating a Neural Network for a Line of Best Fit

[50]:
```
from keras.models import Sequential
from keras.layers import Dense
```

[58]:
```
model = Sequential()
# 4 Neurons, expecting only 1 feature with input_dim=1
model.add(Dense(4, input_dim=1, activation='relu'))
# 4 Neurons (Play around with this number!)
model.add(Dense(4, activation='relu'))
# One final output of y, so only 1 neuron
model.add(Dense(1, activation='linear'))
# Compil the layers
model.compile(loss='mse', optimizer='adam')
```

[59]:
```
model.summary()
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_7 (Dense)              (None, 4)                 8
_________________________________________________________________
dense_8 (Dense)              (None, 4)                 20
_________________________________________________________________
```

```
dense_9 (Dense)              (None, 1)                 5
=================================================================
Total params: 33
Trainable params: 33
Non-trainable params: 0
_________________________________________________________________
```

1.3 Train on Data

** NOTE: FOR THIS SIMPLE EXAMPLE, I WILL SKIP THE TRAIN TEST SPLIT!!!! **

[74]:
```
model.fit(x, y, epochs=500, verbose=1)
```

```
Epoch 1/500
100/100 [==============================] - 0s 128us/step - loss: 16.9098
Epoch 2/500
100/100 [==============================] - 0s 135us/step - loss: 16.9122
Epoch 3/500
100/100 [==============================] - 0s 175us/step - loss: 16.9011
Epoch 4/500
100/100 [==============================] - 0s 361us/step - loss: 16.8552
Epoch 5/500
100/100 [==============================] - 0s 273us/step - loss: 16.8889
Epoch 6/500
100/100 [==============================] - 0s 162us/step - loss: 16.9019
Epoch 7/500
100/100 [==============================] - 0s 204us/step - loss: 16.9354
Epoch 8/500
100/100 [==============================] - 0s 123us/step - loss: 16.9697
Epoch 9/500
100/100 [==============================] - 0s 150us/step - loss: 16.9971
Epoch 10/500
100/100 [==============================] - 0s 186us/step - loss: 16.9511
Epoch 11/500
100/100 [==============================] - 0s 148us/step - loss: 16.8876
Epoch 12/500
100/100 [==============================] - 0s 188us/step - loss: 16.9351
Epoch 13/500
100/100 [==============================] - 0s 140us/step - loss: 16.8796
Epoch 14/500
100/100 [==============================] - 0s 164us/step - loss: 16.8760
Epoch 15/500
100/100 [==============================] - 0s 134us/step - loss: 16.9054
Epoch 16/500
100/100 [==============================] - 0s 184us/step - loss: 16.9024
Epoch 17/500
100/100 [==============================] - 0s 166us/step - loss: 16.8852
```

```
Epoch 18/500
100/100 [==============================] - 0s 216us/step - loss: 16.8804
Epoch 19/500
100/100 [==============================] - 0s 189us/step - loss: 16.8742
Epoch 20/500
100/100 [==============================] - 0s 127us/step - loss: 16.8497
Epoch 21/500
100/100 [==============================] - 0s 217us/step - loss: 16.8576
Epoch 22/500
100/100 [==============================] - 0s 110us/step - loss: 16.8864
Epoch 23/500
100/100 [==============================] - 0s 221us/step - loss: 16.9351
Epoch 24/500
100/100 [==============================] - 0s 155us/step - loss: 16.9284
Epoch 25/500
100/100 [==============================] - 0s 153us/step - loss: 16.9249
Epoch 26/500
100/100 [==============================] - 0s 129us/step - loss: 16.9343
Epoch 27/500
100/100 [==============================] - 0s 166us/step - loss: 16.9420
Epoch 28/500
100/100 [==============================] - 0s 174us/step - loss: 16.9500
Epoch 29/500
100/100 [==============================] - 0s 169us/step - loss: 16.9533
Epoch 30/500
100/100 [==============================] - 0s 199us/step - loss: 16.9039
Epoch 31/500
100/100 [==============================] - 0s 129us/step - loss: 16.8925
Epoch 32/500
100/100 [==============================] - 0s 196us/step - loss: 16.8673
Epoch 33/500
100/100 [==============================] - 0s 230us/step - loss: 16.8790
Epoch 34/500
100/100 [==============================] - 0s 140us/step - loss: 16.8626
Epoch 35/500
100/100 [==============================] - 0s 159us/step - loss: 16.8644
Epoch 36/500
100/100 [==============================] - 0s 136us/step - loss: 16.8679
Epoch 37/500
100/100 [==============================] - 0s 186us/step - loss: 16.8667
Epoch 38/500
100/100 [==============================] - 0s 151us/step - loss: 16.8699
Epoch 39/500
100/100 [==============================] - 0s 181us/step - loss: 16.9021
Epoch 40/500
100/100 [==============================] - 0s 142us/step - loss: 16.9072
Epoch 41/500
100/100 [==============================] - 0s 136us/step - loss: 16.9102
```

```
Epoch 42/500
100/100 [==============================] - 0s 152us/step - loss: 16.8961
Epoch 43/500
100/100 [==============================] - 0s 171us/step - loss: 16.8766
Epoch 44/500
100/100 [==============================] - 0s 105us/step - loss: 16.8526
Epoch 45/500
100/100 [==============================] - 0s 170us/step - loss: 16.8665
Epoch 46/500
100/100 [==============================] - 0s 116us/step - loss: 16.8642
Epoch 47/500
100/100 [==============================] - 0s 191us/step - loss: 16.8923
Epoch 48/500
100/100 [==============================] - 0s 109us/step - loss: 16.9026
Epoch 49/500
100/100 [==============================] - 0s 216us/step - loss: 16.9060
Epoch 50/500
100/100 [==============================] - 0s 116us/step - loss: 16.8810
Epoch 51/500
100/100 [==============================] - 0s 207us/step - loss: 16.8752
Epoch 52/500
100/100 [==============================] - 0s 114us/step - loss: 16.8725
Epoch 53/500
100/100 [==============================] - 0s 197us/step - loss: 16.8634
Epoch 54/500
100/100 [==============================] - 0s 184us/step - loss: 16.8772
Epoch 55/500
100/100 [==============================] - 0s 130us/step - loss: 16.8657
Epoch 56/500
100/100 [==============================] - 0s 160us/step - loss: 16.8716
Epoch 57/500
100/100 [==============================] - 0s 133us/step - loss: 16.8739
Epoch 58/500
100/100 [==============================] - 0s 153us/step - loss: 16.8767
Epoch 59/500
100/100 [==============================] - 0s 120us/step - loss: 16.8868
Epoch 60/500
100/100 [==============================] - 0s 141us/step - loss: 16.8871
Epoch 61/500
100/100 [==============================] - 0s 158us/step - loss: 16.8916
Epoch 62/500
100/100 [==============================] - 0s 230us/step - loss: 16.8810
Epoch 63/500
100/100 [==============================] - 0s 150us/step - loss: 16.8788
Epoch 64/500
100/100 [==============================] - 0s 129us/step - loss: 16.8696
Epoch 65/500
100/100 [==============================] - 0s 213us/step - loss: 16.8738
```

```
Epoch 66/500
100/100 [==============================] - 0s 167us/step - loss: 16.8757
Epoch 67/500
100/100 [==============================] - 0s 248us/step - loss: 16.8789
Epoch 68/500
100/100 [==============================] - 0s 125us/step - loss: 16.8706
Epoch 69/500
100/100 [==============================] - 0s 152us/step - loss: 16.8699
Epoch 70/500
100/100 [==============================] - 0s 130us/step - loss: 16.8640
Epoch 71/500
100/100 [==============================] - 0s 111us/step - loss: 16.8674
Epoch 72/500
100/100 [==============================] - 0s 207us/step - loss: 16.8603
Epoch 73/500
100/100 [==============================] - 0s 159us/step - loss: 16.8582
Epoch 74/500
100/100 [==============================] - 0s 202us/step - loss: 16.8714
Epoch 75/500
100/100 [==============================] - 0s 121us/step - loss: 16.8665
Epoch 76/500
100/100 [==============================] - 0s 171us/step - loss: 16.8755
Epoch 77/500
100/100 [==============================] - 0s 123us/step - loss: 16.8785
Epoch 78/500
100/100 [==============================] - 0s 105us/step - loss: 16.8616
Epoch 79/500
100/100 [==============================] - 0s 123us/step - loss: 16.8815
Epoch 80/500
100/100 [==============================] - 0s 112us/step - loss: 16.8743
Epoch 81/500
100/100 [==============================] - 0s 143us/step - loss: 16.8670
Epoch 82/500
100/100 [==============================] - 0s 113us/step - loss: 16.8668
Epoch 83/500
100/100 [==============================] - 0s 129us/step - loss: 16.8689
Epoch 84/500
100/100 [==============================] - 0s 120us/step - loss: 16.8675
Epoch 85/500
100/100 [==============================] - 0s 155us/step - loss: 16.8665
Epoch 86/500
100/100 [==============================] - 0s 134us/step - loss: 16.8958
Epoch 87/500
100/100 [==============================] - 0s 134us/step - loss: 16.9188
Epoch 88/500
100/100 [==============================] - 0s 122us/step - loss: 16.9020
Epoch 89/500
100/100 [==============================] - 0s 113us/step - loss: 16.9003
```

```
Epoch 90/500
100/100 [==============================] - 0s 150us/step - loss: 16.8561
Epoch 91/500
100/100 [==============================] - 0s 131us/step - loss: 16.8595
Epoch 92/500
100/100 [==============================] - 0s 167us/step - loss: 16.8650
Epoch 93/500
100/100 [==============================] - 0s 118us/step - loss: 16.8621
Epoch 94/500
100/100 [==============================] - 0s 108us/step - loss: 16.8677
Epoch 95/500
100/100 [==============================] - 0s 158us/step - loss: 16.8600
Epoch 96/500
100/100 [==============================] - 0s 113us/step - loss: 16.8681
Epoch 97/500
100/100 [==============================] - 0s 141us/step - loss: 16.8603
Epoch 98/500
100/100 [==============================] - 0s 178us/step - loss: 16.8631
Epoch 99/500
100/100 [==============================] - 0s 120us/step - loss: 16.8592
Epoch 100/500
100/100 [==============================] - 0s 112us/step - loss: 16.8642
Epoch 101/500
100/100 [==============================] - 0s 111us/step - loss: 16.8604
Epoch 102/500
100/100 [==============================] - 0s 173us/step - loss: 16.8583
Epoch 103/500
100/100 [==============================] - 0s 175us/step - loss: 16.8561
Epoch 104/500
100/100 [==============================] - 0s 134us/step - loss: 16.8701
Epoch 105/500
100/100 [==============================] - 0s 257us/step - loss: 16.8722
Epoch 106/500
100/100 [==============================] - 0s 217us/step - loss: 16.8674
Epoch 107/500
100/100 [==============================] - 0s 168us/step - loss: 16.8792
Epoch 108/500
100/100 [==============================] - 0s 125us/step - loss: 16.9080
Epoch 109/500
100/100 [==============================] - 0s 137us/step - loss: 16.9240
Epoch 110/500
100/100 [==============================] - 0s 155us/step - loss: 16.9263
Epoch 111/500
100/100 [==============================] - 0s 137us/step - loss: 16.9806
Epoch 112/500
100/100 [==============================] - 0s 142us/step - loss: 17.0029
Epoch 113/500
100/100 [==============================] - 0s 170us/step - loss: 16.9784
```

```
Epoch 114/500
100/100 [==============================] - 0s 140us/step - loss: 16.9075
Epoch 115/500
100/100 [==============================] - 0s 136us/step - loss: 16.8959
Epoch 116/500
100/100 [==============================] - 0s 139us/step - loss: 16.8353
Epoch 117/500
100/100 [==============================] - 0s 153us/step - loss: 16.8519
Epoch 118/500
100/100 [==============================] - 0s 159us/step - loss: 16.8927
Epoch 119/500
100/100 [==============================] - 0s 153us/step - loss: 16.9158
Epoch 120/500
100/100 [==============================] - 0s 138us/step - loss: 16.8986
Epoch 121/500
100/100 [==============================] - 0s 128us/step - loss: 16.9152
Epoch 122/500
100/100 [==============================] - 0s 163us/step - loss: 16.8609
Epoch 123/500
100/100 [==============================] - 0s 124us/step - loss: 16.8556
Epoch 124/500
100/100 [==============================] - 0s 153us/step - loss: 16.8659
Epoch 125/500
100/100 [==============================] - 0s 139us/step - loss: 16.9084
Epoch 126/500
100/100 [==============================] - 0s 113us/step - loss: 16.9209
Epoch 127/500
100/100 [==============================] - 0s 113us/step - loss: 16.9323
Epoch 128/500
100/100 [==============================] - 0s 127us/step - loss: 16.9208
Epoch 129/500
100/100 [==============================] - 0s 109us/step - loss: 16.9009
Epoch 130/500
100/100 [==============================] - 0s 108us/step - loss: 16.8799
Epoch 131/500
100/100 [==============================] - 0s 127us/step - loss: 16.8556
Epoch 132/500
100/100 [==============================] - 0s 128us/step - loss: 16.8594
Epoch 133/500
100/100 [==============================] - 0s 128us/step - loss: 16.8627
Epoch 134/500
100/100 [==============================] - 0s 121us/step - loss: 16.8594
Epoch 135/500
100/100 [==============================] - 0s 104us/step - loss: 16.8372
Epoch 136/500
100/100 [==============================] - 0s 109us/step - loss: 16.8574
Epoch 137/500
100/100 [==============================] - 0s 108us/step - loss: 16.9267
```

```
Epoch 138/500
100/100 [==============================] - 0s 135us/step - loss: 16.9110
Epoch 139/500
100/100 [==============================] - 0s 126us/step - loss: 16.9303
Epoch 140/500
100/100 [==============================] - 0s 119us/step - loss: 16.8770
Epoch 141/500
100/100 [==============================] - 0s 120us/step - loss: 16.8983
Epoch 142/500
100/100 [==============================] - 0s 102us/step - loss: 16.8781
Epoch 143/500
100/100 [==============================] - 0s 145us/step - loss: 16.8680
Epoch 144/500
100/100 [==============================] - 0s 123us/step - loss: 16.8554
Epoch 145/500
100/100 [==============================] - 0s 137us/step - loss: 16.8527
Epoch 146/500
100/100 [==============================] - 0s 113us/step - loss: 16.8557
Epoch 147/500
100/100 [==============================] - 0s 128us/step - loss: 16.8698
Epoch 148/500
100/100 [==============================] - 0s 128us/step - loss: 16.8696
Epoch 149/500
100/100 [==============================] - 0s 127us/step - loss: 16.8611
Epoch 150/500
100/100 [==============================] - 0s 113us/step - loss: 16.8505
Epoch 151/500
100/100 [==============================] - 0s 146us/step - loss: 16.8762
Epoch 152/500
100/100 [==============================] - 0s 170us/step - loss: 16.8578
Epoch 153/500
100/100 [==============================] - 0s 178us/step - loss: 16.9398
Epoch 154/500
100/100 [==============================] - 0s 118us/step - loss: 16.9389
Epoch 155/500
100/100 [==============================] - 0s 182us/step - loss: 16.9334
Epoch 156/500
100/100 [==============================] - 0s 119us/step - loss: 16.8760
Epoch 157/500
100/100 [==============================] - 0s 129us/step - loss: 16.8472
Epoch 158/500
100/100 [==============================] - 0s 147us/step - loss: 16.8526
Epoch 159/500
100/100 [==============================] - 0s 123us/step - loss: 16.8486
Epoch 160/500
100/100 [==============================] - 0s 143us/step - loss: 16.8655
Epoch 161/500
100/100 [==============================] - 0s 132us/step - loss: 16.9272
```

```
Epoch 162/500
100/100 [==============================] - 0s 166us/step - loss: 16.9259
Epoch 163/500
100/100 [==============================] - 0s 116us/step - loss: 16.9350
Epoch 164/500
100/100 [==============================] - 0s 139us/step - loss: 16.9406
Epoch 165/500
100/100 [==============================] - 0s 100us/step - loss: 16.9028
Epoch 166/500
100/100 [==============================] - 0s 143us/step - loss: 16.8956
Epoch 167/500
100/100 [==============================] - 0s 141us/step - loss: 16.8924
Epoch 168/500
100/100 [==============================] - 0s 120us/step - loss: 16.8826
Epoch 169/500
100/100 [==============================] - 0s 110us/step - loss: 16.8696
Epoch 170/500
100/100 [==============================] - 0s 169us/step - loss: 16.8457
Epoch 171/500
100/100 [==============================] - 0s 121us/step - loss: 16.8623
Epoch 172/500
100/100 [==============================] - 0s 143us/step - loss: 16.8500
Epoch 173/500
100/100 [==============================] - 0s 139us/step - loss: 16.8482
Epoch 174/500
100/100 [==============================] - 0s 115us/step - loss: 16.8576
Epoch 175/500
100/100 [==============================] - 0s 153us/step - loss: 16.8467
Epoch 176/500
100/100 [==============================] - 0s 127us/step - loss: 16.8379
Epoch 177/500
100/100 [==============================] - 0s 141us/step - loss: 16.8660
Epoch 178/500
100/100 [==============================] - 0s 144us/step - loss: 16.9269
Epoch 179/500
100/100 [==============================] - 0s 115us/step - loss: 16.9631
Epoch 180/500
100/100 [==============================] - 0s 148us/step - loss: 16.9733
Epoch 181/500
100/100 [==============================] - 0s 110us/step - loss: 17.0031
Epoch 182/500
100/100 [==============================] - 0s 144us/step - loss: 17.0264
Epoch 183/500
100/100 [==============================] - 0s 121us/step - loss: 17.0413
Epoch 184/500
100/100 [==============================] - 0s 154us/step - loss: 17.0575
Epoch 185/500
100/100 [==============================] - 0s 124us/step - loss: 17.0090
```

```
Epoch 186/500
100/100 [==============================] - 0s 114us/step - loss: 16.9271
Epoch 187/500
100/100 [==============================] - 0s 128us/step - loss: 16.9042
Epoch 188/500
100/100 [==============================] - 0s 139us/step - loss: 16.8493
Epoch 189/500
100/100 [==============================] - 0s 134us/step - loss: 16.8439
Epoch 190/500
100/100 [==============================] - 0s 105us/step - loss: 16.8353
Epoch 191/500
100/100 [==============================] - 0s 148us/step - loss: 16.8542
Epoch 192/500
100/100 [==============================] - 0s 151us/step - loss: 16.8495
Epoch 193/500
100/100 [==============================] - 0s 137us/step - loss: 16.8454
Epoch 194/500
100/100 [==============================] - 0s 111us/step - loss: 16.8404
Epoch 195/500
100/100 [==============================] - 0s 173us/step - loss: 16.8441
Epoch 196/500
100/100 [==============================] - 0s 181us/step - loss: 16.8462
Epoch 197/500
100/100 [==============================] - 0s 164us/step - loss: 16.8449
Epoch 198/500
100/100 [==============================] - 0s 159us/step - loss: 16.8538
Epoch 199/500
100/100 [==============================] - 0s 159us/step - loss: 16.8721
Epoch 200/500
100/100 [==============================] - 0s 182us/step - loss: 16.8751
Epoch 201/500
100/100 [==============================] - 0s 173us/step - loss: 16.8990
Epoch 202/500
100/100 [==============================] - 0s 134us/step - loss: 16.8920
Epoch 203/500
100/100 [==============================] - 0s 167us/step - loss: 16.8906
Epoch 204/500
100/100 [==============================] - 0s 177us/step - loss: 16.8841
Epoch 205/500
100/100 [==============================] - 0s 158us/step - loss: 16.8877
Epoch 206/500
100/100 [==============================] - 0s 154us/step - loss: 16.8952
Epoch 207/500
100/100 [==============================] - 0s 127us/step - loss: 16.8511
Epoch 208/500
100/100 [==============================] - 0s 149us/step - loss: 16.9225
Epoch 209/500
100/100 [==============================] - 0s 121us/step - loss: 16.8473
```

```
Epoch 210/500
100/100 [==============================] - 0s 127us/step - loss: 16.8779
Epoch 211/500
100/100 [==============================] - 0s 143us/step - loss: 16.8935
Epoch 212/500
100/100 [==============================] - 0s 155us/step - loss: 16.8892
Epoch 213/500
100/100 [==============================] - 0s 141us/step - loss: 16.8861
Epoch 214/500
100/100 [==============================] - 0s 128us/step - loss: 16.8657
Epoch 215/500
100/100 [==============================] - 0s 128us/step - loss: 16.8696
Epoch 216/500
100/100 [==============================] - 0s 135us/step - loss: 16.8793
Epoch 217/500
100/100 [==============================] - 0s 175us/step - loss: 16.8694
Epoch 218/500
100/100 [==============================] - 0s 159us/step - loss: 16.8614
Epoch 219/500
100/100 [==============================] - 0s 154us/step - loss: 16.8554
Epoch 220/500
100/100 [==============================] - 0s 130us/step - loss: 16.8612
Epoch 221/500
100/100 [==============================] - 0s 140us/step - loss: 16.8412
Epoch 222/500
100/100 [==============================] - 0s 164us/step - loss: 16.9032
Epoch 223/500
100/100 [==============================] - 0s 160us/step - loss: 16.9329
Epoch 224/500
100/100 [==============================] - 0s 181us/step - loss: 16.9485
Epoch 225/500
100/100 [==============================] - 0s 166us/step - loss: 16.9991
Epoch 226/500
100/100 [==============================] - 0s 132us/step - loss: 17.0176
Epoch 227/500
100/100 [==============================] - 0s 166us/step - loss: 16.9603
Epoch 228/500
100/100 [==============================] - 0s 176us/step - loss: 16.8813
Epoch 229/500
100/100 [==============================] - 0s 163us/step - loss: 16.8466
Epoch 230/500
100/100 [==============================] - 0s 120us/step - loss: 16.8465
Epoch 231/500
100/100 [==============================] - 0s 146us/step - loss: 16.8339
Epoch 232/500
100/100 [==============================] - 0s 175us/step - loss: 16.8625
Epoch 233/500
100/100 [==============================] - 0s 164us/step - loss: 16.8572
```

```
Epoch 234/500
100/100 [==============================] - 0s 128us/step - loss: 16.8518
Epoch 235/500
100/100 [==============================] - 0s 131us/step - loss: 16.8362
Epoch 236/500
100/100 [==============================] - 0s 149us/step - loss: 16.8175
Epoch 237/500
100/100 [==============================] - 0s 165us/step - loss: 16.8675
Epoch 238/500
100/100 [==============================] - 0s 137us/step - loss: 16.8786
Epoch 239/500
100/100 [==============================] - 0s 155us/step - loss: 16.8653
Epoch 240/500
100/100 [==============================] - 0s 169us/step - loss: 16.8807
Epoch 241/500
100/100 [==============================] - 0s 134us/step - loss: 16.8906
Epoch 242/500
100/100 [==============================] - 0s 130us/step - loss: 16.8758
Epoch 243/500
100/100 [==============================] - 0s 164us/step - loss: 16.8313
Epoch 244/500
100/100 [==============================] - 0s 178us/step - loss: 16.8204
Epoch 245/500
100/100 [==============================] - 0s 144us/step - loss: 16.8485
Epoch 246/500
100/100 [==============================] - 0s 141us/step - loss: 16.8640
Epoch 247/500
100/100 [==============================] - 0s 157us/step - loss: 16.8553
Epoch 248/500
100/100 [==============================] - 0s 123us/step - loss: 16.8433
Epoch 249/500
100/100 [==============================] - 0s 141us/step - loss: 16.8463
Epoch 250/500
100/100 [==============================] - 0s 153us/step - loss: 16.8362
Epoch 251/500
100/100 [==============================] - 0s 124us/step - loss: 16.8288
Epoch 252/500
100/100 [==============================] - 0s 136us/step - loss: 16.8332
Epoch 253/500
100/100 [==============================] - 0s 120us/step - loss: 16.8814
Epoch 254/500
100/100 [==============================] - 0s 149us/step - loss: 16.8890
Epoch 255/500
100/100 [==============================] - 0s 124us/step - loss: 16.8802
Epoch 256/500
100/100 [==============================] - 0s 158us/step - loss: 16.8553
Epoch 257/500
100/100 [==============================] - 0s 157us/step - loss: 16.8690
```

```
Epoch 258/500
100/100 [==============================] - 0s 135us/step - loss: 16.8458
Epoch 259/500
100/100 [==============================] - 0s 167us/step - loss: 16.8369
Epoch 260/500
100/100 [==============================] - 0s 141us/step - loss: 16.8362
Epoch 261/500
100/100 [==============================] - 0s 147us/step - loss: 16.8554
Epoch 262/500
100/100 [==============================] - 0s 154us/step - loss: 16.8663
Epoch 263/500
100/100 [==============================] - 0s 173us/step - loss: 16.8978
Epoch 264/500
100/100 [==============================] - 0s 122us/step - loss: 16.8939
Epoch 265/500
100/100 [==============================] - 0s 136us/step - loss: 16.8775
Epoch 266/500
100/100 [==============================] - 0s 125us/step - loss: 16.8647
Epoch 267/500
100/100 [==============================] - 0s 146us/step - loss: 16.8717
Epoch 268/500
100/100 [==============================] - 0s 126us/step - loss: 16.8760
Epoch 269/500
100/100 [==============================] - 0s 141us/step - loss: 16.8521
Epoch 270/500
100/100 [==============================] - 0s 137us/step - loss: 16.9245
Epoch 271/500
100/100 [==============================] - 0s 122us/step - loss: 16.8680
Epoch 272/500
100/100 [==============================] - 0s 141us/step - loss: 16.8937
Epoch 273/500
100/100 [==============================] - 0s 125us/step - loss: 16.9354
Epoch 274/500
100/100 [==============================] - 0s 120us/step - loss: 16.9963
Epoch 275/500
100/100 [==============================] - 0s 160us/step - loss: 16.9280
Epoch 276/500
100/100 [==============================] - 0s 133us/step - loss: 16.8496
Epoch 277/500
100/100 [==============================] - 0s 114us/step - loss: 16.8673
Epoch 278/500
100/100 [==============================] - 0s 126us/step - loss: 16.8742
Epoch 279/500
100/100 [==============================] - 0s 114us/step - loss: 16.8565
Epoch 280/500
100/100 [==============================] - 0s 136us/step - loss: 16.8511
Epoch 281/500
100/100 [==============================] - 0s 118us/step - loss: 16.8423
```

```
Epoch 282/500
100/100 [==============================] - 0s 110us/step - loss: 16.8493
Epoch 283/500
100/100 [==============================] - 0s 139us/step - loss: 16.8567
Epoch 284/500
100/100 [==============================] - 0s 126us/step - loss: 16.8379
Epoch 285/500
100/100 [==============================] - 0s 147us/step - loss: 16.8242
Epoch 286/500
100/100 [==============================] - 0s 146us/step - loss: 16.8592
Epoch 287/500
100/100 [==============================] - 0s 182us/step - loss: 16.9439
Epoch 288/500
100/100 [==============================] - 0s 202us/step - loss: 16.9527
Epoch 289/500
100/100 [==============================] - 0s 186us/step - loss: 16.9628
Epoch 290/500
100/100 [==============================] - 0s 119us/step - loss: 16.9445
Epoch 291/500
100/100 [==============================] - 0s 125us/step - loss: 16.9114
Epoch 292/500
100/100 [==============================] - 0s 133us/step - loss: 16.8984
Epoch 293/500
100/100 [==============================] - 0s 140us/step - loss: 16.8550
Epoch 294/500
100/100 [==============================] - 0s 138us/step - loss: 16.8210
Epoch 295/500
100/100 [==============================] - 0s 174us/step - loss: 16.8528
Epoch 296/500
100/100 [==============================] - 0s 153us/step - loss: 16.8655
Epoch 297/500
100/100 [==============================] - 0s 152us/step - loss: 16.8732
Epoch 298/500
100/100 [==============================] - 0s 150us/step - loss: 16.8700
Epoch 299/500
100/100 [==============================] - 0s 155us/step - loss: 16.8990
Epoch 300/500
100/100 [==============================] - 0s 156us/step - loss: 16.8999
Epoch 301/500
100/100 [==============================] - 0s 154us/step - loss: 16.8583
Epoch 302/500
100/100 [==============================] - 0s 138us/step - loss: 16.8369
Epoch 303/500
100/100 [==============================] - 0s 143us/step - loss: 16.8419
Epoch 304/500
100/100 [==============================] - 0s 131us/step - loss: 16.8411
Epoch 305/500
100/100 [==============================] - 0s 180us/step - loss: 16.8361
```

```
Epoch 306/500
100/100 [==============================] - 0s 130us/step - loss: 16.8378
Epoch 307/500
100/100 [==============================] - 0s 125us/step - loss: 16.8326
Epoch 308/500
100/100 [==============================] - 0s 162us/step - loss: 16.8359
Epoch 309/500
100/100 [==============================] - 0s 139us/step - loss: 16.8409
Epoch 310/500
100/100 [==============================] - 0s 150us/step - loss: 16.8366
Epoch 311/500
100/100 [==============================] - 0s 165us/step - loss: 16.8181
Epoch 312/500
100/100 [==============================] - 0s 152us/step - loss: 16.8331
Epoch 313/500
100/100 [==============================] - 0s 133us/step - loss: 16.8534
Epoch 314/500
100/100 [==============================] - 0s 184us/step - loss: 16.9322
Epoch 315/500
100/100 [==============================] - 0s 178us/step - loss: 16.9432
Epoch 316/500
100/100 [==============================] - 0s 169us/step - loss: 16.9674
Epoch 317/500
100/100 [==============================] - 0s 154us/step - loss: 16.9785
Epoch 318/500
100/100 [==============================] - 0s 140us/step - loss: 17.0209
Epoch 319/500
100/100 [==============================] - 0s 142us/step - loss: 17.0127
Epoch 320/500
100/100 [==============================] - 0s 138us/step - loss: 16.8976
Epoch 321/500
100/100 [==============================] - 0s 132us/step - loss: 16.8459
Epoch 322/500
100/100 [==============================] - 0s 138us/step - loss: 16.8292
Epoch 323/500
100/100 [==============================] - 0s 160us/step - loss: 16.8332
Epoch 324/500
100/100 [==============================] - 0s 124us/step - loss: 16.8533
Epoch 325/500
100/100 [==============================] - 0s 155us/step - loss: 16.8549
Epoch 326/500
100/100 [==============================] - 0s 158us/step - loss: 16.9275
Epoch 327/500
100/100 [==============================] - 0s 110us/step - loss: 16.8767
Epoch 328/500
100/100 [==============================] - 0s 145us/step - loss: 16.8706
Epoch 329/500
100/100 [==============================] - 0s 125us/step - loss: 16.8576
```

```
Epoch 330/500
100/100 [==============================] - 0s 126us/step - loss: 16.8226
Epoch 331/500
100/100 [==============================] - 0s 162us/step - loss: 16.8493
Epoch 332/500
100/100 [==============================] - 0s 101us/step - loss: 16.8330
Epoch 333/500
100/100 [==============================] - 0s 171us/step - loss: 16.8414
Epoch 334/500
100/100 [==============================] - 0s 153us/step - loss: 16.8280
Epoch 335/500
100/100 [==============================] - 0s 153us/step - loss: 16.8330
Epoch 336/500
100/100 [==============================] - 0s 130us/step - loss: 16.8324
Epoch 337/500
100/100 [==============================] - 0s 131us/step - loss: 16.8396
Epoch 338/500
100/100 [==============================] - 0s 143us/step - loss: 16.8335
Epoch 339/500
100/100 [==============================] - 0s 144us/step - loss: 16.8188
Epoch 340/500
100/100 [==============================] - 0s 152us/step - loss: 16.8257
Epoch 341/500
100/100 [==============================] - 0s 185us/step - loss: 16.8875
Epoch 342/500
100/100 [==============================] - 0s 141us/step - loss: 16.8218
Epoch 343/500
100/100 [==============================] - 0s 124us/step - loss: 16.8426
Epoch 344/500
100/100 [==============================] - 0s 156us/step - loss: 16.8339
Epoch 345/500
100/100 [==============================] - 0s 109us/step - loss: 16.8435
Epoch 346/500
100/100 [==============================] - 0s 135us/step - loss: 16.8571
Epoch 347/500
100/100 [==============================] - 0s 156us/step - loss: 16.8598
Epoch 348/500
100/100 [==============================] - 0s 133us/step - loss: 16.8530
Epoch 349/500
100/100 [==============================] - 0s 156us/step - loss: 16.8539
Epoch 350/500
100/100 [==============================] - 0s 126us/step - loss: 16.9163
Epoch 351/500
100/100 [==============================] - 0s 151us/step - loss: 16.9253
Epoch 352/500
100/100 [==============================] - 0s 152us/step - loss: 16.8814
Epoch 353/500
100/100 [==============================] - 0s 127us/step - loss: 16.8302
```

```
Epoch 354/500
100/100 [==============================] - 0s 113us/step - loss: 16.8226
Epoch 355/500
100/100 [==============================] - 0s 102us/step - loss: 16.8375
Epoch 356/500
100/100 [==============================] - 0s 144us/step - loss: 16.8903
Epoch 357/500
100/100 [==============================] - 0s 140us/step - loss: 16.9277
Epoch 358/500
100/100 [==============================] - 0s 145us/step - loss: 17.0036
Epoch 359/500
100/100 [==============================] - 0s 128us/step - loss: 17.0295
Epoch 360/500
100/100 [==============================] - 0s 155us/step - loss: 16.9973
Epoch 361/500
100/100 [==============================] - 0s 146us/step - loss: 16.8862
Epoch 362/500
100/100 [==============================] - 0s 135us/step - loss: 16.7683
Epoch 363/500
100/100 [==============================] - 0s 120us/step - loss: 16.8236
Epoch 364/500
100/100 [==============================] - 0s 140us/step - loss: 16.9085
Epoch 365/500
100/100 [==============================] - 0s 127us/step - loss: 17.0736
Epoch 366/500
100/100 [==============================] - 0s 117us/step - loss: 17.2525
Epoch 367/500
100/100 [==============================] - 0s 149us/step - loss: 17.2110
Epoch 368/500
100/100 [==============================] - 0s 114us/step - loss: 17.1286
Epoch 369/500
100/100 [==============================] - 0s 121us/step - loss: 17.1057
Epoch 370/500
100/100 [==============================] - 0s 149us/step - loss: 17.0543
Epoch 371/500
100/100 [==============================] - 0s 120us/step - loss: 16.8895
Epoch 372/500
100/100 [==============================] - 0s 136us/step - loss: 16.8546
Epoch 373/500
100/100 [==============================] - 0s 122us/step - loss: 16.8388
Epoch 374/500
100/100 [==============================] - 0s 130us/step - loss: 16.8336
Epoch 375/500
100/100 [==============================] - 0s 132us/step - loss: 16.8280
Epoch 376/500
100/100 [==============================] - 0s 114us/step - loss: 16.8489
Epoch 377/500
100/100 [==============================] - 0s 157us/step - loss: 16.8358
```

```
Epoch 378/500
100/100 [==============================] - 0s 133us/step - loss: 16.8380
Epoch 379/500
100/100 [==============================] - 0s 163us/step - loss: 16.8590
Epoch 380/500
100/100 [==============================] - 0s 107us/step - loss: 16.8238
Epoch 381/500
100/100 [==============================] - 0s 134us/step - loss: 16.8295
Epoch 382/500
100/100 [==============================] - 0s 135us/step - loss: 16.8317
Epoch 383/500
100/100 [==============================] - 0s 136us/step - loss: 16.8185
Epoch 384/500
100/100 [==============================] - 0s 152us/step - loss: 16.8461
Epoch 385/500
100/100 [==============================] - 0s 136us/step - loss: 16.8474
Epoch 386/500
100/100 [==============================] - 0s 124us/step - loss: 16.8867
Epoch 387/500
100/100 [==============================] - 0s 153us/step - loss: 16.8892
Epoch 388/500
100/100 [==============================] - 0s 171us/step - loss: 16.8735
Epoch 389/500
100/100 [==============================] - 0s 131us/step - loss: 16.8301
Epoch 390/500
100/100 [==============================] - 0s 106us/step - loss: 16.8019
Epoch 391/500
100/100 [==============================] - 0s 114us/step - loss: 16.8519
Epoch 392/500
100/100 [==============================] - 0s 134us/step - loss: 16.8838
Epoch 393/500
100/100 [==============================] - 0s 113us/step - loss: 16.8923
Epoch 394/500
100/100 [==============================] - 0s 112us/step - loss: 16.9086
Epoch 395/500
100/100 [==============================] - 0s 103us/step - loss: 16.9320
Epoch 396/500
100/100 [==============================] - 0s 197us/step - loss: 16.9244
Epoch 397/500
100/100 [==============================] - 0s 155us/step - loss: 16.8947
Epoch 398/500
100/100 [==============================] - 0s 147us/step - loss: 16.8399
Epoch 399/500
100/100 [==============================] - 0s 165us/step - loss: 16.8760
Epoch 400/500
100/100 [==============================] - 0s 161us/step - loss: 16.8641
Epoch 401/500
100/100 [==============================] - 0s 159us/step - loss: 16.8994
```

```
Epoch 402/500
100/100 [==============================] - 0s 154us/step - loss: 16.9473
Epoch 403/500
100/100 [==============================] - 0s 171us/step - loss: 17.0108
Epoch 404/500
100/100 [==============================] - 0s 145us/step - loss: 16.9692
Epoch 405/500
100/100 [==============================] - 0s 146us/step - loss: 16.9127
Epoch 406/500
100/100 [==============================] - 0s 132us/step - loss: 16.8526
Epoch 407/500
100/100 [==============================] - 0s 162us/step - loss: 16.8632
Epoch 408/500
100/100 [==============================] - 0s 145us/step - loss: 16.8020
Epoch 409/500
100/100 [==============================] - 0s 167us/step - loss: 16.8387
Epoch 410/500
100/100 [==============================] - 0s 126us/step - loss: 16.8680
Epoch 411/500
100/100 [==============================] - 0s 148us/step - loss: 16.9320
Epoch 412/500
100/100 [==============================] - 0s 175us/step - loss: 16.9654
Epoch 413/500
100/100 [==============================] - 0s 174us/step - loss: 16.9049
Epoch 414/500
100/100 [==============================] - 0s 167us/step - loss: 16.8731
Epoch 415/500
100/100 [==============================] - 0s 136us/step - loss: 16.8238
Epoch 416/500
100/100 [==============================] - 0s 144us/step - loss: 16.8421
Epoch 417/500
100/100 [==============================] - 0s 160us/step - loss: 16.9863
Epoch 418/500
100/100 [==============================] - 0s 170us/step - loss: 16.9132
Epoch 419/500
100/100 [==============================] - 0s 125us/step - loss: 16.9058
Epoch 420/500
100/100 [==============================] - 0s 150us/step - loss: 16.8519
Epoch 421/500
100/100 [==============================] - 0s 175us/step - loss: 16.8333
Epoch 422/500
100/100 [==============================] - 0s 151us/step - loss: 16.8431
Epoch 423/500
100/100 [==============================] - 0s 141us/step - loss: 16.8332
Epoch 424/500
100/100 [==============================] - 0s 170us/step - loss: 16.8260
Epoch 425/500
100/100 [==============================] - 0s 171us/step - loss: 16.8252
```

```
Epoch 426/500
100/100 [==============================] - 0s 177us/step - loss: 16.8479
Epoch 427/500
100/100 [==============================] - 0s 128us/step - loss: 16.8912
Epoch 428/500
100/100 [==============================] - 0s 137us/step - loss: 16.8747
Epoch 429/500
100/100 [==============================] - 0s 197us/step - loss: 16.8246
Epoch 430/500
100/100 [==============================] - 0s 157us/step - loss: 16.8171
Epoch 431/500
100/100 [==============================] - 0s 130us/step - loss: 16.8663
Epoch 432/500
100/100 [==============================] - 0s 195us/step - loss: 16.8451
Epoch 433/500
100/100 [==============================] - 0s 115us/step - loss: 16.8354
Epoch 434/500
100/100 [==============================] - 0s 139us/step - loss: 16.8326
Epoch 435/500
100/100 [==============================] - 0s 188us/step - loss: 16.8142
Epoch 436/500
100/100 [==============================] - 0s 157us/step - loss: 16.8313
Epoch 437/500
100/100 [==============================] - 0s 138us/step - loss: 16.8403
Epoch 438/500
100/100 [==============================] - 0s 149us/step - loss: 16.8609
Epoch 439/500
100/100 [==============================] - 0s 132us/step - loss: 16.8504
Epoch 440/500
100/100 [==============================] - 0s 155us/step - loss: 16.8662
Epoch 441/500
100/100 [==============================] - 0s 175us/step - loss: 16.8496
Epoch 442/500
100/100 [==============================] - 0s 132us/step - loss: 16.8499
Epoch 443/500
100/100 [==============================] - 0s 115us/step - loss: 16.8344
Epoch 444/500
100/100 [==============================] - 0s 143us/step - loss: 16.8181
Epoch 445/500
100/100 [==============================] - 0s 134us/step - loss: 16.8115
Epoch 446/500
100/100 [==============================] - 0s 105us/step - loss: 16.8842
Epoch 447/500
100/100 [==============================] - 0s 176us/step - loss: 16.8821
Epoch 448/500
100/100 [==============================] - 0s 138us/step - loss: 16.9170
Epoch 449/500
100/100 [==============================] - 0s 125us/step - loss: 16.9402
```

```
Epoch 450/500
100/100 [==============================] - 0s 146us/step - loss: 16.9084
Epoch 451/500
100/100 [==============================] - 0s 140us/step - loss: 16.8585
Epoch 452/500
100/100 [==============================] - 0s 144us/step - loss: 16.8370
Epoch 453/500
100/100 [==============================] - 0s 136us/step - loss: 16.8353
Epoch 454/500
100/100 [==============================] - 0s 144us/step - loss: 16.9024
Epoch 455/500
100/100 [==============================] - 0s 114us/step - loss: 16.9096
Epoch 456/500
100/100 [==============================] - 0s 161us/step - loss: 16.8705
Epoch 457/500
100/100 [==============================] - 0s 151us/step - loss: 16.8570
Epoch 458/500
100/100 [==============================] - 0s 126us/step - loss: 16.8262
Epoch 459/500
100/100 [==============================] - 0s 148us/step - loss: 16.8266
Epoch 460/500
100/100 [==============================] - 0s 124us/step - loss: 16.8276
Epoch 461/500
100/100 [==============================] - 0s 144us/step - loss: 16.8305
Epoch 462/500
100/100 [==============================] - 0s 139us/step - loss: 16.8709
Epoch 463/500
100/100 [==============================] - 0s 121us/step - loss: 16.8785
Epoch 464/500
100/100 [==============================] - 0s 173us/step - loss: 16.8802
Epoch 465/500
100/100 [==============================] - 0s 134us/step - loss: 16.8778
Epoch 466/500
100/100 [==============================] - 0s 140us/step - loss: 16.8711
Epoch 467/500
100/100 [==============================] - 0s 136us/step - loss: 16.8571
Epoch 468/500
100/100 [==============================] - 0s 134us/step - loss: 16.8045
Epoch 469/500
100/100 [==============================] - 0s 142us/step - loss: 16.8227
Epoch 470/500
100/100 [==============================] - 0s 135us/step - loss: 16.8564
Epoch 471/500
100/100 [==============================] - 0s 135us/step - loss: 16.9610
Epoch 472/500
100/100 [==============================] - 0s 117us/step - loss: 16.9566
Epoch 473/500
100/100 [==============================] - 0s 147us/step - loss: 16.9341
```

```
Epoch 474/500
100/100 [==============================] - 0s 131us/step - loss: 16.8581
Epoch 475/500
100/100 [==============================] - 0s 147us/step - loss: 16.8108
Epoch 476/500
100/100 [==============================] - 0s 125us/step - loss: 16.8460
Epoch 477/500
100/100 [==============================] - 0s 133us/step - loss: 16.8758
Epoch 478/500
100/100 [==============================] - 0s 152us/step - loss: 16.9071
Epoch 479/500
100/100 [==============================] - 0s 150us/step - loss: 17.0029
Epoch 480/500
100/100 [==============================] - 0s 161us/step - loss: 17.0298
Epoch 481/500
100/100 [==============================] - 0s 147us/step - loss: 16.9633
Epoch 482/500
100/100 [==============================] - 0s 146us/step - loss: 16.8756
Epoch 483/500
100/100 [==============================] - 0s 155us/step - loss: 16.8179
Epoch 484/500
100/100 [==============================] - 0s 130us/step - loss: 16.8555
Epoch 485/500
100/100 [==============================] - 0s 159us/step - loss: 16.9432
Epoch 486/500
100/100 [==============================] - 0s 125us/step - loss: 16.9850
Epoch 487/500
100/100 [==============================] - 0s 116us/step - loss: 16.9851
Epoch 488/500
100/100 [==============================] - 0s 135us/step - loss: 16.9700
Epoch 489/500
100/100 [==============================] - 0s 118us/step - loss: 16.9424
Epoch 490/500
100/100 [==============================] - 0s 144us/step - loss: 16.9033
Epoch 491/500
100/100 [==============================] - 0s 126us/step - loss: 16.8870
Epoch 492/500
100/100 [==============================] - 0s 136us/step - loss: 16.8659
Epoch 493/500
100/100 [==============================] - 0s 156us/step - loss: 16.8837
Epoch 494/500
100/100 [==============================] - 0s 149us/step - loss: 16.8645
Epoch 495/500
100/100 [==============================] - 0s 129us/step - loss: 16.8804
Epoch 496/500
100/100 [==============================] - 0s 153us/step - loss: 16.8188
Epoch 497/500
100/100 [==============================] - 0s 158us/step - loss: 16.8162
```

```
Epoch 498/500
100/100 [==============================] - 0s 130us/step - loss: 16.8556
Epoch 499/500
100/100 [==============================] - 0s 152us/step - loss: 16.8539
Epoch 500/500
100/100 [==============================] - 0s 159us/step - loss: 16.8295
```

[74]:
```
<keras.callbacks.History at 0x1a3b772400>
```

1.4 Predicting on new x points

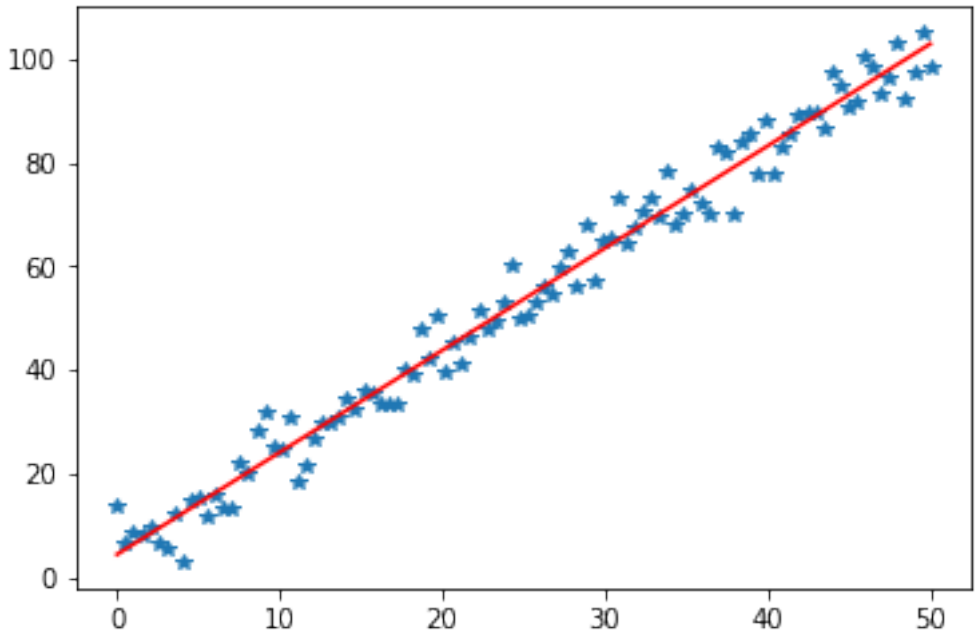
Our previous x was 50 linspace points between 0 and 100. Let's predict for 1000 values between 0 and 100, drawing a line for our predictions (our line of best fit).

[75]:
```
x_for_predictions = np.linspace(0,50,1000)
```

[76]:
```
y_predicted = model.predict(x_for_predictions)
```

[78]:
```
# Original X and Y
plt.plot(x,y,'*')
# Our Model's prediction Line
plt.plot(x_for_predictions,y_predicted,'r')
```

[78]:
```
[<matplotlib.lines.Line2D at 0x1a3bb2c2b0>]
```



2 Evaluating Our Error

[82]:
```
from sklearn.metrics import mean_squared_error,mean_absolute_error
```

[83]:
```
# Labels we do know
prediction_for_true_y = model.predict(x)
```

[84]:
```
mean_squared_error(y,prediction_for_true_y)
```

[84]:
```
16.820542043655355
```

[85]:
```
mean_absolute_error(y,prediction_for_true_y)
```

[85]:
```
3.291464809895978
```

Notice how MSE value was being reported out by Keras during training!

Is this a good error value? Really depends on the context, refer back to our model evaluation lecture for full details!