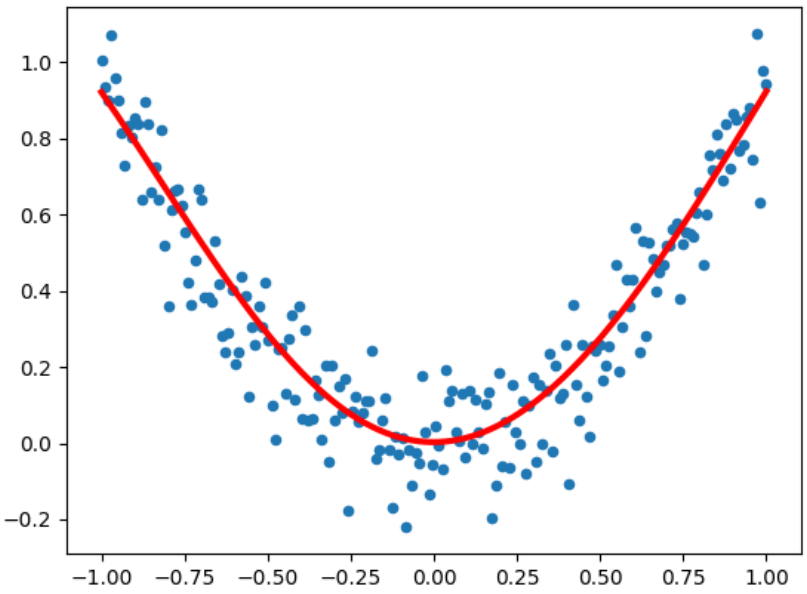
Overview

The goal of this assignment was to use Multi Layer Perceptrons (MLP) to detect handwritten prime digits. To accomplish this task, most of the functions were given in the initial code and all one had to was to implement the remaining functions as given in the description. Several test files were included to test the implementation of all the functions at various points. The most common error faced by almost everyone in the class was the shape of the matrixes when calculating weights and bias in DenseLayer functions. This problem was tackled by taking the transpose of the matrixes involved in the dot product.

From this figure below we can clearly see that the predicted function is similar to $f(x) = x^2$ and matches the validation data.



data_function.png

Model's Loss for toy_example_regressor.py

Loss: 0.01128530784036602

Detailed Output:

```
[Epoch 0]: loss: 11.849840680207045
[Epoch 0]: loss: 6.415041388570392
[Epoch 0]: loss: 3.2045493964415552
[Epoch 50]: loss: 0.08639302372940084
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[Epoch 50]: loss: 0.06355492087682417
[Epoch 50]: loss: 0.10430830250754455
[Epoch 100]: loss: 0.0667864986274947
[Epoch 100]: loss: 0.043070342402683266
[Epoch 100]: loss: 0.07336165251287292
[Epoch 150]: loss: 0.058024677774894944
[Epoch 150]: loss: 0.03501619889368944
[Epoch 150]: loss: 0.05945252714791631
[Epoch 200]: loss: 0.05015711709868256
[Epoch 200]: loss: 0.0291554545756946
[Epoch 200]: loss: 0.05007075093495725
[Epoch 250]: loss: 0.042617746830282154
[Epoch 250]: loss: 0.02415525989724089
[Epoch 250]: loss: 0.04253706011446123
[Epoch 300]: loss: 0.03585074147278868
[Epoch 300]: loss: 0.019992677375035926
[Epoch 300]: loss: 0.03626870717954512
[Epoch 350]: loss: 0.030126536711588357
[Epoch 350]: loss: 0.016711992078656167
[Epoch 350]: loss: 0.03113406771250146
[Epoch 400]: loss: 0.02549545618901762
[Epoch 400]: loss: 0.014268265884217932
[Epoch 400]: loss: 0.027049655917991123
[Epoch 450]: loss: 0.021873288891892752
[Epoch 450]: loss: 0.012547788294916581
[Epoch 450]: loss: 0.02389634611342621
[Epoch 500]: loss: 0.01911211153806263
[Epoch 500]: loss: 0.011406532030974512
[Epoch 500]: loss: 0.021524380151930256
[Epoch 550]: loss: 0.017046724026484963
[Epoch 550]: loss: 0.01070009800911031
[Epoch 550]: loss: 0.01977676853518588
[Epoch 600]: loss: 0.015521602593686588
[Epoch 600]: loss: 0.010301524807819252
[Epoch 600]: loss: 0.018508520399747173
[Epoch 650]: loss: 0.01440376231539285
[Epoch 650]: loss: 0.010108810777512606
[Epoch 650]: loss: 0.01759690772700774
[Epoch 700]: loss: 0.013586451521400483
[Epoch 700]: loss: 0.01004544743300226
[Epoch 700]: loss: 0.0169443067865402
[Epoch 750]: loss: 0.012987649335143785
[Epoch 750]: loss: 0.010057251985814728
[Epoch 750]: loss: 0.01647648951766266
[Epoch 800]: loss: 0.012546277972433077
[Epoch 800]: loss: 0.010107806902074088
[Epoch 800]: loss: 0.016138861647197238
[Epoch 850]: loss: 0.012217840730803536
[Epoch 850]: loss: 0.01017386559008349
[Epoch 850]: loss: 0.01589226800834974
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[Epoch 900]: loss: 0.011970390642428712
[Epoch 900]: loss: 0.01024147445393219
[Epoch 900]: loss: 0.01570909960403362
[Epoch 950]: loss: 0.011781199604152755
[Epoch 950]: loss: 0.010302929658207116
[Epoch 950]: loss: 0.015570140226694493
```
Validation Loss 0.01128530784036602

Model’s Loss and Accuracy for Prime digit detection

Loss: 0.02454448
Accuracy: 97.12%

```
Detailed Output:
[Epoch 0]:   validation loss: 0.20135027,   validation accuracy: 69.36%
[Epoch 1]:   validation loss: 0.11589750,   validation accuracy: 85.96%
[Epoch 2]:   validation loss: 0.09951013,   validation accuracy: 87.46%
[Epoch 3]:   validation loss: 0.09272672,   validation accuracy: 88.22%
[Epoch 4]:   validation loss: 0.08894021,   validation accuracy: 88.76%
[Epoch 5]:   validation loss: 0.08646042,   validation accuracy: 89.03%
[Epoch 6]:   validation loss: 0.08460486,   validation accuracy: 89.33%
[Epoch 7]:   validation loss: 0.08283331,   validation accuracy: 89.45%
[Epoch 8]:   validation loss: 0.08034576,   validation accuracy: 89.83%
[Epoch 9]:   validation loss: 0.07701915,   validation accuracy: 90.26%
[Epoch 10]:  validation loss: 0.07336158,   validation accuracy: 90.82%
[Epoch 11]:  validation loss: 0.06953909,   validation accuracy: 91.49%
[Epoch 12]:  validation loss: 0.06556480,   validation accuracy: 92.03%
[Epoch 13]:  validation loss: 0.06145956,   validation accuracy: 92.71%
[Epoch 14]:  validation loss: 0.05736161,   validation accuracy: 93.29%
[Epoch 15]:  validation loss: 0.05348172,   validation accuracy: 93.83%
[Epoch 16]:  validation loss: 0.05002990,   validation accuracy: 94.34%
[Epoch 17]:  validation loss: 0.04706440,   validation accuracy: 94.62%
[Epoch 18]:  validation loss: 0.04454474,   validation accuracy: 94.83%
[Epoch 19]:  validation loss: 0.04240104,   validation accuracy: 95.09%
[Epoch 20]:  validation loss: 0.04056526,   validation accuracy: 95.27%
[Epoch 21]:  validation loss: 0.03898068,   validation accuracy: 95.49%
[Epoch 22]:  validation loss: 0.03760219,   validation accuracy: 95.70%
[Epoch 23]:  validation loss: 0.03639403,   validation accuracy: 95.88%
[Epoch 24]:  validation loss: 0.03532722,   validation accuracy: 95.97%
[Epoch 25]:  validation loss: 0.03437793,   validation accuracy: 96.06%
[Epoch 26]:  validation loss: 0.03352654,   validation accuracy: 96.10%
[Epoch 27]:  validation loss: 0.03275712,   validation accuracy: 96.23%
[Epoch 28]:  validation loss: 0.03205689,   validation accuracy: 96.30%
[Epoch 29]:  validation loss: 0.03141567,   validation accuracy: 96.38%
[Epoch 30]:  validation loss: 0.03082534,   validation accuracy: 96.43%
[Epoch 31]:  validation loss: 0.03027935,   validation accuracy: 96.48%
[Epoch 32]:  validation loss: 0.02977239,   validation accuracy: 96.54%
[Epoch 33]:  validation loss: 0.02930009,   validation accuracy: 96.61%
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[Epoch 34]:  validation loss: 0.02885878,   validation accuracy: 96.62%
[Epoch 35]:  validation loss: 0.02844536,   validation accuracy: 96.64%
[Epoch 36]:  validation loss: 0.02805717,   validation accuracy: 96.65%
[Epoch 37]:  validation loss: 0.02769191,   validation accuracy: 96.73%
[Epoch 38]:  validation loss: 0.02734757,   validation accuracy: 96.76%
[Epoch 39]:  validation loss: 0.02702238,   validation accuracy: 96.81%
[Epoch 40]:  validation loss: 0.02671475,   validation accuracy: 96.81%
[Epoch 41]:  validation loss: 0.02642328,   validation accuracy: 96.86%
[Epoch 42]:  validation loss: 0.02614671,   validation accuracy: 96.89%
[Epoch 43]:  validation loss: 0.02588390,   validation accuracy: 96.97%
[Epoch 44]:  validation loss: 0.02563382,   validation accuracy: 96.99%
[Epoch 45]:  validation loss: 0.02539553,   validation accuracy: 97.04%
[Epoch 46]:  validation loss: 0.02516819,   validation accuracy: 97.05%
[Epoch 47]:  validation loss: 0.02495103,   validation accuracy: 97.08%
[Epoch 48]: validation loss: 0.02474334,   validation accuracy: 97.11%
[Epoch 49]: validation loss: 0.02454448,   validation accuracy:97.12%
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