

# ECGR 5105 Homework 5: Pytorch with SGD and Adam Optimizers

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November 9, 2023

## GitHub Link

[Click here to view the code](#)

## Problem 1.

### 1. SGD Optimizer Loss Values for Different Learning Rates:

The loss values for the SGD Optimizer with a learning rate of 0.1 can be seen below. The values were too large to display properly.

Figure 1: SGD with Learning Rate of 0.1

```
Learning rate of 0.1
Epochs: 500, Training Loss: nan, Validation Loss: nan
Epochs: 1000, Training Loss: nan, Validation Loss: nan
Epochs: 1500, Training Loss: nan, Validation Loss: nan
Epochs: 2000, Training Loss: nan, Validation Loss: nan
Epochs: 2500, Training Loss: nan, Validation Loss: nan
Epochs: 3000, Training Loss: nan, Validation Loss: nan
Epochs: 3500, Training Loss: nan, Validation Loss: nan
Epochs: 4000, Training Loss: nan, Validation Loss: nan
Epochs: 4500, Training Loss: nan, Validation Loss: nan
Epochs: 5000, Training Loss: nan, Validation Loss: nan
```

The loss values for the SGD Optimizer with a learning rate of 0.01 can be seen below. The values were too large to display properly.

Figure 2: SGD with Learning Rate of 0.01

```
Learning rate of 0.01
Epochs: 500, Training Loss: nan, Validation Loss: nan
Epochs: 1000, Training Loss: nan, Validation Loss: nan
Epochs: 1500, Training Loss: nan, Validation Loss: nan
Epochs: 2000, Training Loss: nan, Validation Loss: nan
Epochs: 2500, Training Loss: nan, Validation Loss: nan
Epochs: 3000, Training Loss: nan, Validation Loss: nan
Epochs: 3500, Training Loss: nan, Validation Loss: nan
Epochs: 4000, Training Loss: nan, Validation Loss: nan
Epochs: 4500, Training Loss: nan, Validation Loss: nan
Epochs: 5000, Training Loss: nan, Validation Loss: nan
```

The loss values for the SGD Optimizer with a learning rate of 0.001 can be seen below. The values were too large to display properly.

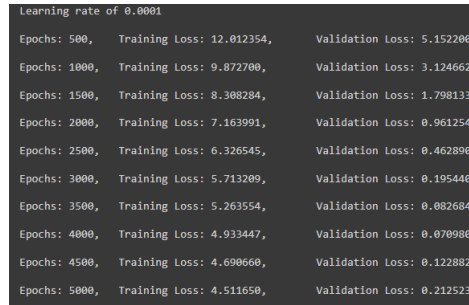
Figure 3: SGD with Learning Rate of 0.001



```
Learning rate of 0.001
Epochs: 500, Training Loss: nan, Validation Loss: nan
Epochs: 1000, Training Loss: nan, Validation Loss: nan
Epochs: 1500, Training Loss: nan, Validation Loss: nan
Epochs: 2000, Training Loss: nan, Validation Loss: nan
Epochs: 2500, Training Loss: nan, Validation Loss: nan
Epochs: 3000, Training Loss: nan, Validation Loss: nan
Epochs: 3500, Training Loss: nan, Validation Loss: nan
Epochs: 4000, Training Loss: nan, Validation Loss: nan
Epochs: 4500, Training Loss: nan, Validation Loss: nan
Epochs: 5000, Training Loss: nan, Validation Loss: nan
```

The loss values for the SGD Optimizer with a learning rate of 0.0001 can be seen below. The values were finally small enough that we can see a drop in the loss values over time.

Figure 4: SGD with Learning Rate of 0.0001

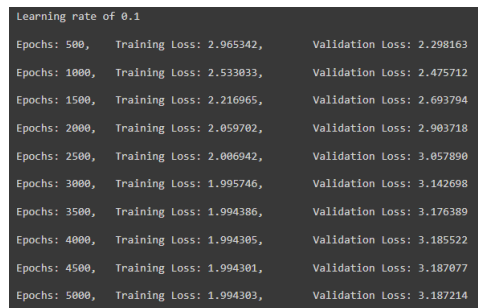


```
Learning rate of 0.0001
Epochs: 500, Training Loss: 12.012354, Validation Loss: 5.152200
Epochs: 1000, Training Loss: 9.872700, Validation Loss: 3.124662
Epochs: 1500, Training Loss: 8.308284, Validation Loss: 1.798133
Epochs: 2000, Training Loss: 7.163991, Validation Loss: 0.961254
Epochs: 2500, Training Loss: 6.326545, Validation Loss: 0.462890
Epochs: 3000, Training Loss: 5.713209, Validation Loss: 0.195440
Epochs: 3500, Training Loss: 5.263554, Validation Loss: 0.082684
Epochs: 4000, Training Loss: 4.933447, Validation Loss: 0.070980
Epochs: 4500, Training Loss: 4.690660, Validation Loss: 0.122882
Epochs: 5000, Training Loss: 4.511650, Validation Loss: 0.212523
```

## 2. Adam Optimizer Loss Values for Different Learning Rates:

The loss values for the Adam Optimizer with a learning rate of 0.1 can be seen below.

Figure 5: Adam with Learning Rate of 0.1



```
Learning rate of 0.1
Epochs: 500, Training Loss: 2.965342, Validation Loss: 2.298163
Epochs: 1000, Training Loss: 2.533033, Validation Loss: 2.475712
Epochs: 1500, Training Loss: 2.216965, Validation Loss: 2.693794
Epochs: 2000, Training Loss: 2.059702, Validation Loss: 2.903718
Epochs: 2500, Training Loss: 2.006942, Validation Loss: 3.057890
Epochs: 3000, Training Loss: 1.995746, Validation Loss: 3.142698
Epochs: 3500, Training Loss: 1.994386, Validation Loss: 3.176389
Epochs: 4000, Training Loss: 1.994305, Validation Loss: 3.185522
Epochs: 4500, Training Loss: 1.994301, Validation Loss: 3.187077
Epochs: 5000, Training Loss: 1.994303, Validation Loss: 3.187214
```

The loss values for the Adam Optimizer with a learning rate of 0.01 can be seen below.

Figure 6: Adam with Learning Rate of 0.01

Learning rate of 0.01		
Epochs: 500,	Training Loss: 7.278435,	Validation Loss: 1.161389
Epochs: 1000,	Training Loss: 4.729887,	Validation Loss: 0.128108
Epochs: 1500,	Training Loss: 3.551420,	Validation Loss: 0.672878
Epochs: 2000,	Training Loss: 3.208128,	Validation Loss: 1.564775
Epochs: 2500,	Training Loss: 3.098825,	Validation Loss: 2.069755
Epochs: 3000,	Training Loss: 3.010406,	Validation Loss: 2.243273
Epochs: 3500,	Training Loss: 2.908556,	Validation Loss: 2.301728
Epochs: 4000,	Training Loss: 2.791894,	Validation Loss: 2.345571
Epochs: 4500,	Training Loss: 2.663229,	Validation Loss: 2.398024
Epochs: 5000,	Training Loss: 2.527826,	Validation Loss: 2.463071

The loss values for the Adam Optimizer with a learning rate of 0.001 can be seen below.

Figure 7: Adam with Learning Rate of 0.001

Learning rate of 0.001		
Epochs: 500,	Training Loss: 115.469864,	Validation Loss: 54.371811
Epochs: 1000,	Training Loss: 14.630404,	Validation Loss: 8.374663
Epochs: 1500,	Training Loss: 9.322581,	Validation Loss: 3.009368
Epochs: 2000,	Training Loss: 8.939436,	Validation Loss: 2.344259
Epochs: 2500,	Training Loss: 8.533458,	Validation Loss: 2.022329
Epochs: 3000,	Training Loss: 8.047647,	Validation Loss: 1.672640
Epochs: 3500,	Training Loss: 7.487889,	Validation Loss: 1.295072
Epochs: 4000,	Training Loss: 6.868734,	Validation Loss: 0.915157
Epochs: 4500,	Training Loss: 6.214909,	Validation Loss: 0.568584
Epochs: 5000,	Training Loss: 5.560564,	Validation Loss: 0.297809

The loss values for the Adam Optimizer with a learning rate of 0.0001 can be seen below.

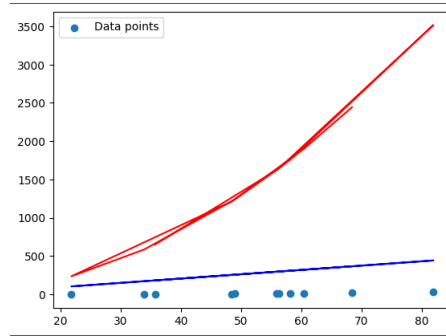
Figure 8: Adam with Learning Rate of 0.0001

Learning rate of 0.0001		
Epochs: 500,	Training Loss: 651.506653,	Validation Loss: 248.671066
Epochs: 1000,	Training Loss: 552.839478,	Validation Loss: 214.257492
Epochs: 1500,	Training Loss: 465.190277,	Validation Loss: 183.393814
Epochs: 2000,	Training Loss: 387.536499,	Validation Loss: 155.749847
Epochs: 2500,	Training Loss: 319.043335,	Validation Loss: 131.057678
Epochs: 3000,	Training Loss: 259.025208,	Validation Loss: 109.090174
Epochs: 3500,	Training Loss: 206.907440,	Validation Loss: 89.694557
Epochs: 4000,	Training Loss: 162.190628,	Validation Loss: 72.691063
Epochs: 4500,	Training Loss: 124.418594,	Validation Loss: 57.953503
Epochs: 5000,	Training Loss: 93.149040,	Validation Loss: 45.355362

### 3. Nonlinear vs Linear Model:

The nonlinear vs linear model plot can be seen below. The nonlinear plot is in red while the linear plot is in blue. As can be seen, the linear plot is a better approximation of the data.

Figure 9: Linear vs Nonlinear Plot



## Problem 2.

### 1. SGD Optimizer Loss Values for Different Learning Rates:

The loss values for the SGD Optimizer with a learning rate of 0.1 can be seen below.

Figure 10: SGD with Learning Rate of 0.1

Learning rate of 0.1		
Epochs: 500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 1000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 1500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 2000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 2500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 3000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 3500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 4000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 4500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 5000,	Training Loss: 0.458730,	Validation Loss: 0.361019

The loss values for the SGD Optimizer with a learning rate of 0.01 can be seen below.

Figure 11: SGD with Learning Rate of 0.01

Learning rate of 0.01		
Epochs: 500,	Training Loss: 0.458730,	Validation Loss: 0.360941
Epochs: 1000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 1500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 2000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 2500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 3000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 3500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 4000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 4500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 5000,	Training Loss: 0.458730,	Validation Loss: 0.361019

The loss values for the SGD Optimizer with a learning rate of 0.001 can be seen below.

Figure 12: SGD with Learning Rate of 0.001

Learning rate of 0.001		
Epochs: 500,	Training Loss: 0.570169,	Validation Loss: 0.412291
Epochs: 1000,	Training Loss: 0.464871,	Validation Loss: 0.359314
Epochs: 1500,	Training Loss: 0.459953,	Validation Loss: 0.358675
Epochs: 2000,	Training Loss: 0.459058,	Validation Loss: 0.359242
Epochs: 2500,	Training Loss: 0.458823,	Validation Loss: 0.359850
Epochs: 3000,	Training Loss: 0.458757,	Validation Loss: 0.360304
Epochs: 3500,	Training Loss: 0.458738,	Validation Loss: 0.360598
Epochs: 4000,	Training Loss: 0.458732,	Validation Loss: 0.360776
Epochs: 4500,	Training Loss: 0.458731,	Validation Loss: 0.360880
Epochs: 5000,	Training Loss: 0.458730,	Validation Loss: 0.360940

The loss values for the SGD Optimizer with a learning rate of 0.0001 can be seen below.

Figure 13: SGD with Learning Rate of 0.0001

Learning rate of 0.0001		
Epochs: 500,	Training Loss: 4.516347,	Validation Loss: 2.664685
Epochs: 1000,	Training Loss: 3.138701,	Validation Loss: 1.877434
Epochs: 1500,	Training Loss: 2.232395,	Validation Loss: 1.358958
Epochs: 2000,	Training Loss: 1.635600,	Validation Loss: 1.017460
Epochs: 2500,	Training Loss: 1.242145,	Validation Loss: 0.792516
Epochs: 3000,	Training Loss: 0.982360,	Validation Loss: 0.644344
Epochs: 3500,	Training Loss: 0.810508,	Validation Loss: 0.546747
Epochs: 4000,	Training Loss: 0.696553,	Validation Loss: 0.482466
Epochs: 4500,	Training Loss: 0.620764,	Validation Loss: 0.440133
Epochs: 5000,	Training Loss: 0.570169,	Validation Loss: 0.412257

## 2. Adam Optimizer Loss Values for Different Learning Rates:

The loss values for the Adam Optimizer with a learning rate of 0.1 can be seen below.

Figure 14: Adam with Learning Rate of 0.1

Learning rate of 0.1		
Epochs: 500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 1000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 1500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 2000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 2500,	Training Loss: 0.458731,	Validation Loss: 0.361037
Epochs: 3000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 3500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 4000,	Training Loss: 0.458730,	Validation Loss: 0.361028
Epochs: 4500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 5000,	Training Loss: 0.458778,	Validation Loss: 0.360968

The loss values for the Adam Optimizer with a learning rate of 0.01 can be seen below.

Figure 15: Adam with Learning Rate of 0.01

Learning rate of 0.01		
Epochs: 500,	Training Loss: 0.458731,	Validation Loss: 0.361048
Epochs: 1000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 1500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 2000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 2500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 3000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 3500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 4000,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 4500,	Training Loss: 0.458730,	Validation Loss: 0.361019
Epochs: 5000,	Training Loss: 0.458730,	Validation Loss: 0.361019

The loss values for the Adam Optimizer with a learning rate of 0.001 can be seen below.

Figure 16: Adam with Learning Rate of 0.001

Learning rate of 0.001		
Epochs: 500,	Training Loss: 1.776844,	Validation Loss: 1.014792
Epochs: 1000,	Training Loss: 0.619942,	Validation Loss: 0.400609
Epochs: 1500,	Training Loss: 0.475987,	Validation Loss: 0.354935
Epochs: 2000,	Training Loss: 0.462052,	Validation Loss: 0.358322
Epochs: 2500,	Training Loss: 0.459338,	Validation Loss: 0.360279
Epochs: 3000,	Training Loss: 0.458803,	Validation Loss: 0.360959
Epochs: 3500,	Training Loss: 0.458735,	Validation Loss: 0.361059
Epochs: 4000,	Training Loss: 0.458730,	Validation Loss: 0.361035
Epochs: 4500,	Training Loss: 0.458730,	Validation Loss: 0.361022
Epochs: 5000,	Training Loss: 0.458730,	Validation Loss: 0.361019

The loss values for the Adam Optimizer with a learning rate of 0.0001 can be seen below.

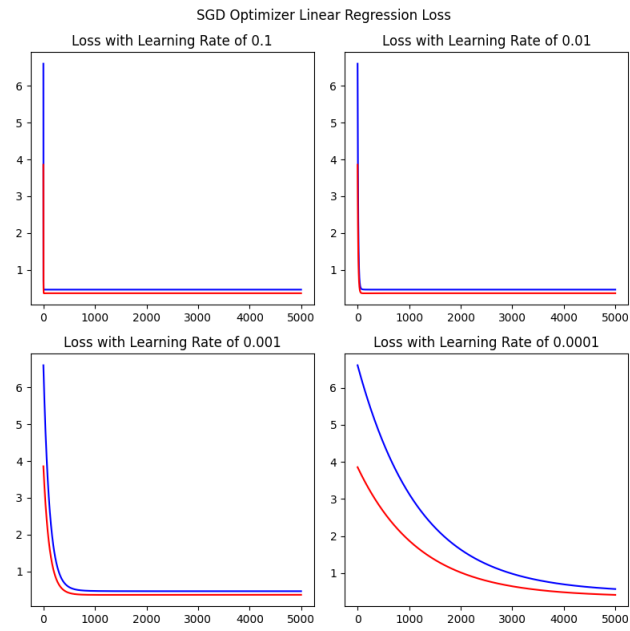
Figure 17: Adam with Learning Rate of 0.0001

Learning rate of 0.0001		
Epochs: 500,	Training Loss: 5.850170,	Validation Loss: 3.425856
Epochs: 1000,	Training Loss: 5.164905,	Validation Loss: 3.023235
Epochs: 1500,	Training Loss: 4.543100,	Validation Loss: 2.649935
Epochs: 2000,	Training Loss: 3.978789,	Validation Loss: 2.310029
Epochs: 2500,	Training Loss: 3.467673,	Validation Loss: 2.003829
Epochs: 3000,	Training Loss: 3.006290,	Validation Loss: 1.729487
Epochs: 3500,	Training Loss: 2.591812,	Validation Loss: 1.485153
Epochs: 4000,	Training Loss: 2.221882,	Validation Loss: 1.269259
Epochs: 4500,	Training Loss: 1.894465,	Validation Loss: 1.080443
Epochs: 5000,	Training Loss: 1.607718,	Validation Loss: 0.917448

### 3. Comparing Results to Homework 2:

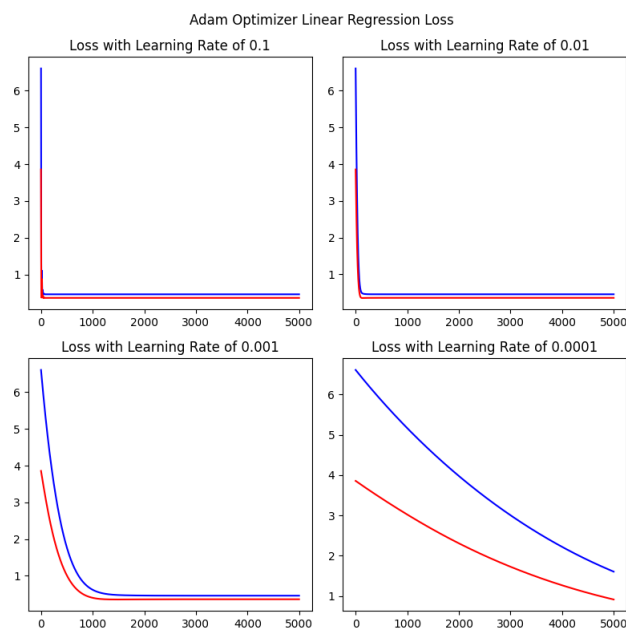
The loss value plots for the SGD Optimizer for all learning rates can be seen below.

Figure 18: SGD Loss Value Plots



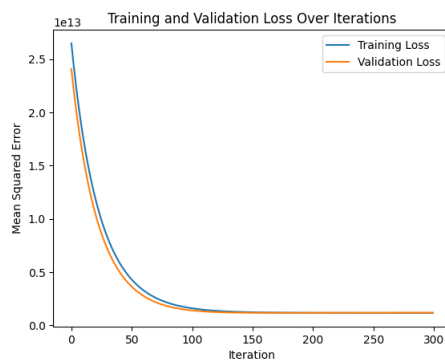
The loss value plots for the Adam Optimizer for all learning rates can be seen below.

Figure 19: Adam Loss Value Plots



The loss value plot from Homework 2 can be seen below. With a larger learning rate for the Adam or SGD optimizer, the loss converges faster than the plot in Homework 2. However, with a smaller learning rate, the linear regression plot from Homework 2 converges faster.

Figure 20: Homework 2 Loss Value Plots



## Problem 3.

### 1. SGD Optimizer Loss Values for Different Learning Rates:

The loss values for the SGD Optimizer with a learning rate of 0.1 can be seen below.



Figure 21: SGD with Learning Rate of 0.1

Learning rate of 0.1		
Epochs: 500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 1000,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 1500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 2000,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 2500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 3000,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 3500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 4000,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 4500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 5000,	Training Loss: 0.327611,	Validation Loss: 0.347557

The loss values for the SGD Optimizer with a learning rate of 0.01 can be seen below.

Figure 22: SGD with Learning Rate of 0.01

Learning rate of 0.01		
Epochs: 500,	Training Loss: 0.327614,	Validation Loss: 0.346775
Epochs: 1000,	Training Loss: 0.327611,	Validation Loss: 0.347543
Epochs: 1500,	Training Loss: 0.327611,	Validation Loss: 0.347556
Epochs: 2000,	Training Loss: 0.327611,	Validation Loss: 0.347556
Epochs: 2500,	Training Loss: 0.327611,	Validation Loss: 0.347556
Epochs: 3000,	Training Loss: 0.327611,	Validation Loss: 0.347556
Epochs: 3500,	Training Loss: 0.327611,	Validation Loss: 0.347556
Epochs: 4000,	Training Loss: 0.327611,	Validation Loss: 0.347556
Epochs: 4500,	Training Loss: 0.327611,	Validation Loss: 0.347556
Epochs: 5000,	Training Loss: 0.327611,	Validation Loss: 0.347556

The loss values for the SGD Optimizer with a learning rate of 0.001 can be seen below.

Figure 23: SGD with Learning Rate of 0.001

Learning rate of 0.001		
Epochs: 500,	Training Loss: 0.698988,	Validation Loss: 0.690179
Epochs: 1000,	Training Loss: 0.363056,	Validation Loss: 0.346409
Epochs: 1500,	Training Loss: 0.333716,	Validation Loss: 0.335741
Epochs: 2000,	Training Loss: 0.328943,	Validation Loss: 0.338984
Epochs: 2500,	Training Loss: 0.327971,	Validation Loss: 0.341872
Epochs: 3000,	Training Loss: 0.327728,	Validation Loss: 0.343774
Epochs: 3500,	Training Loss: 0.327655,	Validation Loss: 0.345014
Epochs: 4000,	Training Loss: 0.327629,	Validation Loss: 0.345838
Epochs: 4500,	Training Loss: 0.327619,	Validation Loss: 0.346393
Epochs: 5000,	Training Loss: 0.327614,	Validation Loss: 0.346770

The loss values for the SGD Optimizer with a learning rate of 0.0001 can be seen below.

Figure 24: SGD with Learning Rate of 0.0001

Learning rate of 0.0001		
Epochs: 500,	Training Loss: 10.976434,	Validation Loss: 12.851481
Epochs: 1000,	Training Loss: 7.296107,	Validation Loss: 8.524354
Epochs: 1500,	Training Loss: 4.929107,	Validation Loss: 5.723977
Epochs: 2000,	Training Loss: 3.398851,	Validation Loss: 3.903997
Epochs: 2500,	Training Loss: 2.403218,	Validation Loss: 2.715422
Epochs: 3000,	Training Loss: 1.750390,	Validation Loss: 1.934889
Epochs: 3500,	Training Loss: 1.318346,	Validation Loss: 1.419089
Epochs: 4000,	Training Loss: 1.029275,	Validation Loss: 1.075836
Epochs: 4500,	Training Loss: 0.833404,	Validation Loss: 0.845630
Epochs: 5000,	Training Loss: 0.698782,	Validation Loss: 0.689937

## 2. Adam Optimizer Loss Values for Different Learning Rates:

The loss values for the Adam Optimizer with a learning rate of 0.1 can be seen below.

Figure 25: Adam with Learning Rate of 0.1

Learning rate of 0.1		
Epochs: 500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 1000,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 1500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 2000,	Training Loss: 0.327611,	Validation Loss: 0.347485
Epochs: 2500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 3000,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 3500,	Training Loss: 0.327611,	Validation Loss: 0.347647
Epochs: 4000,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 4500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 5000,	Training Loss: 0.327614,	Validation Loss: 0.347107

The loss values for the Adam Optimizer with a learning rate of 0.01 can be seen below.

Figure 26: Adam with Learning Rate of 0.01

Learning rate of 0.01		
Epochs: 500,	Training Loss: 0.327644,	Validation Loss: 0.345123
Epochs: 1000,	Training Loss: 0.327611,	Validation Loss: 0.347555
Epochs: 1500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 2000,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 2500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 3000,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 3500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 4000,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 4500,	Training Loss: 0.327611,	Validation Loss: 0.347557
Epochs: 5000,	Training Loss: 0.327611,	Validation Loss: 0.347557

The loss values for the Adam Optimizer with a learning rate of 0.001 can be seen below.

Figure 27: Adam with Learning Rate of 0.001

Learning rate of 0.001		
Epochs: 500,	Training Loss: 4.365370,	Validation Loss: 4.919113
Epochs: 1000,	Training Loss: 0.912715,	Validation Loss: 0.894507
Epochs: 1500,	Training Loss: 0.380849,	Validation Loss: 0.339822
Epochs: 2000,	Training Loss: 0.336079,	Validation Loss: 0.324214
Epochs: 2500,	Training Loss: 0.330054,	Validation Loss: 0.332314
Epochs: 3000,	Training Loss: 0.328214,	Validation Loss: 0.338652
Epochs: 3500,	Training Loss: 0.327719,	Validation Loss: 0.343363
Epochs: 4000,	Training Loss: 0.327624,	Validation Loss: 0.346048
Epochs: 4500,	Training Loss: 0.327612,	Validation Loss: 0.347167
Epochs: 5000,	Training Loss: 0.327611,	Validation Loss: 0.347491

The loss values for the Adam Optimizer with a learning rate of 0.0001 can be seen below.

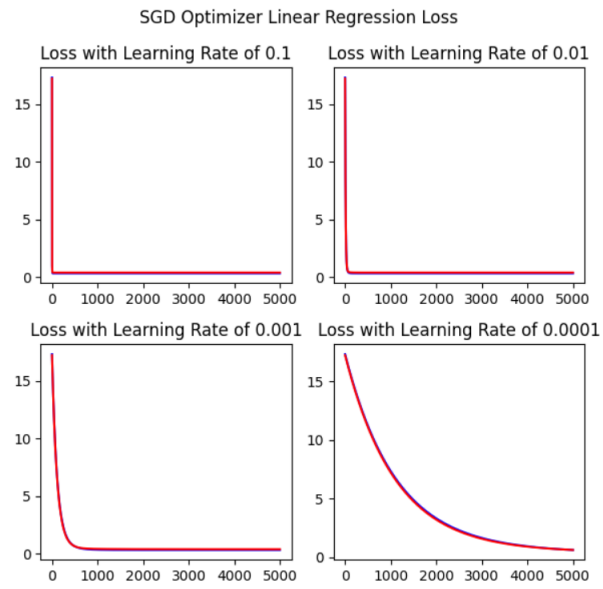
Figure 28: Adam with Learning Rate of 0.0001

Learning rate of 0.0001		
Epochs: 500,	Training Loss: 14.850813,	Validation Loss: 17.369620
Epochs: 1000,	Training Loss: 13.150164,	Validation Loss: 15.361338
Epochs: 1500,	Training Loss: 11.593034,	Validation Loss: 13.510539
Epochs: 2000,	Training Loss: 10.166720,	Validation Loss: 11.810945
Epochs: 2500,	Training Loss: 8.861798,	Validation Loss: 10.256541
Epochs: 3000,	Training Loss: 7.670779,	Validation Loss: 8.839624
Epochs: 3500,	Training Loss: 6.587610,	Validation Loss: 7.553000
Epochs: 4000,	Training Loss: 5.607339,	Validation Loss: 6.390676
Epochs: 4500,	Training Loss: 4.725801,	Validation Loss: 5.347606
Epochs: 5000,	Training Loss: 3.939345,	Validation Loss: 4.419360

### 3. Comparing Results to Homework 2:

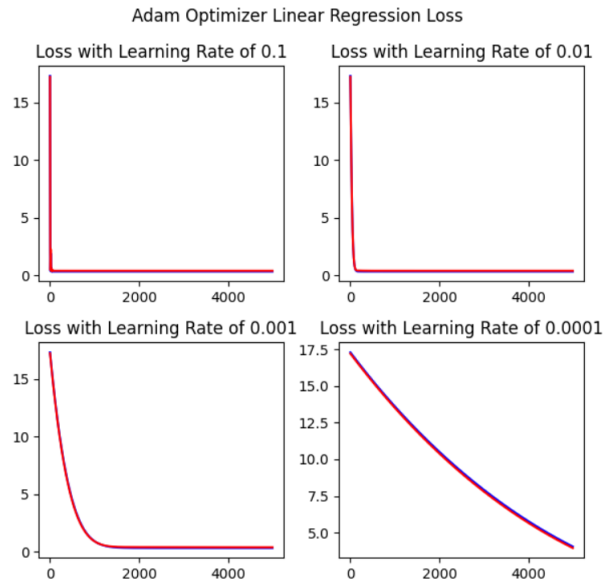
The loss value plots for the SGD Optimizer for all learning rates can be seen below.

Figure 29: SGD Loss Value Plots



The loss value plots for the Adam Optimizer for all learning rates can be seen below.

Figure 30: Adam Loss Value Plots



The loss value plot from Homework 2 can be seen below. With a larger learning rate for the Adam or SGD optimizer, the loss converges faster than the plot in Homework 2. However, with a smaller learning rate, the linear regression plot from Homework 2 converges faster.

Figure 31: Homework 2 Loss Value Plots

