CAP-6610 HW 2

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Perceptron Learning Algorithm

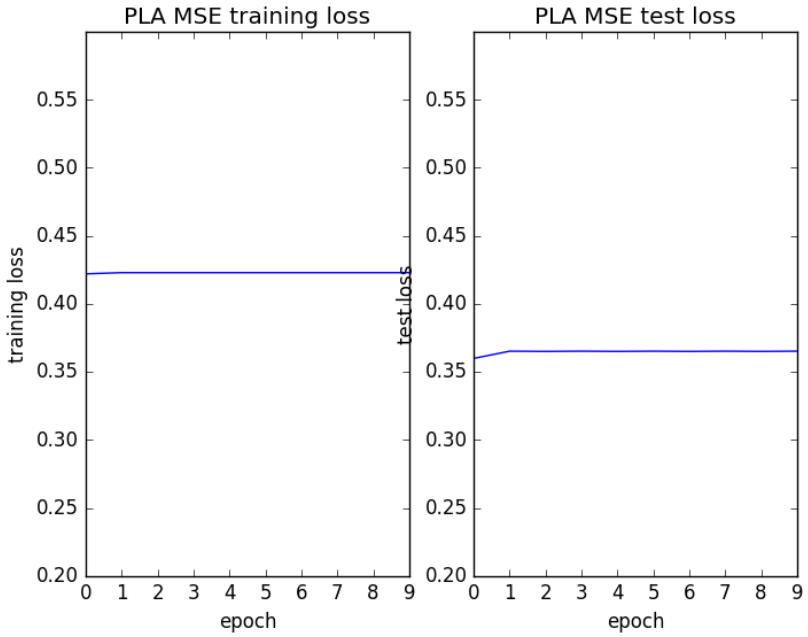
Run with `pla.py --model PLA --n_epochs 10`

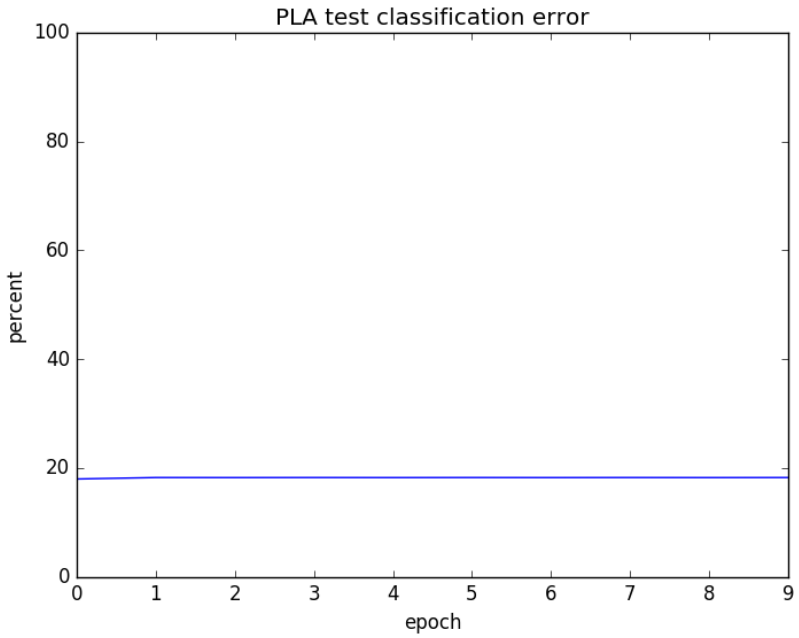
No need to specify the random seed in the arguments, since the 5 seeds are pre-specified within the code.

On the Bank Marketing Data Set, using 10% of the data, PLA achieves a classification error of `18.26 %`, train MSE of `0.42282176`, and test MSE of `0.36513274`. Results are averaged over 5 random seeds and are shown for 10 epochs.

The performance on the dataset is benchmarked by 2 methods.

1. Always guessing the label 1.0 (No response) achieved `11.64 %` classification error averaged across 5 random seeds.
2. The `sklearn` Logistic Regression classifier with default parameters achieved `2.22 %` classification error averaged across 5 random seeds.



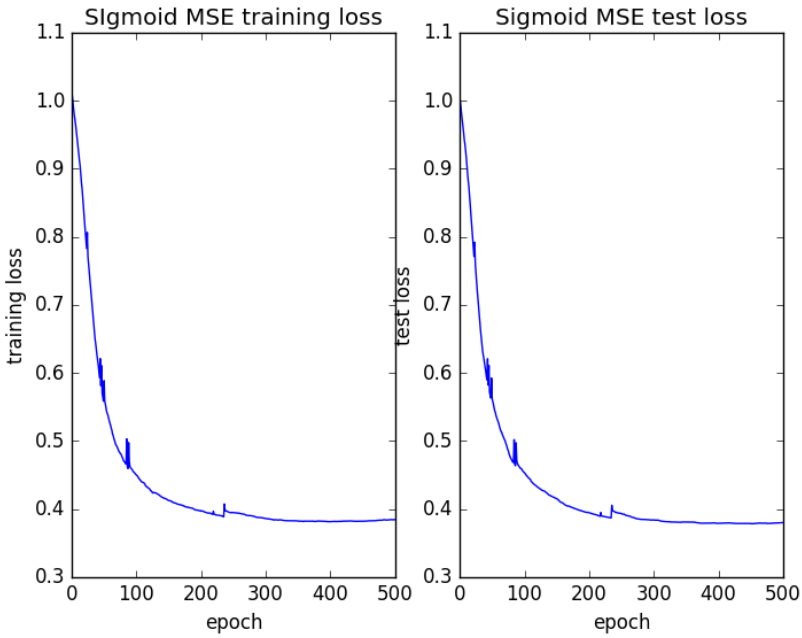


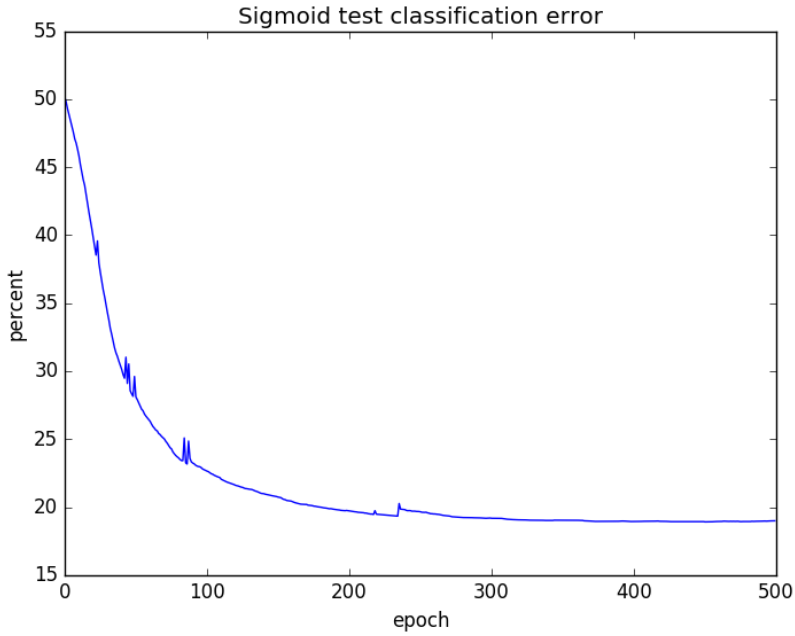
The data was not reshuffled between epochs; after one pass over the dataset, if the training data was re-sampled, the weights completely changed.

Single-node Neural Network

Run with `pla.py --model sigmoid --learning_rate 0.1 --n_epochs 500`

On the Bank Marketing Data Set, using 10% of the data, the single-node neural net achieved a classification error of `18.99 %`, train MSE of `0.384254754533`, and test MSE `0.37982300885`. Results averaged over 5 random seeds. No need to specify the random seed in the arguments, since the 5 seeds are pre-specified within the code. After a hyper-parameter search, a learning rate of `0.1` was selected. The weights were initially sampled from a standard normal distribution.


SIgmoid MSE training loss
training loss
epoch
Sigmoid MSE test loss
test loss
epoch


Sigmoid test classification error
percent
epoch

Multi-Layer Perceptron

Run with `python mlp.py --random_seed 82727 --n_epochs 20000 --learning_rate 0.025`

3-layer MLP with two input units, ten hidden units, and one output unit. Objective is to learn the concept of a circle in 2D space. A label of +1 is assigned if `(x - a)^2 + (y - b)^2 < r^2` and is labeled -1 otherwise.

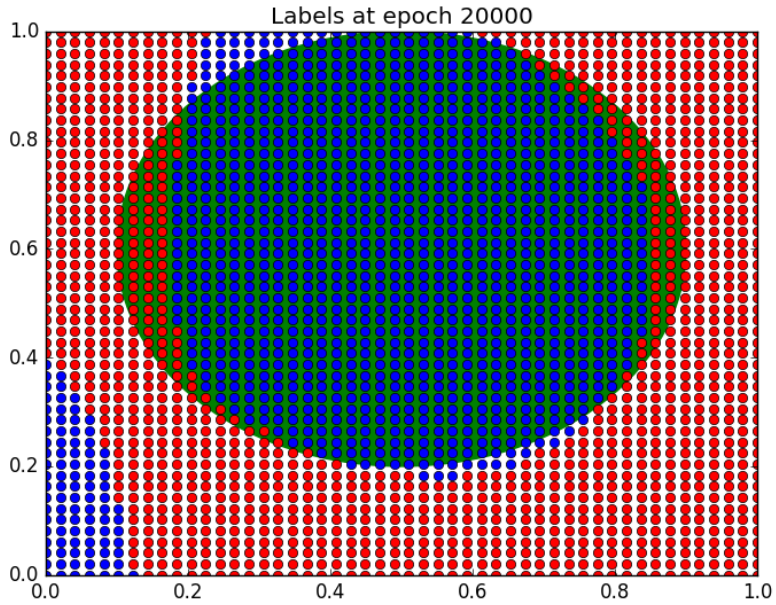
All data is drawn from the unit square, and `a = 0.5`, `b = 0.6`, and `r = 0.4`.

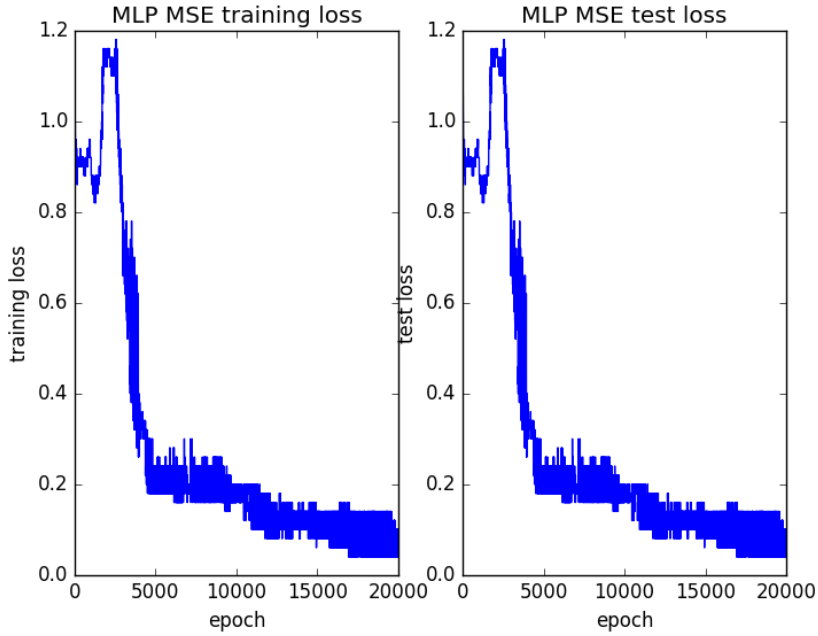
Training data is 100 random samples uniformly distributed on the unit square, and test data is 100 random samples drawn similarly.

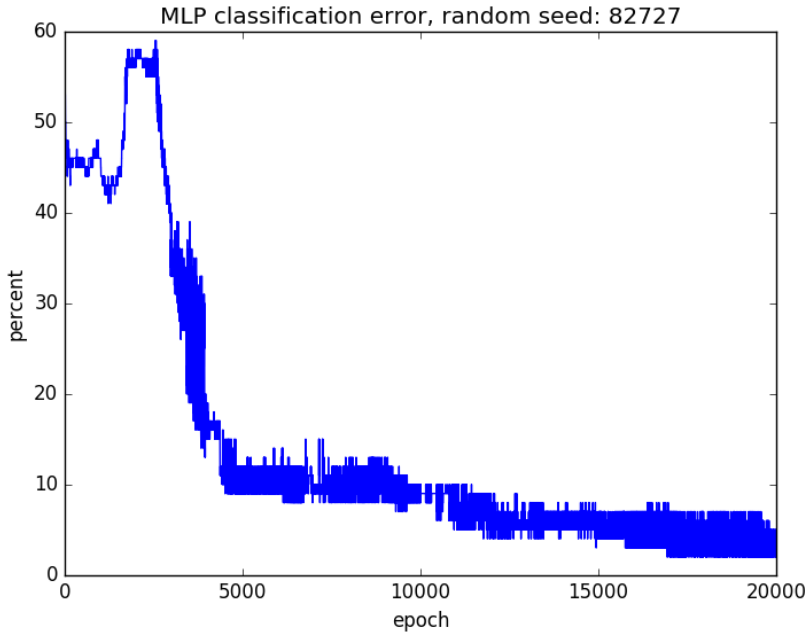
Best results over running 5 different random seeds for 20,000 epochs was a test MSE of `0.06` and a classification error of `2.00 %`.

After a hyper-parameter search over 5 different random seeds, the learning rate of `0.025` was selected. Weights were initialized from a normal distribution with std dev of `2`.

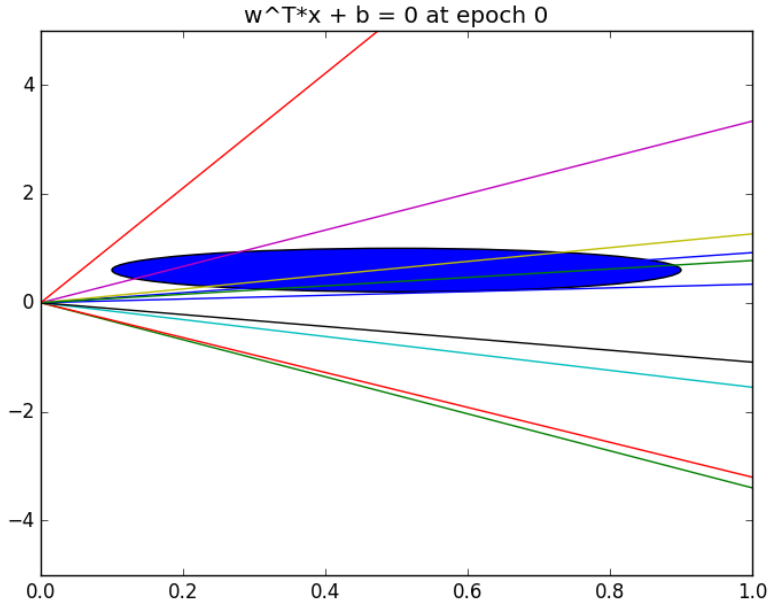
After 20,000 epochs, the network was able to learn the concept of the circle:

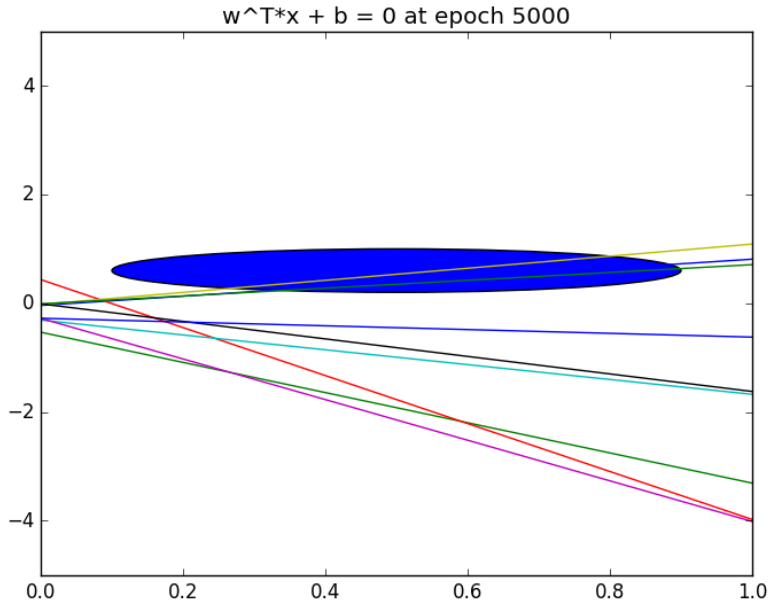


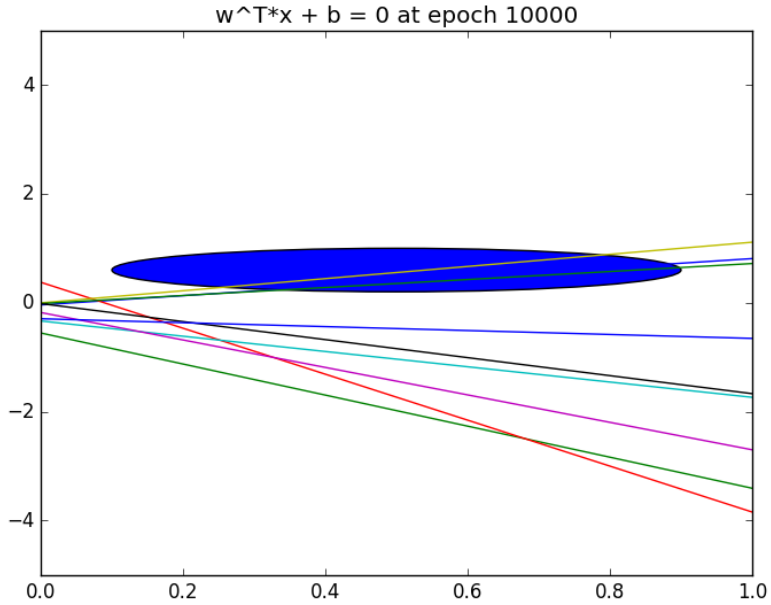


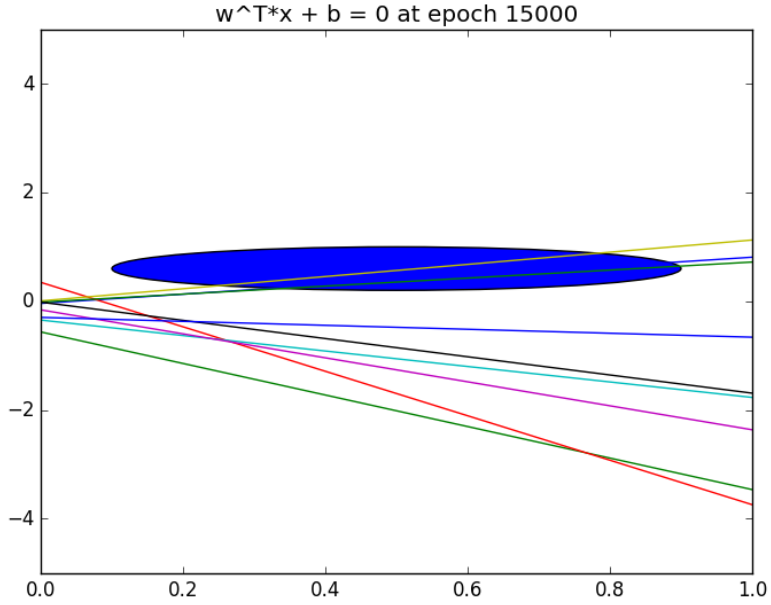


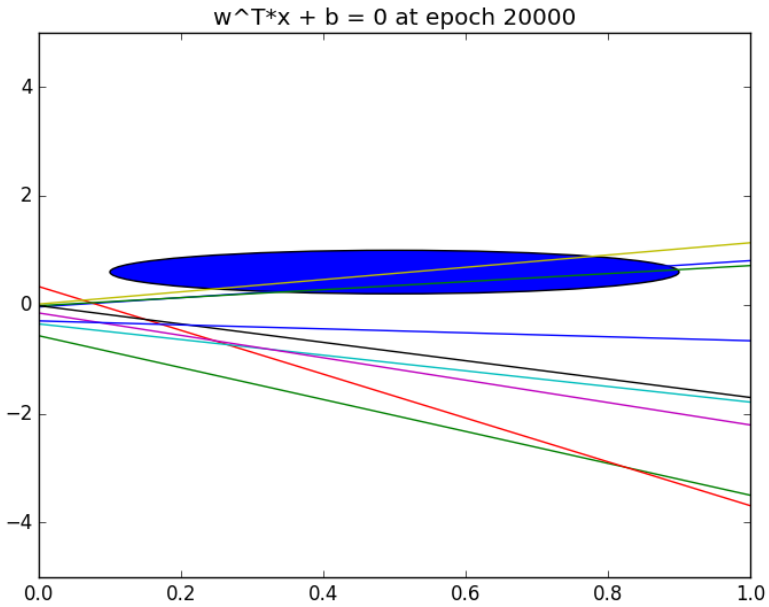
Hyperplanes `\sum w_i x_i + b = 0` plotted at intervals:


w^T*x + b = 0 at epoch 0
4
2
0
−2
−4
0.0
0.2
0.4
0.6
0.8
1.0


w^T*x + b = 0 at epoch 5000
4
2
0
−2
−4
0.0
0.2
0.4
0.6
0.8
1.0


w^T*x + b = 0 at epoch 10000
4
2
0
−2
−4
0.0
0.2
0.4
0.6
0.8
1.0


w^T*x + b = 0 at epoch 15000
4
2
0
−2
−4
0.0
0.2
0.4
0.6
0.8
1.0



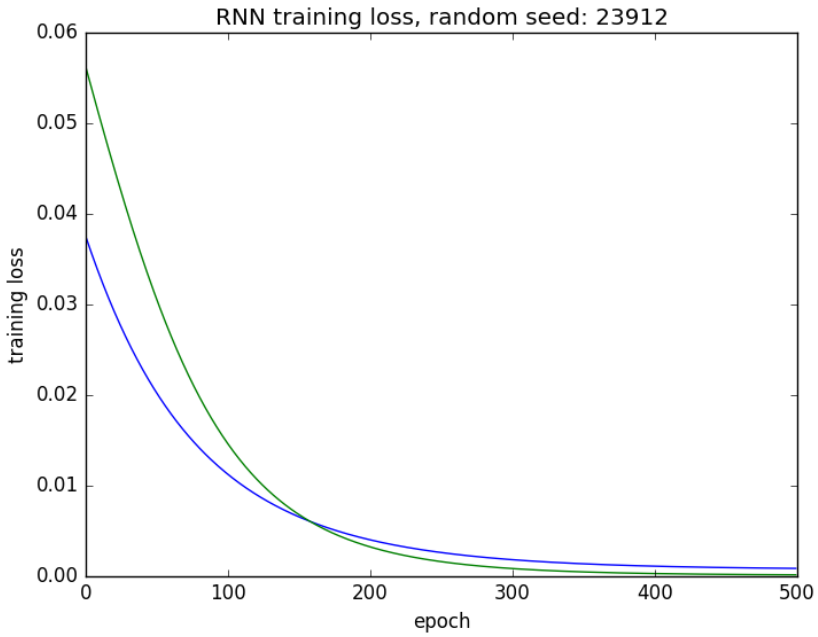
Recurrent Neural-Network

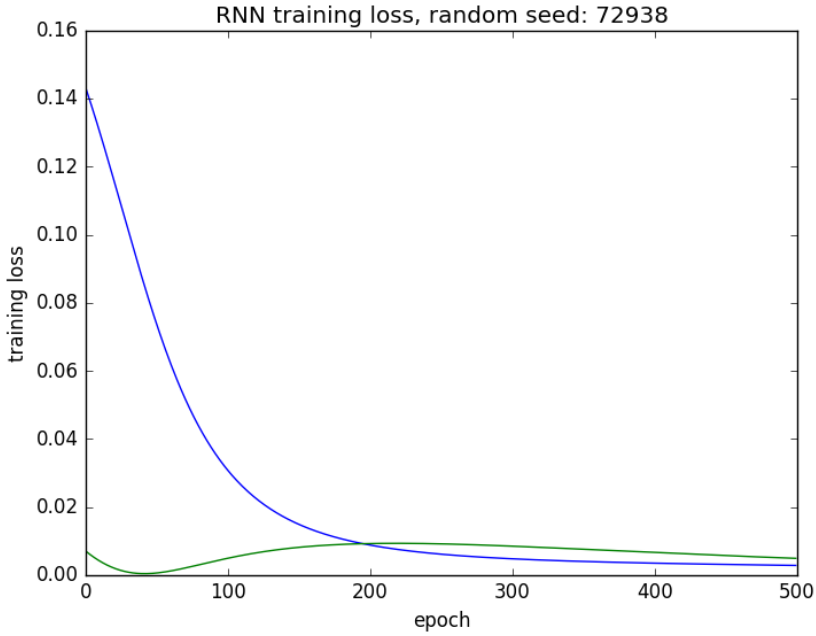
Run with `python rnn.py --random_seed 1234 --learning_rate 0.1 --n_epochs 500`

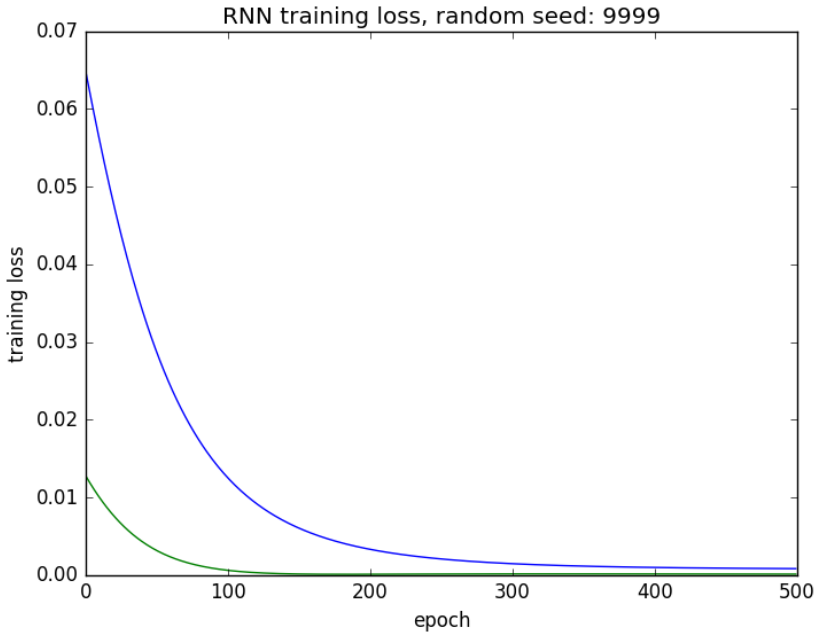
Goal was to determine the weights for a simple RNN architecture that produced outputs `y1` and `y1` for 200 input pairs `x1` and `x2`. These are the results of running 5 experiments, each with a different random seed. After a hyper-parameter search, a learning rate of `0.1` was chosen for gradient descent. Weights were initialized from a normal distribution with a std dev of `3`. Each entry of the table shows the resulting weights after `500` epochs for a different random seed. The plots show the MSE of the training loss vs. epochs.

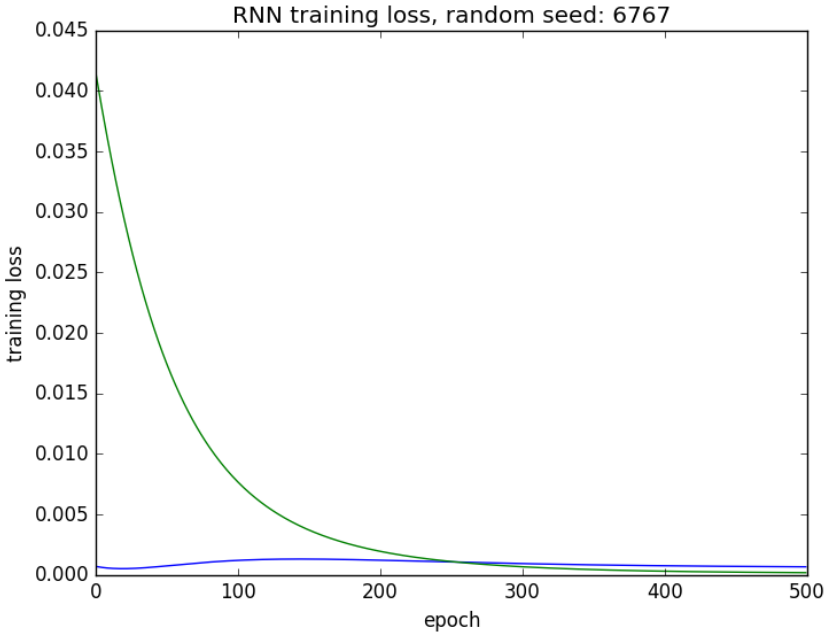
Random Seed	y1 (MSE)	y2 (MSE)
23912	0.0008	0.0001
72938	0.0028	0.0049
9999	0.0008	0.0001
6767	0.0007	0.0002
1123	0.0009	0.0001

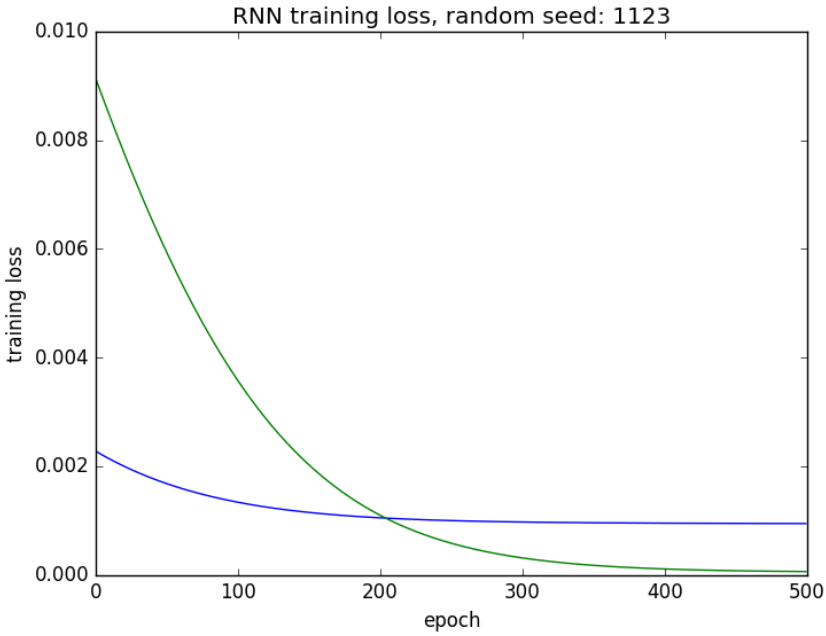
w1	w2	w1_hat	w2_hat	bias1	bias2
-0.08824226	1.05798196	0.56187399	-2.40338361	0.65013105	-1.24926364
-4.03109385	-0.90386201	1.6435506	-2.49336755	1.31868148	-0.46683088
-1.11172633	-0.17362505	1.77607984	-1.46465122	1.00974762	-0.51267624
1.41394524	0.46672458	-1.39501531	-1.31052867	0.15320471	-0.83057737
1.4844188	-1.55841486	-0.65509823	-0.38466215	0.01454801	0.47195181




RNN training loss, random seed: 72938
training loss
epoch
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
100
200
300
400
500


RNN training loss, random seed: 9999
training loss
epoch
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0
100
200
300
400
500


RNN training loss, random seed: 6767
training loss
epoch
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
100
200
300
400
500


RNN training loss, random seed: 1123
training loss
epoch
0.010
0.008
0.006
0.004
0.002
0.000
0
100
200
300
400
500