Homework 6. Eye Blink Model

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Eye Blink Model

Now tune neural networks to produce the best model you can.

Use just the training data to tune your parameters (cross validation or a hold-out set); reserve the test set for final accuracy measurement.

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1 Point -- Change the features in at least one way [ increase or decrease the
image scaling provided by the sample, change normalization, or add momentum to
your back propagation. ]. Include a table showing the results and a few sentences
describing if and how it helped.

1 Point -- Use 2-3 tables and not more than 200 words to describe the parameter
tuning you did. Describe one place where you examined the output of the modeling
process and used the insight to improve your modeling process. What was this
output? What change did you make because of it?

1 Point -- Include an ROC curve comparing the best random forest model you got on
hand-crafted features (last assignment); your initial Neural Network (before any
tuning); and your final resulting network.

1 Point -- In no more than 300 words describe the process, which model is best,
why, and what you think could improve your results further.
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I took four approaches to tune the model; 1) image size, 2) normalization, 3) step size(η), and 3) momentum in Mitchell (4.18). And a particular step size and momentum parameter cases produced a slightly better performance from learning rate and/or accuracies perspectives.

First of all, reducing image scale didn't help at all. I tried to reduce the dimension of the problem in feature selection hoping the overfitting observed in neural network assignment but it turned out losing accuracy, 0.82. And I reconfigured to use 12 x 12 scale but changed the normalization of intensity and got below results, which are pretty similar results among them.

Changing Image Scale by 4 (to 6 x 6)

- Statistics:

	1	0
1	(TP) 488	(FN) 110
0	(FP) 107	(TN) 507

Accuracy: 0.820957095709571

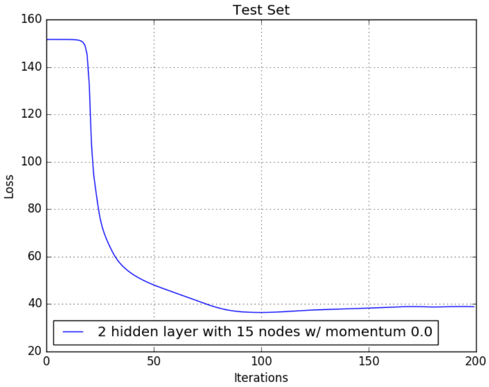
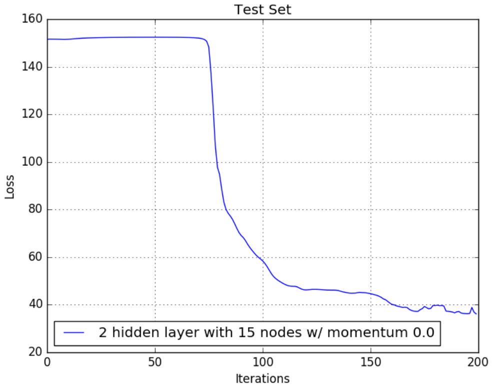
And I reconfigured to use 12 x 12 scale but changed the normalization of intensity and got below results, which are pretty similar results among them.

Chaning Normalization

Factors	133	255	510
Accuracies	0.9166666666666666	0.9133663366336634	0.9051155115511551

Tunning step size change

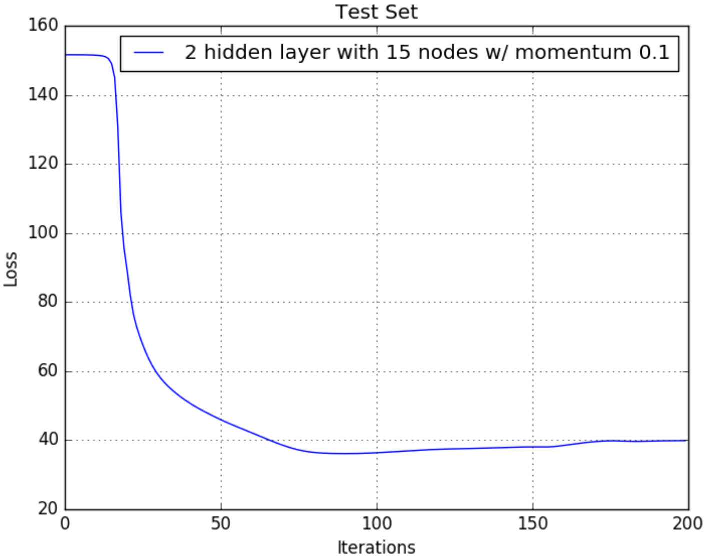
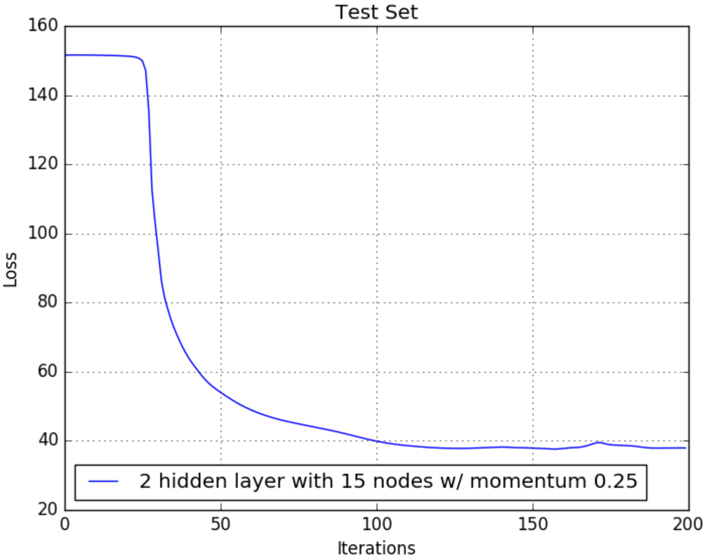
With the not so impressive results above, I examined output data and graphs and noticed the there is an initial period where loss function doesn't decrease. I thought it is related to the learning rate (η). I tunned step size and got accuracy results below. What interesting to me was the step size with 0.08 (aggressive learning rate) took more time actually to start dropping (visiable) loss. And also the loss function ($\eta=0.08$) overfitting after 120 iterations. I think the learning rate is little too high to find the minimum in our 145-dimensional problem.

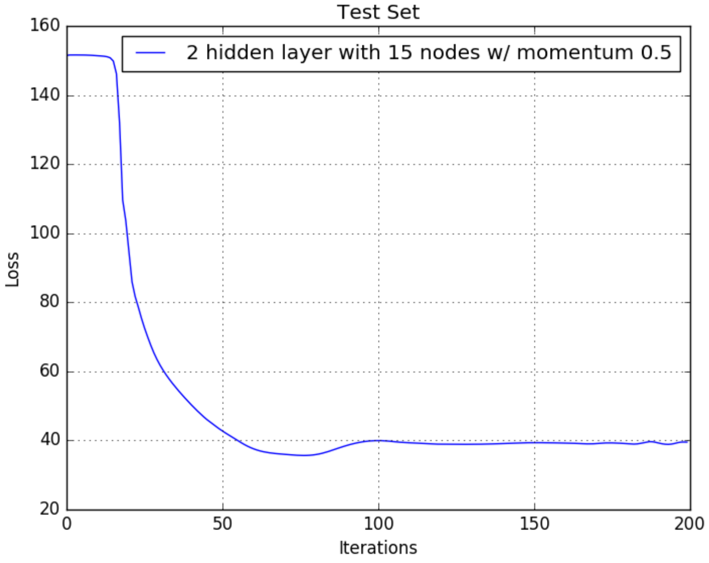
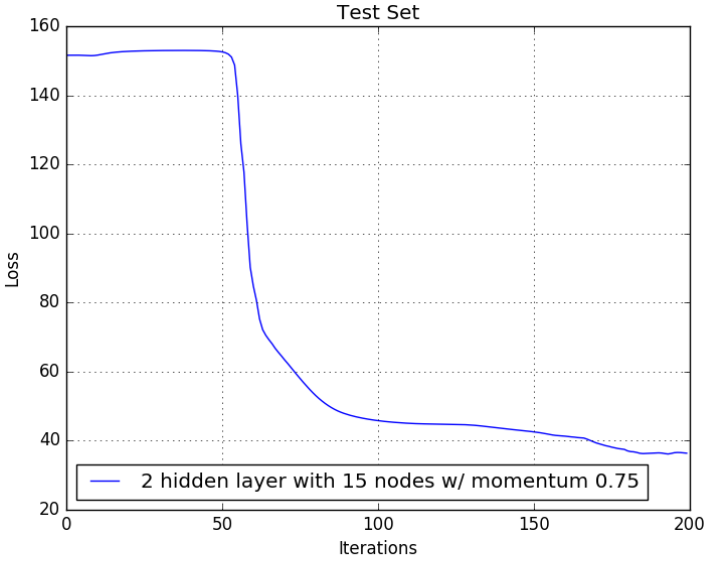
Step Size	0.05	0.08
Accuracies	0.9224422442244224	0.9257425742574258
Loss		

Adding Momentum

Once I feel the network model produces expected results, I added momentum in model based on Mitchell's (4.18) equation. Below table shows the accuracy results and loss varying momentum values between 0 and 1. It looks to me the momentum(0.1 and 0.5) accelerates the gradient descent and reduces the overfitting. I didn't get a chance to find the best momentum values for our case.

Momentum	Accuracy at 200 iteration (Highest Accuracy)	Loss

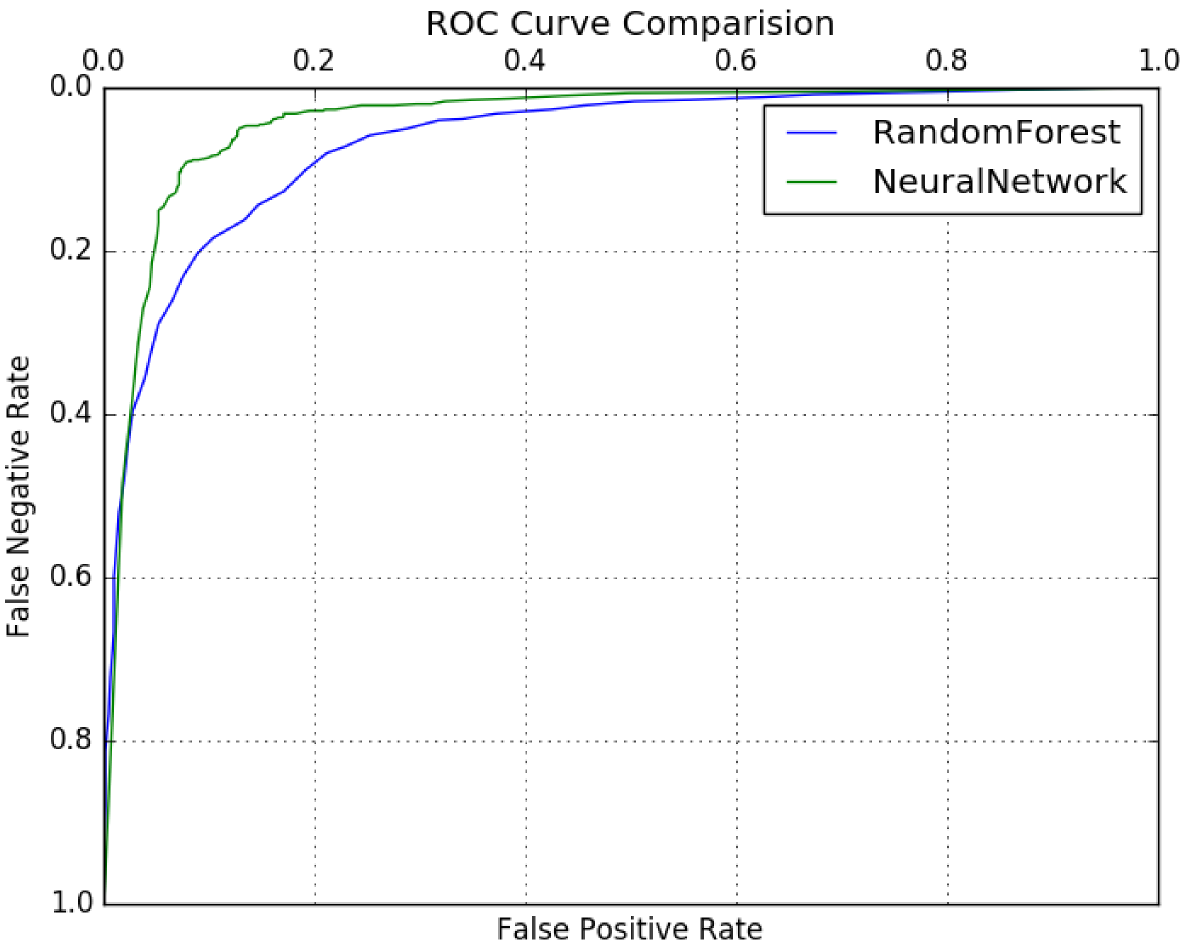
Momentum	Accuracy at 200 iteration (Highest Accuracy)	Loss
0.1	0.9117161716171617 (0.9249174917491749)	
0.25	0.9183168316831684 (0.9249174917491749)	

Momentum	Accuracy at 200 iteration (Highest Accuracy)	Loss
0.5	0.9166666666666666 (0.9298679867986799)	
0.75	0.9207920792079208 (0.9257425742574258)	

ROC Curve Comparison

For ROC curve comparison, I used the following parameters, which was aggregated from previous homework and defaults for the neural network model. The plot below indicates higher AUC and accuracies on Neural Network.

```
    config = {'min_to_split': 2,
              'bagging_w_replacement': True,
              'num_trees': 40,
              'feature_restriction': 0,    # all features
              'num_hidden_layer' : 2,
              'num_nodes' : 15,
              'step_size' : 0.05,
                'iterations' : 200}
```



Appendix

A. Accuracy Data Log for Parameter Sweeps

1. Changing Normalization

Factors	133	255	510
Accuracies	0.9166666666666666	0.9133663366336634	0.9051155115511551

a. norm_factor = 133

- Statistics:

	1	0
1	(TP) 533	(FN) 65
0	(FP) 36	(TN) 578

Accuracy: 0.9166666666666666 Precision: 0.9367311072056239 Recall: 0.8913043478260869 FPR: 0.05863192182410423 FNR: 0.10869565217391304

b. norm_factor = 255

- Statistics:

	1	0
1	(TP) 515	(FN) 83
0	(FP) 22	(TN) 592

Accuracy: 0.9133663366336634 Precision: 0.9590316573556797 Recall: 0.8612040133779264 FPR: 0.035830618892508145 FNR: 0.13879598662207357

c. norm_factor = 510

- Statistics:

	1	0
1	(TP) 548	(FN) 50
0	(FP) 65	(TN) 549

Accuracy: 0.9051155115511551 Precision: 0.8939641109298532 Recall: 0.9163879598662207 FPR: 0.10586319218241043 FNR: 0.08361204013377926

2. Changing Step Size

a. Step Size = 0.05

- Statistics:

	1	0
1	(TP) 526	(FN) 72
0	(FP) 22	(TN) 592

Accuracy: 0.9224422442244224 Precision: 0.9598540145985401 Recall: 0.8795986622073578 FPR: 0.035830618892508145 FNR: 0.12040133779264214

b. Step Size = 0.08

- Statistics:

	1	0
1	(TP) 550	(FN) 48

	1	0
0	(FP) 42	(TN) 572

Accuracy: 0.9257425742574258 Precision: 0.9290540540540541 Recall: 0.919732441471572 FPR: 0.06840390879478828 FNR: 0.0802675585284281

3. Adding (weight) Momentums

a. Momentum = 0.0 (no momentum)

Best Accuracy at 83 / 200 iterations

- Statistics:

	1	0
1	(TP) 561	(FN) 37
0	(FP) 54	(TN) 560

Accuracy: 0.9249174917491749 Precision: 0.9121951219512195 Recall: 0.9381270903010034 FPR: 0.08794788273615635 FNR: 0.061872909698996656

- Statistics:

	1	0
1	(TP) 526	(FN) 72
0	(FP) 22	(TN) 592

Accuracy: 0.9224422442244224 Precision: 0.9598540145985401 Recall: 0.8795986622073578 FPR: 0.035830618892508145 FNR: 0.12040133779264214

a. Momentum = 0.1

Best Accuracy at 78 / 200 iterations

- Statistics:

	1	0
1	(TP) 556	(FN) 42
0	(FP) 49	(TN) 565

Accuracy: 0.9249174917491749 Precision: 0.9190082644628099 Recall: 0.9297658862876255 FPR: 0.07980456026058631 FNR: 0.07023411371237458

- Statistics:

	1	0
1	(TP) 521	(FN) 77
0	(FP) 30	(TN) 584

Accuracy: 0.9117161716171617 Precision: 0.9455535390199638 Recall: 0.8712374581939799 FPR: 0.048859934853420196 FNR: 0.12876254180602006

b. Momentum = 0.25

Best Accuracy at 110 / 200 iterations

- Statistics:

	1	0
1	(TP) 555	(FN) 43
0	(FP) 48	(TN) 566

Accuracy: 0.9249174917491749 Precision: 0.9203980099502488 Recall: 0.9280936454849499 FPR: 0.0781758957654723 FNR: 0.07190635451505016

- Statistics:

	1	0
1	(TP) 523	(FN) 75
0	(FP) 24	(TN) 590

Accuracy: 0.9183168316831684 Precision: 0.9561243144424132 Recall: 0.8745819397993311 FPR: 0.03908794788273615 FNR: 0.1254180602006689

c. Momentum = 0.5

Best Accuracy at 71 / 200 iterations

- Statistics:

	1	0
1	(TP) 553	(FN) 45
0	(FP) 40	(TN) 574

Accuracy: 0.9298679867986799 Precision: 0.9325463743676222 Recall: 0.9247491638795987 FPR: 0.06514657980456026 FNR: 0.07525083612040134

- Statistics:

	1	0
1	(TP) 525	(FN) 73
0	(FP) 28	(TN) 586

Accuracy: 0.9166666666666666 Precision: 0.9493670886075949 Recall: 0.8779264214046822 FPR: 0.04560260586319218 FNR: 0.12207357859531773

d. Momentum = 0.75

Best Accuracy at 187 / 200 iterations

- Statistics:

	1	0
1	(TP) 548	(FN) 50
0	(FP) 40	(TN) 574

Accuracy: 0.9257425742574258 Precision: 0.9319727891156463 Recall: 0.9163879598662207 FPR: 0.06514657980456026 FNR: 0.08361204013377926

- Statistics:

	1	0
1	(TP) 546	(FN) 52
0	(FP) 44	(TN) 570

Accuracy: 0.9207920792079208 Precision: 0.9254237288135593 Recall: 0.9130434782608695 FPR: 0.07166123778501629 FNR: 0.08695652173913043
