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Perceptron

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OVERVIEW

The goal of a perceptron is to linearly classify data (with numeric attributes) by incrementally adjusting a weight vector. The dot product of the weight vector with the instance's numeric attributes (and bias) is used to predict the class.

GOALS

1. Create a simple perceptron in Python.
2. Analyze the performance and impact of number of epochs and learning rate.

RESULTS

Correct Implementation

After running the `fit` and `score` methods on the test data with a learning rate of `0.1` and a deterministic number of epochs (10), the perceptron produced the following weights and accuracy:

Accuracy:
Weights:

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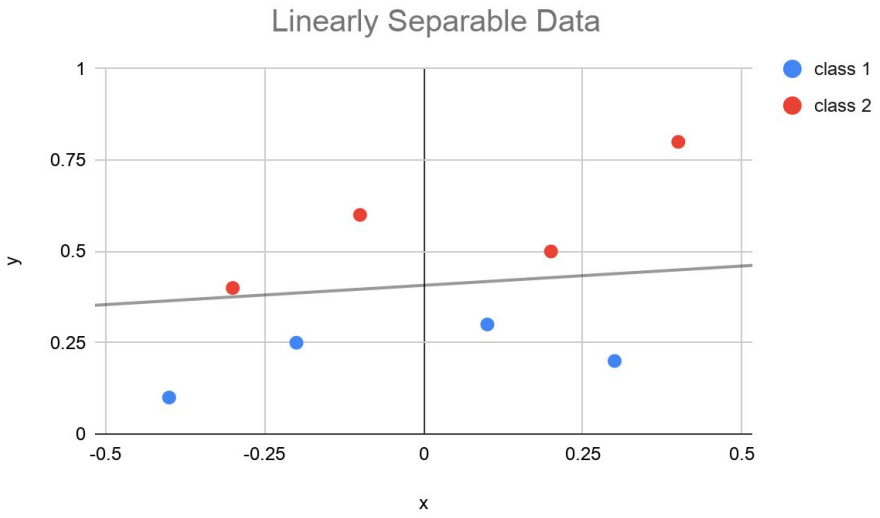
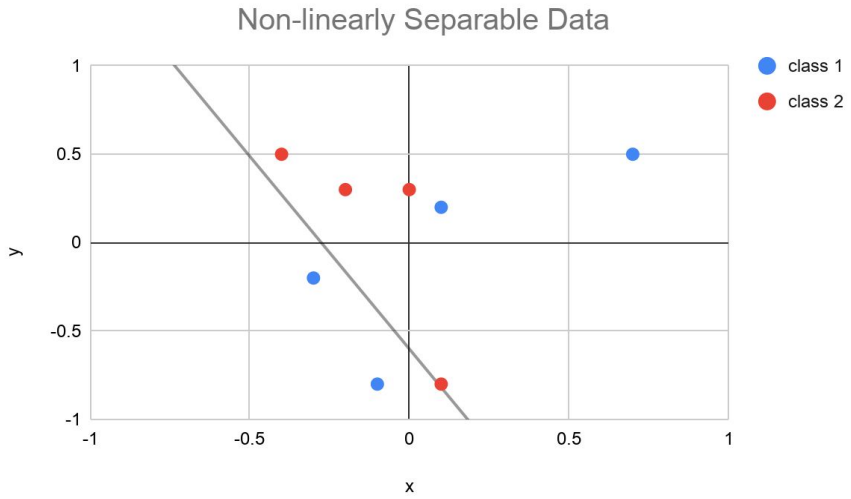
Test Data Sets

Two test files were created, both with 8 instances using 2 real valued inputs (ranging between -1 and 1) with 4 instances from each class. One test set was linearly separable while the other was not. The files/data are included in the Appendix of this document.

Graphs

The following charts show the "learned separator" with a learning rate of 0.1. The data were randomly shuffled after each epoch.





Effect of Learning Rate on Epochs

In the experiments run, for learning rate values < 0.5 there was no noticeable effect from the learning rate on the number of epochs. Over 10 runs, the linearly separable data would complete with 100% accuracy in 9.9 epochs. The non-linearly separable data training stopped in 17.1 epochs.

Voting Data

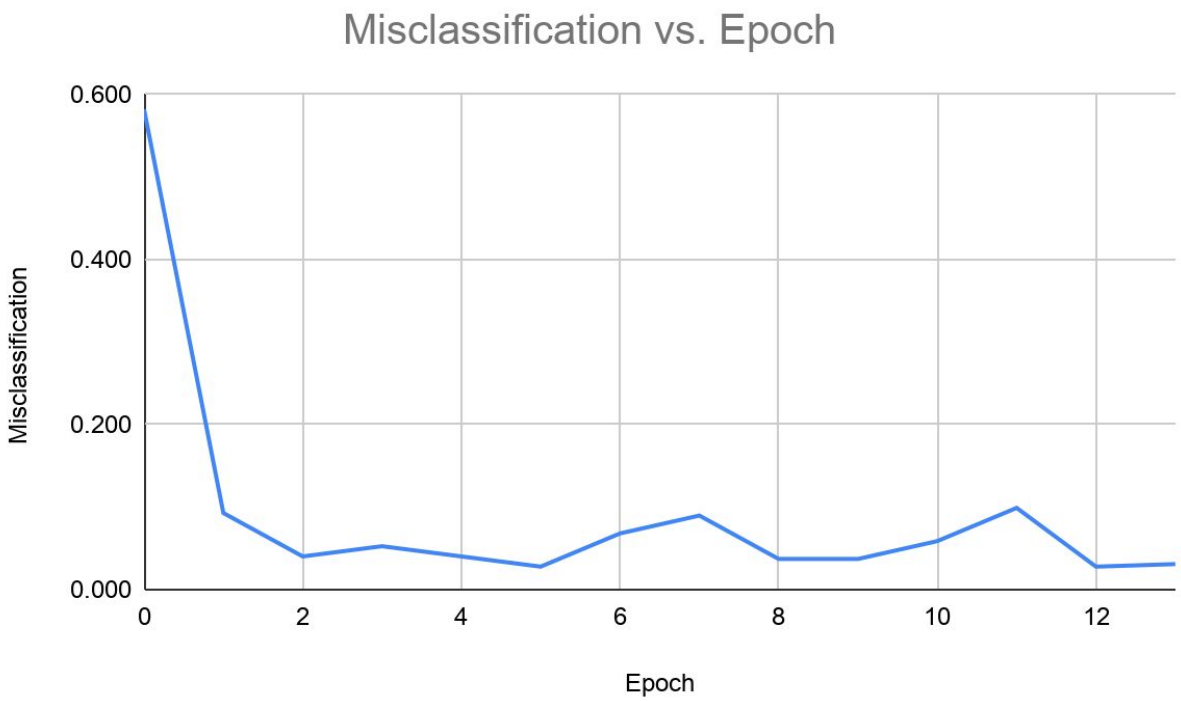
The perceptrons handled the voting classification task relatively well, with an average test accuracy of 95.5% and an average training accuracy of 96.3%.

	Test Accuracy	Training Accuracy	Number of Epochs
Perceptron 1	0.964	0.975	12
Perceptron 2	0.949	0.966	12
Perceptron 3	0.964	0.963	15
Perceptron 4	0.957	0.957	13
Perceptron 5	0.942	0.957	14
Average	**0.955**	**0.963**	**13**

As evidenced in the chart below, it appears that the most positively correlated data in determining a representative's party is republican was the vote on the REDACTED *(average weight of 1.76)*. Additionally, in predicting a representative was a democrat, the most critical data points were [redacted] REDACTED [redacted] and the [redacted] REDACTED *(average weight of -0.91 and -0.88 respectively)*. The most negligible data points were superfund right to sue and education, *(average weights of 0.03 and 0.04)*.

Misclassification

As expected the training misclassification sharply decreased after the first epoch, and slowly tapered down until the algorithm decided to stop.



scikit-learn

In experimenting with the scikit-learn module, it was interesting how consistent the classification was for the data. The vote data set was used, along with the classic ionosphere dataset. The Perceptron consistently learned the voting data set with 96.5% accuracy and the ionosphere data set with 90.0% accuracy. When the max_iter hyperparameter was set to a value less than 10, the accuracies were noticeably impacted. Additionally, the early stopping attribute had a negative impact on the voting model, but no virtually impact on the ionosphere model.

Extra-Credit: Iris

A new MultiPerceptron class was created to handle multiple classification. The class takes as input a 2D array of data, and a 2D array of targets. For each target, the class creates a new perceptron, and massages the expected target value to be positive for its class, and negative for

the other classes. The fit method, trains the data on each perceptron, and the predict method chooses the class whose bid is the highest.

Empirically tested 10 times, the average accuracy is 79.8%. Additional tuning could be done to improve accuracy.

Appendix

Linearly Separable Data Set:

```
% 1. Title: Linearly Separable data set
%
% 2. Sources:
%      (a) Creator: [redacted] [redacted]
%      (b) Date: [redacted] [redacted] [redacted]
%

@relation linsep
@attribute a1 real
@attribute a2 real
@attribute class {0,1}
@data
-0.4, 0.1, 0
```


```
0.4, 0.8, 1
```

Non-linearly Separable Data Set:

```
% 1. Title: Non-Linearly Separable data set
%
% 2. Sources:
%      (a) Creator: [redacted] [redacted]
%      (b) Date: [redacted] [redacted] [redacted]
%

@relation nonlinsep
@attribute a1 real
@attribute a2 real
@attribute class {0,1}
@data
```

```
-0.3, -0.2, 1
```

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```
0.7, 0.5, 1
```

Weights and Accuracy for Voting Tasks

	handicapped-infants	water-project-cost-sharing	adoption-of-the-budget-resolution	physician-fee-freeze	anti-satellite-test-ban	el-salvador-aid	religious-groups-in-schools	aid-to-nicaraguan-contras	mx-missile	immigration	synfuels-corporation-cutback	education-spending	superfund-right-to-sue	crime	duty-free-exports	export-administration-act-south-africa	bias	Test Accuracy	Training Accuracy	Number of Epochs
Perceptron 1	0.017																			12
Perceptron 2	-0.250																			12
Perceptron 3	-0.110																			15
Perceptron 4	-0.074																			13
Perceptron 5	-0.119																			14
Average	-0.107																			13

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