Program 1 - Perceptron

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1 Description

Contained in this package are two items:

- Pilot program, `prog1.py`
- `myml` module

I have opted to move `ML.py` to a full python module since we will be adding to it over the semester and I could already start to see it getting bloated when adding the plotting functions.

1.1 myml.util

plot_decision_regions :: Will print a 2D scattery plot along with a line that separates two regions in accordance with the perceptron passed in.

plot_decision_regions_3d :: Will print a 3D scattery plot along with a plane that separates two regions in accordance with the perceptron passed in.

1.2 myml.Perceptron

1.2.1 Description

The perceptron follows the data fitting algorithm presented on Wikipedia closely. It initializes weights to 0. For each sample, it calculates the actual output,and then changes the weight to reflect the difference between this output and the desired output. This process repeats until the specified number of iterations is reached or there is an iteration error rate of 0. In order to preserve data, both the number of errors and weight at each step is recorded. These can be accessed through *Perceptron*`.weights` and *Perceptron*`.errors`.

1.2.2 Attributes

1.2.3 Methods

Perceptron`.__init__` :: The initilizer takes 2 arguments: the first is the learning rate, a float between 0 and 1. The second is the max number of iterations. These values can be accessed again with *Perceptron*`.rate` and *Perceptron*`.niter`.

Perceptron`.fit` :: Takes arguments `X` (numpy array with shape (*nSamples*, *nFeatures*)) and `d` (also a numpy array with shape (*nSamples*)). This function applies the steps described above and "validates" the errors and weights arrays.

Perceptron`.net_input` :: Returns the weighted values of some given input `X` (of type numpy array with shape (*nSamples, nFeatures*)) as a numpy array with shape (*nSamples*).

Perceptron`.predict` :: Returns labels (-1 or 1) for a given `X` of type numpy array with shape (*nSamples, nFeatures*) as a numpy array of shape (*nSamples*).

`Perceptron.f` :: a static method which returns the label given `w` (a numpy array of shape (*nFeatures*+1)), and `x`, a sample with shape (*nFeatures*). Note, they're not the same size but that's because `w[0]` acts as a bias.

1.3 myml.LinearRegressor

1.3.1 Description

The linear regressor uses fits assumed linear data with a line using a gradient descent algorithm. It starts assuming $\beta = [0, ..., 0]$ instead of random numbers. It then calulates partial derivatives of the error term J, for each independant variable in X. J is defined as $\sum_{i=1}^{n}(y_i - (\beta \cdot \mathbf{X_i^T}))^2$. Using the partial derivatives and the error rate, a new β is determined for the next epoch. This is repeated until the given number of epochs.

1.3.2 Usage

```
lr = LinearRegressor(rate, epochs)
lr.fit(X, y)
lr.predict(Z)
```

`X` is a numpy.ndarray of shape (n, p)

`y` is a numpy.ndarray of shape (n)

where n is the number of samples and p is the number of independant variables

1.3.3 Properties

Note: Attributes are meant to be read-only. Modify them at your own risk. I have not chosen to enforce this since anyone can break it if they wanted anyways.

LinearRegressor`.rate` :: learning rate

LinearRegressor`.epochs` :: epochs

LinearRegressor`.w` :: matrix of values of β. This is a numpy.ndarray of shape ($epochs$, p).

LinearRegressor`.errors` :: matrix of values of ϵ. ϵ is the error between each predicted y_i and its real value, d_i, such that $\epsilon + y_i = d_i$

1.3.4 Methods

LinearRegressor.`__init__(rate, epochs)` :: Simply sets the learning rate and attributes of a linear regressor so it's ready to be fitted.

LinearRegressor.`fit(X, y)` :: Takes X (numpy.ndarray of shape (n, p)) and y (numpy.ndarray of shape (n)). n is the number of samples while p is the number of independant variables.

LinearRegressor.`predict(X)` :: takes a matrix of **x**s, and spits out their predicted **y**s using the β of the last epoch. Note that the Linear Regressor must be fitted first!

2 Importing the Module

Due to the heavy reliance on numpy arrays, obviously the numpy module should be installed. This is also a design decision as numpy arrays are much faster than python lists.

```
import <predictor> from myml

import myml.util as util
```

3 Testing

Several manual tests were used in the Iris dataset. These tests included all combinations of flowers with varying features. Some converged and some did not. I also did some 3 feature learning, to test that functionality. Although there much more manual tests, two can be found in the example `prog.py` (commit tagged prog1). The first is a 2 feature test which takes almost 800 iterations to converge while the second is a 3 feature test which converges quickly. Both of these use the first two flower species as they were the easiest to get to converge.