# Perceptron Learning Exercise

June 29, 2019

## 1 Perceptron Learning for Handwritten Digit Recognition

In this exercise you will implement the perceptron algorithm for training a perceptron to classify handwritten digits.

We will use the `sklearn` version of the MNIST data set.

You will need to complete **one line**, the gradient descent step, of a pre implemented perceptron training function.

```
In [2]: import scipy as sp
        from sklearn.datasets import load_digits
        from sklearn.model_selection import train_test_split
        import matplotlib.pyplot as plt
        %matplotlib inline

        def perceptron_train(X_train,Y_train, X_val, Y_val, iterations=100,eta=.1):
            '''
            Trains a perceptron and returns the learning curve for train and validation set
            '''
            acc_train = sp.zeros(iterations)
            acc_val = sp.zeros(iterations)
            # initialize weight vector
            weights = sp.random.randn(X_train.shape[1]) * 1e-5
            for it in sp.arange(iterations):
                # indices of misclassified data
                wrong = (sp.sign(X_train @ weights) != Y_train).nonzero()[0]
                if wrong.shape[0] > 0:
                    # pick a random misclassified data point
                    rand_ex = sp.random.randint(0,wrong.shape[0])
                    # update weight vector by multiplying a random X and Y that was wrongly cl
                    weights += eta/(it+1) * X_train[wrong[rand_ex]]*Y_train[wrong[rand_ex]]
                    # compute accuracy
                    acc_train[it] = sp.mean(sp.sign(X_train @ weights)==Y_train)
                    acc_val[it] = sp.mean(sp.sign(X_val @ weights)==Y_val)
            # return weight vector and accuracy
            return acc_train, acc_val
```

### 1.1 Test whether your code works: Handwritten digit recognition

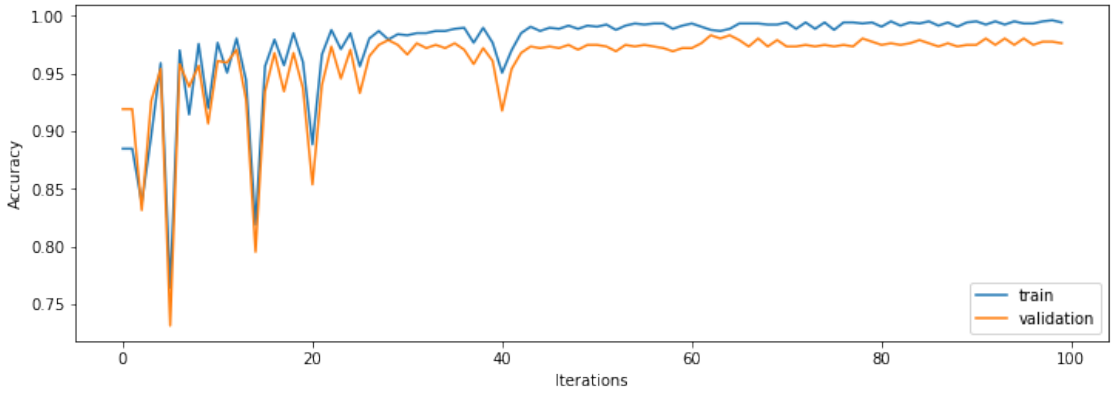
Execute the following code and check whether the learning curves look like the model improves over time.

Feel free to change the learning rate or the validation split and observe the effects on the model training.

```
In [30]: digit_to_recognize = 5
         X, Y = load_digits(n_class=10, return_X_y=True)
         # transform the 10-class labels into binary form
         y = sp.sign((Y==digit_to_recognize)* 1.0 - .5)
         X_train, X_val, Y_train, Y_val = train_test_split(X, y, test_size=.4)
         acc_train, acc_val = perceptron_train(X_train, Y_train, X_val, Y_val)

         plt.figure(figsize=[12,4])
         plt.plot(acc_train)
         plt.plot(acc_val)
         plt.xlabel("Iterations");plt.ylabel("Accuracy");plt.legend(['train','validation']);
         acc_val[99]
```

```
Out[30]: 0.9763560500695411
```




```
In [37]: train_test_split?
```

```
In [23]: a = sp.arange(10)
         b = sp.arange(10)
         print(a)
         print(b)
         a.T @ b
```

```
[0 1 2 3 4 5 6 7 8 9]
[0 1 2 3 4 5 6 7 8 9]
```

```
Out[23]: 285
```