RNN_classification

May 5, 2017

1 Recurrent Neural Network

1.1 Classifier: Traffic as Low, Medium, or High

Import necessary modules.

```
In [2]: import numpy as np
        from matplotlib import pyplot as plt
```

Load data from text file.

```
In [3]: data = np.genfromtxt('/Users/mitch/Dropbox/FinalProject/traffic2.txt')
```

Define functions and derivatives of those functions to be used in the RNN.

```
In [4]: def sigmoid(x):
            return 1.0/(1.0 + np.exp(-x))

        def relu(x):
            return np.maximum(x,np.zeros_like(x))

        def Leaky_ReLU_deriv(x):
            dRLU = np.empty(len(x))
            for i in range(len(x)):
                if x[i] > 0:
                    dRLU[i] = 1
                else:
                    dRLU[i] = 0.1
            return dRLU

        # Rename function for convenience
        LRD = Leaky_ReLU_deriv
```

Define a recurrent neural network class, which repeats a single layer.

```
In [5]: class OneLayerRNN:

            def __init__(self,hidden_units=10,output_units=3):
                self.V = None
```

```
        self.W = None
        self.h = None
        self.z = None
        self.hidden_units = hidden_units
        self.output_units = output_units
        self.windowlen = None
        self.futuretime = None

    def initialize(self,X):
        # Weight matrices start as normal distributions
        self.V = np.random.normal(scale=1.0/np.sqrt(self.hidden_units),size
        self.W = np.random.normal(scale=1.0/np.sqrt(self.hidden_units),size
        self.h = np.zeros((len(X),self.hidden_units))
        self.z = np.zeros((len(X),self.output_units))

        # Matrices for gradient update
        self.gV = np.zeros_like(self.V)
        self.gW = np.zeros_like(self.W)


    def forward(self,X):
        for i in range(len(X)):
            x = X[i]

            self.h[i] = relu(np.dot(self.V,x)).flatten()        # calculate
            self.z[i] = sigmoid(np.dot(self.W,self.h[i]))

    def backward(self,X,y):
        """Backpropagation through time"""
        for i in range(len(X)):
            x = X[i]
            Q = self.z[i] - y
            self.gV += np.array([np.dot(self.W.T,Q)*LRD(self.h[i]*x)]).T
            self.gW += np.outer(Q,self.h[i])

    def update_VW(self,epsilon):
        """Update"""
        self.V = self.V - epsilon*self.gV
        self.W = self.W - epsilon*self.gW

    def one_hot_encode(self,occ):
        if occ < 0.33: return np.array([1,0,0])
        elif occ >= 0.33 and occ < 0.67: return np.array([0,1,0])
        elif occ >= 0.67: return np.array([0,0,1])
        else: print('Error: the given occupancy value was ',occ)


    def train(self,timeframe,epsilon,windowlen=24,futuretime=0):
```

```
        """
        Train the neural network given input data as X
        X:    - a series of occupancies
        """
        self.windowlen=windowlen
        self.futuretime = futuretime

        windowstart = 0
        firstwindow = timeframe[:windowlen]
        self.initialize(firstwindow)
        counter,total = 0,0
        trainingerrors = []
        while windowstart < len(timeframe)-windowlen-futuretime-1:
            timewindow = timeframe[windowstart:windowstart+windowlen]
            timewindowlabel = self.one_hot_encode(timeframe[windowstart+wir
            trueforecast = np.argmax(timewindowlabel)

            self.forward(timewindow)
            self.backward(timewindow,timewindowlabel)
            self.update_VW(epsilon)

            prediction = np.argmax(np.average(self.z,axis=0))

            if prediction == trueforecast:
                counter += 1
            total += 1

            TE = counter/total
            if windowstart%1000==0:
                #print(windowstart,'\t',TE)
                trainingerrors.append(TE)
            windowstart=windowstart+1
        #print(counter/total)
        return trainingerrors


    def predict(self,timeframe,predicttime,predictgap=0):
        timewindow = timeframe[predicttime-predictgap-self.windowlen:predic
        self.forward(timewindow)
        classification = np.argmax(np.average(self.z,axis=0))
        '''if classification==0:
            print('low')
        elif classification==1:
            print('med')
        elif classification==2:
            print('high')'''

        return classification
```

Calculate the test error from each of 8 sensors for a set of 100 test points.

```
In [6]: for sensor in range(8):
            RNN = OneLayerRNN()
            RNN.train(data[sensor,:60000],0.001)
            counter,total = 0,0
            for j in range(100): # loop over several test points
                predictpoint = 60000+25*j
                prediction = RNN.predict(data[sensor,60000:],predictpoint)
                truevalue = data[20,predictpoint]
                if prediction==np.argmax(RNN.one_hot_encode(truevalue)):
                    counter += 1
                total += 1
            print(counter/total)
```

```
/Users/mitch/anaconda/lib/python3.6/site-packages/ipykernel/__main__.py:2: RuntimeW
  from ipykernel import kernelapp as app


0.99
0.99
0.99
0.99
0.99
0.99
0.99
0.99
```

Train the neural network on the first 20 sensors. Save the training accuracies after each rolling window has been entirely calculated.

```
In [7]: sensortrials = []
        for i in range(20):
            timeframe = data[i,:60000]
            RNN = OneLayerRNN()
            print('Sensor',i)
            trainingerrors=RNN.train(timeframe,0.001)
            sensortrials.append(trainingerrors)
            # predict statement
```

```
Sensor 0


/Users/mitch/anaconda/lib/python3.6/site-packages/ipykernel/__main__.py:2: RuntimeW
  from ipykernel import kernelapp as app
```

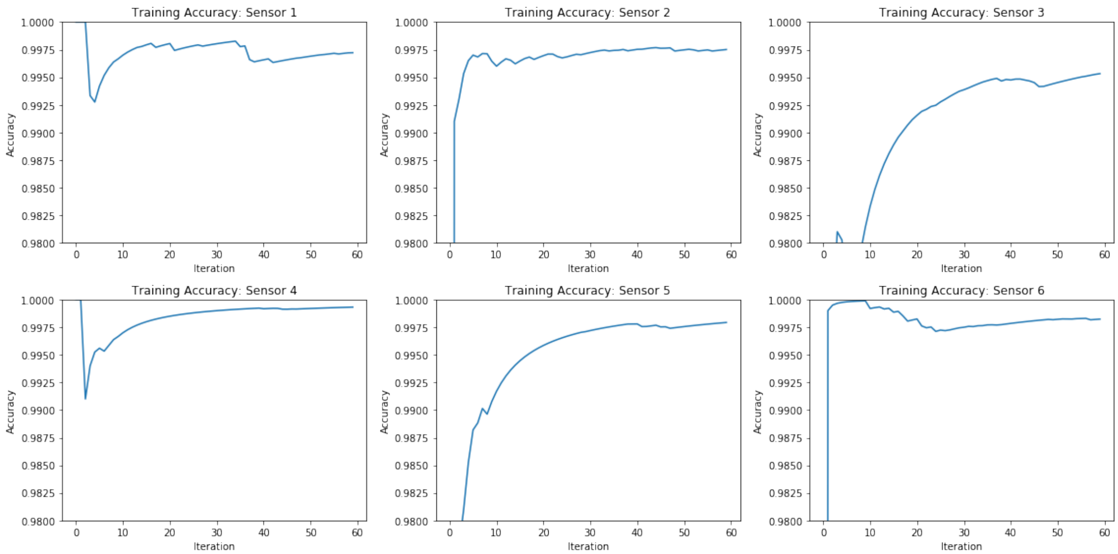
```
Sensor 1
Sensor 2
Sensor 3
Sensor 4
Sensor 5
Sensor 6
Sensor 7
Sensor 8
Sensor 9
Sensor 10
Sensor 11
Sensor 12
Sensor 13
Sensor 14
Sensor 15
Sensor 16
Sensor 17
Sensor 18
Sensor 19
```

```
In [8]: RNN.predict(timeframe,60100)
```

```
Out[8]: 0
```

Plot the training errors for each sensor.

```
In [9]: fig = plt.figure(figsize=(16,8))
        for i in range(6):
            fig.add_subplot(2,3,i+1)
            plt.plot(sensortrials[i])
            plt.ylim(0.98,1.00)
            plt.tight_layout()
            plt.title('Training Accuracy: Sensor '+str(i+1))
            plt.xlabel('Iteration')
            plt.ylabel('Accuracy')
        plt.show()
        plt.savefig('train_acc_10hu.jpg')
```


Training Accuracy: Sensor 1
Training Accuracy: Sensor 2
Training Accuracy: Sensor 3
Training Accuracy: Sensor 4
Training Accuracy: Sensor 5
Training Accuracy: Sensor 6
Accuracy
Iteration
1.0000
0.9975
0.9950
0.9925
0.9900
0.9875
0.9850
0.9825
0.9800
0
10
20
30
40
50
60