Forecasting using RNN

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In [1]:
```
#What are we working with?
import sys
sys.version
```

Out[1]:
```
'3.6.3 |Anaconda custom (64-bit)| (default, Oct 13 2017, 12:02:49) \n[GCC
7.2.0]'
```

In [3]:
```
#Import Libraries
import tensorflow as tf
import pandas as pd
import numpy as np
import os
import matplotlib
import matplotlib.pyplot as plt
import random
%matplotlib inline
import tensorflow as tf
import shutil
import tensorflow.contrib.learn as tflearn
import tensorflow.contrib.layers as tflayers
from tensorflow.contrib.learn.python.learn import learn_runner
import tensorflow.contrib.metrics as metrics
import tensorflow.contrib.rnn as rnn
```

In [4]:
```
#TF Version
tf.__version__
```

Out[4]:
```
'1.3.0'
```

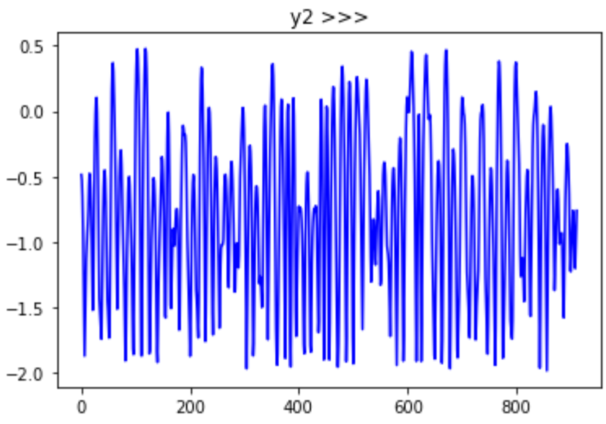
In [ ]:
```
# for each experiment value of l1,l2,m1,m2 and th1,th2,w1,w2 are same so
explicitely add these features after training.

G = 9.8  # acceleration due to gravity, in m/s^2
L1 = 1.0  # length of pendulum 1 in m
L2 = 1.0  # length of pendulum 2 in m
M1 = 1.0  # mass of pendulum 1 in kg
M2 = 1.0  # mass of pendulum 2 in kg


def derivs(state, t):

    dydx = np.zeros_like(state)
    dydx[0] = state[1]

    del_ = state[2] - state[0]
    den1 = (M1 + M2)*L1 - M2*L1*cos(del_)*cos(del_)
    dydx[1] = (M2*L1*state[1]*state[1]*sin(del_)*cos(del_) +
               M2*G*sin(state[2])*cos(del_) +
               M2*L2*state[3]*state[3]*sin(del_) -
               (M1 + M2)*G*sin(state[0]))/den1

    dydx[2] = state[3]

    den2 = (L2/L1)*den1
    dydx[3] = (-M2*L2*state[3]*state[3]*sin(del_)*cos(del_) +
               (M1 + M2)*G*sin(state[0])*cos(del_) -
               (M1 + M2)*L1*state[1]*state[1]*sin(del_) -
               (M1 + M2)*G*sin(state[2]))/den2

    return dydx

# create a time array from 0..100 sampled at 0.05 second steps
dt = 0.1
t = np.arange(0.0, 100, dt)

# th1 and th2 are the initial angles (degrees)
# w10 and w20 are the initial angular velocities (degrees per second)

th1 = 120.0
w1 = 0.0
th2 = 0.0
w2 = 0.0

# initial state
state = np.radians([th1, w1, th2, w2])

# integrate your ODE using scipy.integrate.
y = integrate.odeint(derivs, state, t)

x1 = L1*sin(y[:, 0])
y1 = -L1*cos(y[:, 0])

#print("x1 : ",x1)
#print("y1 : ",y1)

x2 = L2*sin(y[:, 2]) + x1
y2 = -L2*cos(y[:, 2]) + y1

#print("x2 : ",x2)
#print("y2 : ",y2)

fig = plt.figure()
ax = fig.add_subplot(111, autoscale_on=False, xlim=(-2, 2), ylim=(-2, 2)
)
ax.grid()

line, = ax.plot([], [], 'o-', lw=2)
```

Generate some data

In [5]:
```
random.seed(111)
rng = pd.date_range(start='2000', periods=9, freq='M')
ts = pd.Series(np.random.uniform(-10, 10, size=len(rng)), rng).cumsum()

#ts.head(10)

f = open("data/y2.txt" , "r")
t = open("data/time_slots.txt" , "r")
array1 = []
array2 = []

for line in f.read().split('\n') :
  array1.append(line )
for line in t.read().split('\n') :
  array2.append(line )
f.close()
t.close()
array1.pop()
array2.pop()
data = []

for i in range(len(array1)):
    data.append([array1[i]])
test = np.array(data)
mylist = test.astype(np.float)

print("length of test data : ",len(mylist))
print(mylist.shape)
mylist.reshape(1,-1)
#print(mylist)

ts = np.delete(mylist,[i for i in range(912,1001)],0)

print("length of test data : ",len(ts))
print(ts.shape)
ts.reshape(1,-1)
#print(ts)

plt.plot(ts,c='b')
plt.title('y2 >>>')
plt.show()
```

```
length of test data :  1000
(1000, 1)
length of test data :  912
(912, 1)
```

```
/home/omkarthawakar/anaconda3/lib/python3.6/site-packages/ipykernel_launc
her.py:32: DeprecationWarning: in the future out of bounds indices will r
aise an error instead of being ignored by `numpy.delete`.
```



Convert data into array that can be broken up into training "batches" that we will feed into our RNN model. Note the shape of the arrays.

In [6]:
```
TS = np.array(ts)
num_periods = 100
f_horizon = 1  #forecast horizon, one period into the future

x_data = TS[:(len(TS)-(len(TS) % num_periods))]
print(x_data.shape)
x_batches = x_data.reshape(-1, 100, 1)
print (len(x_batches))
print (x_batches.shape)
#print ("x_batches : ",x_batches)
y_data = TS[1:(len(TS)-(len(TS) % num_periods))+f_horizon]
print(y_data.shape)
y_batches = y_data.reshape(-1, 100, 1)


print ("y_batches : ",y_batches)
print (y_batches.shape)
```

```
(900, 1)
9
(9, 100, 1)
(900, 1)
y_batches :  [[[ -5.24476449e-01]
  [ -6.48676966e-01]
  [ -8.71019532e-01]
  [ -1.20275951e+00]
  [ -1.62066548e+00]
  [ -1.86911222e+00]
  [ -1.59735687e+00]
  [ -1.31756139e+00]
  [ -1.13473550e+00]
  [ -1.02169831e+00]
  [ -9.32942575e-01]
  [ -8.55187067e-01]
  [ -7.49839803e-01]
  [ -5.67737096e-01]
  [ -4.75580003e-01]
  [ -4.92185552e-01]
  [ -5.85496494e-01]
  [ -7.55875900e-01]
  [ -1.01412612e+00]
  [ -1.29605878e+00]
  [ -1.51912616e+00]
  [ -1.38845605e+00]
  [ -8.96292936e-01]
  [ -4.91861962e-01]
  [ -2.08158459e-01]
  [ -2.10590930e-02]
  [  8.99717824e-02]
  [  1.03748882e-01]
  [ -1.26967951e-02]
  [ -2.78601145e-01]
  [ -6.96712328e-01]
  [ -1.18360217e+00]
  [ -1.42744340e+00]
  [ -1.51295215e+00]
  [ -1.57100333e+00]
  [ -1.66760359e+00]
  [ -1.74005964e+00]
  [ -1.47478390e+00]
  [ -1.10170996e+00]
  [ -7.99786295e-01]
  [ -5.89758230e-01]
  [ -4.72670174e-01]
  [ -4.50507424e-01]
  [ -5.26004251e-01]
  [ -6.99907560e-01]
  [ -9.65328322e-01]
  [ -1.27579873e+00]
  [ -1.45013129e+00]
  [ -1.51995661e+00]
  [ -1.62507518e+00]
  [ -1.73144610e+00]
  [ -1.67600030e+00]
  [ -1.18787200e+00]
  [ -6.04400981e-01]
  [ -1.48154495e-01]
  [  1.57790117e-01]
  [  3.24794483e-01]
  [  3.68930359e-01]
  [  3.05609755e-01]
  [  1.57121559e-01]
  [ -3.99164153e-02]
  [ -2.58930410e-01]
  [ -5.27611174e-01]
  [ -8.93537907e-01]
```

Pull out our test data

In [7]:
```
def test_data(series,forecast,num_periods):
    test_x_setup = TS[-(num_periods + forecast):]
    testX = test_x_setup[:num_periods].reshape(-1, 100, 1)
    testY = TS[-(num_periods):].reshape(-1, 100, 1)
    return testX,testY

X_test, Y_test = test_data(TS,f_horizon,num_periods )
print (X_test.shape)
#print (X_test)
print (Y_test.shape)
```

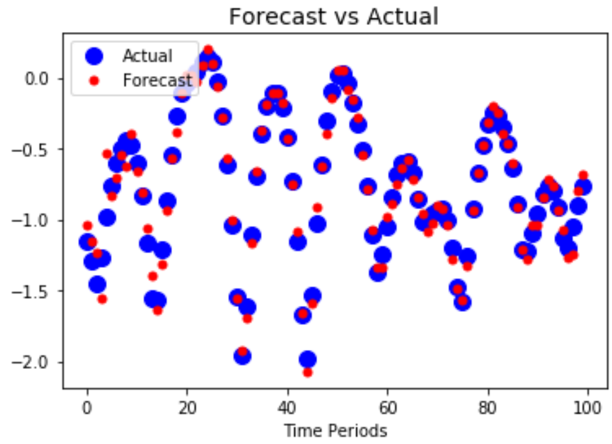
```
(1, 100, 1)
(1, 100, 1)
```

In [8]:
```
tf.reset_default_graph()   #We didn't have any previous graph objects ru
nning, but this would reset the graphs

num_periods = 100      #number of periods per vector we are using to pre
dict one period ahead
inputs = 1            #number of vectors submitted
hidden = 100          #number of neurons we will recursively work throug
h, can be changed to improve accuracy
output = 1            #number of output vectors

X = tf.placeholder(tf.float32, [None, num_periods, inputs])   #create va
riable objects
y = tf.placeholder(tf.float32, [None, num_periods, output])


basic_cell = tf.contrib.rnn.BasicRNNCell(num_units=hidden, activation=tf
.nn.relu)   #create our RNN object
rnn_output, states = tf.nn.dynamic_rnn(basic_cell, X, dtype=tf.float32)
#choose dynamic over static

learning_rate = 0.001   #small learning rate so we don't overshoot the m
inimum

stacked_rnn_output = tf.reshape(rnn_output, [-1, hidden])           #cha
nge the form into a tensor
stacked_outputs = tf.layers.dense(stacked_rnn_output, output)        #sp
ecify the type of layer (dense)
outputs = tf.reshape(stacked_outputs, [-1, num_periods, output])
#shape of results

loss = tf.reduce_sum(tf.square(outputs - y))    #define the cost functio
n which evaluates the quality of our model
optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate)
#gradient descent method
training_op = optimizer.minimize(loss)          #train the result of the
application of the cost_function

init = tf.global_variables_initializer()           #initialize all the v
ariables
```

In [13]:
```
epochs = 2000     #number of iterations or training cycles, includes bot
h the FeedFoward and Backpropogation
errors = []
iterations = []
with tf.Session() as sess:
    init.run()
    for ep in range(epochs):
        sess.run(training_op, feed_dict={X: x_batches, y: y_batches})
        errors.append(loss.eval(feed_dict={X: x_batches, y: y_batches}))
        iterations.append(ep)
        if ep % 100 == 0:
            mse = loss.eval(feed_dict={X: x_batches, y: y_batches})
            print(ep, "\tMSE:", mse)
    y_pred = sess.run(outputs, feed_dict={X: X_test})
    print(y_pred)
```

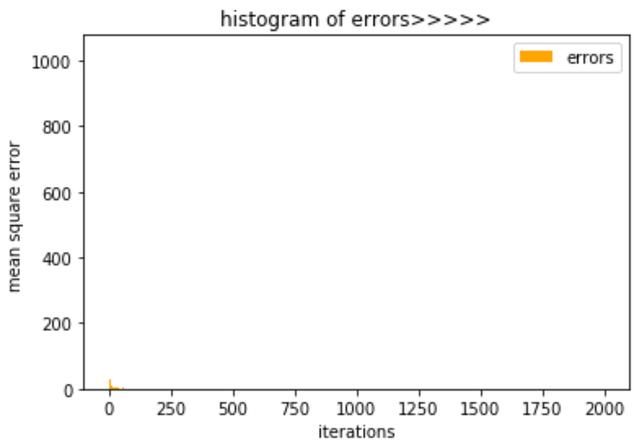
```
0       MSE: 976.734
100     MSE: 23.7015
200     MSE: 9.74641
300     MSE: 5.50508
400     MSE: 3.8686
500     MSE: 3.03159
600     MSE: 3.02459
700     MSE: 2.70022
800     MSE: 2.36303
900     MSE: 1.82926
1000    MSE: 1.91116
1100    MSE: 1.75556
1200    MSE: 1.48153
1300    MSE: 1.36247
1400    MSE: 1.304
1500    MSE: 1.14388
1600    MSE: 1.50855
1700    MSE: 1.17008
1800    MSE: 1.82753
1900    MSE: 1.58235
[[[-1.03502464]
  [-1.15167904]
  [-1.23701942]
  [-1.55589604]
  [-0.53603297]
  [-0.83044797]
  [-0.70525253]
  [-0.54032379]
  [-0.62140155]
  [-0.39356789]
  [-0.66593486]
  [-0.80497718]
  [-1.06383657]
  [-1.40197682]
  [-1.63456631]
  [-1.31720948]
  [-0.93527901]
  [-0.56344503]
  [-0.38245267]
  [-0.10980153]
  [ 0.016493  ]
  [ 0.01546127]
  [-0.03424772]
  [ 0.08681718]
  [ 0.19851047]
  [ 0.10346407]
  [-0.06481653]
  [-0.2791754 ]
  [-0.56324613]
  [-1.0036602 ]
  [-1.55512249]
  [-1.9276197 ]
  [-1.7000798 ]
  [-1.16608512]
  [-0.66216338]
  [-0.37122253]
  [-0.19513896]
  [-0.11288485]
  [-0.10370913]
  [-0.17433986]
  [-0.43649754]
  [-0.74766672]
  [-1.08541369]
  [-1.66275942]
  [-2.07369518]
  [-1.59218204]
  [-0.9147315 ]
  [-0.6282292 ]
```

In [14]:
```
plt.title("Forecast vs Actual", fontsize=14)
plt.plot(pd.Series(np.ravel(Y_test)), "bo", markersize=10, label="Actual
")
#plt.plot(pd.Series(np.ravel(Y_test)), "w*", markersize=10)
plt.plot(pd.Series(np.ravel(y_pred)), "r.", markersize=10, label="Foreca
st")
plt.legend(loc="upper left")
plt.xlabel("Time Periods")

plt.show()
```



In [15]:
```
#!/usr/bin/env python
import numpy as np
import matplotlib.mlab as mlab
import matplotlib.pyplot as plt

errors=np.array(errors)
iterations=np.array(iterations)
print(errors.shape)
#print(errors)

plt.hist(errors,iterations,label='errors', facecolor='orange')

plt.xlabel('iterations')
plt.ylabel('mean square error ')
plt.title('histogram of errors>>>>>')
plt.legend()
plt.show()
```

```
(2000,)
```



In [16]:
```
#!/usr/bin/env python
import numpy as np
import matplotlib.mlab as mlab
import matplotlib.pyplot as plt

errors=np.array(errors)
iterations=np.array(iterations)
print(errors.shape)
#print(errors)

plt.plot(errors,iterations,label='errors',color='green')

plt.xlabel('iterations')
plt.ylabel('mean square error ')
plt.title('plot of errors>>>>>')
plt.legend()
plt.show()
```

```
(2000,)
```