RNN_scratch

July 10, 2018

```
In [2]: import numpy as np
        import tensorflow as tf
        import matplotlib.pyplot as plt
        %matplotlib inline
```

```
/home/kushashwa/.local/lib/python3.6/site-packages/h5py/__init__.py:36: FutureWarning: Convers
  from ._conv import register_converters as _register_converters
```

```
In [3]: num_inputs = 2
        num_neurons = 3

In [4]: x0 = tf.placeholder(tf.float32, [None, num_inputs])
        x1 = tf.placeholder(tf.float32, [None, num_inputs])

In [5]: Wx = tf.random_normal(shape=[num_inputs, num_neurons])
        Wy = tf.random_normal(shape=[num_neurons, num_neurons])
        b = tf.zeros([1, num_neurons])

In [6]: # graphs
        y0 = tf.tanh(tf.matmul(x0, Wx) + b)
        # feedback + present
        y1 = tf.tanh(tf.matmul(y0, Wy) + tf.matmul(x1, Wx) + b)

In [7]: # intialize variables
        init = tf.global_variables_initializer()

In [8]: # create data
        # time stamp at t = 0
        x0_batch = np.array([ [0, 1], [2, 3], [4, 5] ])
        # time stamp at t = t + 1 = 1
        x1_batch = np.array([ [100, 101], [102, 103], [104, 105] ])

In [9]: with tf.Session() as sess:
            sess.run(init)

            y0_output_vals, y1_output_vals = sess.run([y0, y1],
                                    feed_dict = {x0:x0_batch, x1:x1_batch})
```

```
In [10]: y0_output_vals

Out[10]: array([[ 0.46511364, -0.921773  ,  0.9284943 ],
                [ 0.96557266, -0.9307549 ,  0.9783266 ],
                [ 0.9983207 , -0.93873835,  0.993547  ]], dtype=float32)

In [11]: y1_output_vals

Out[11]: array([[ 1.        , -0.99936646,  1.        ],
                [ 1.        , -0.9977223 ,  1.        ],
                [ 1.        , -0.99780226,  1.        ]], dtype=float32)
```

0.1 Vanishing Gradients

While backpropagating, in deeper networks, gradients get smaller and at some point, they stop changing significantly.

GRU and LSTM can be used to fix them (in RNN)

Depends on activation function choice.

Like **sigmoid:**

$$\sigma(z) = \frac{1}{1 + e^{-z}}$$

It saturates both positive and negative values.

Solution:

Use **ReLU** (doesn't saturate positive values.) Problem: for -ve numbers, always 0.

Solution:

Use **Leaky ReLU.**

Others: **ELU** (Exponential Linear Unit)

Another solution: Use Batch Normalization, Gradient Clipping (cut off gradients to be b/w -1 and 1 : example)

0.2 Introduction to RNN using TF API

Problem: Time series. ($sin(t)$, t = time)

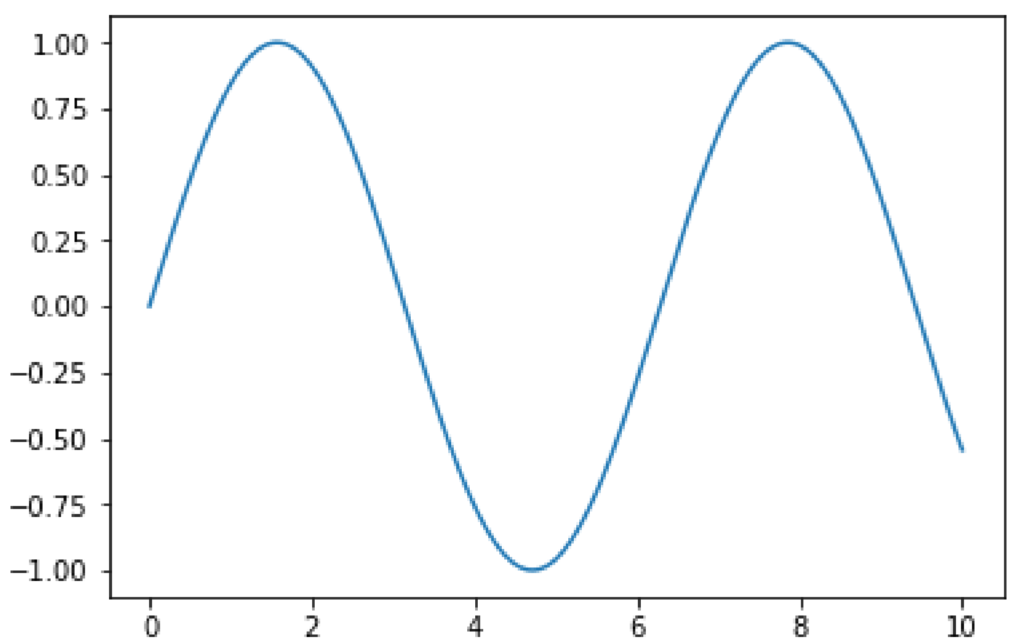
```
In [30]: import numpy as np
         import tensorflow as tf
         import matplotlib.pyplot as plt
         %matplotlib inline

In [17]: class TimeSeriesData():
             def __init__(self, num_points, xmin, xmax):
                 # creates data
                 self.xmin = xmin
                 self.xmax = xmax
                 self.num_points = num_points
                 self.resolution = (self.xmax - self.xmin)/(self.num_points)
                 self.x_data = np.linspace(self.xmin, self.xmax, self.num_points)
                 self.y_true = np.sin(self.x_data)
```

```python
    def ret_true(self, x_series):
        return np.sin(x_series)

    def next_batch(self, batch_size, steps, return_batch_ts=False):
        # grab random starting point for each batch
        rand_start = np.random.rand(batch_size, 1)
        # convert to be on time series
        ts_start = rand_start * (self.xmax - self.xmin - \
                                (steps * self.resolution))
        # create batch series : x axis
        batch_ts = ts_start + np.arange(0.0, steps + 1) * \
        self.resolution
        # create y data for each x axis point
        y_batch = np.sin(batch_ts)
        # formatting for RNN
        if return_batch_ts:
            return y_batch[:, :-1].reshape(-1, steps, 1), \
        y_batch[:, 1:].reshape(-1, steps, 1), batch_ts
        else:
            # returns at t = t and t = t + 1
            return y_batch[:, :-1].reshape(-1, steps, 1), \
        y_batch[:, 1:].reshape(-1, steps, 1)
```

In [18]:
```python
ts_data = TimeSeriesData(250, 0, 10)
```

In [20]:
```python
plt.plot(ts_data.x_data, ts_data.y_true)
```

Out[20]: [<matplotlib.lines.Line2D at 0x7f285e27d780>]



In [21]:
```
num_timesteps = 30 # number of steps in each batch
```

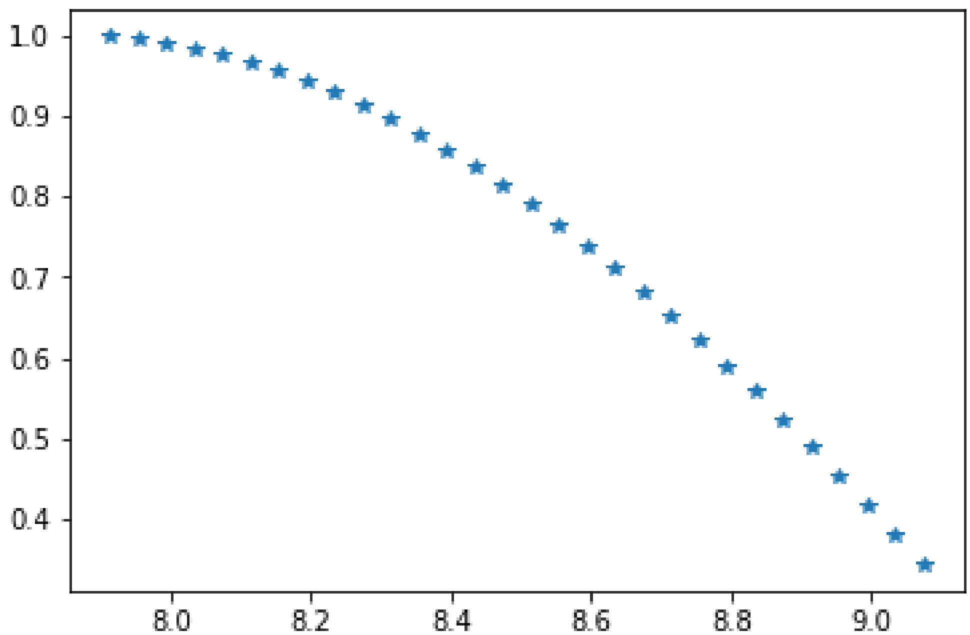
In [40]:
```
def generateNextBatch(num_timesteps):
    y1, y2, ts = ts_data.next_batch(1, num_timesteps, True)
    return y1, y2, ts
```

In [28]:
```
ts.shape
# needs to be flattened
```

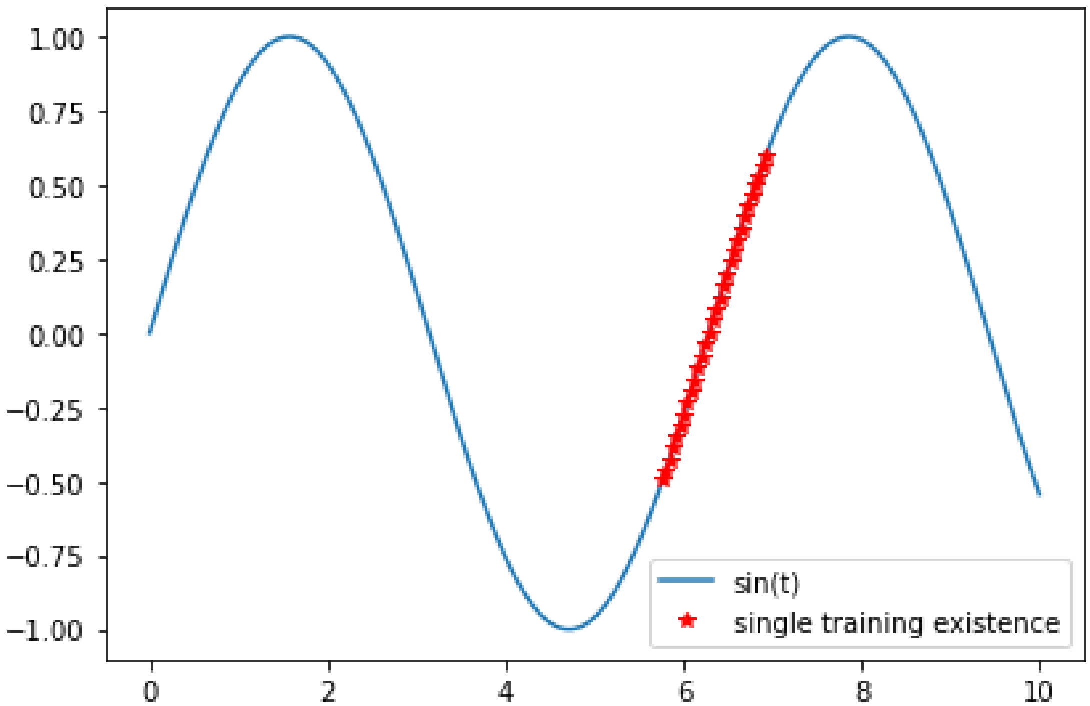
Out[28]: (1, 30, 1)

In [31]:
```
plt.plot(ts.flatten()[1:], y2.flatten(), '*')
```

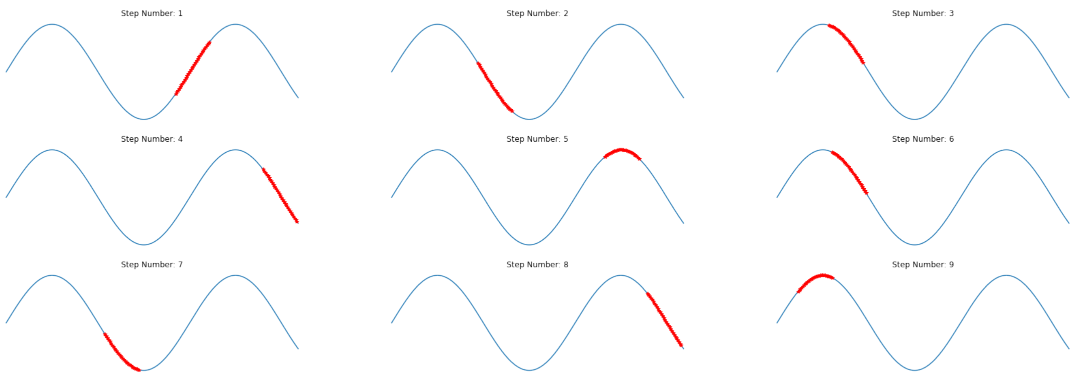
Out[31]: [<matplotlib.lines.Line2D at 0x7f285c74dcf8>]



In [42]:
```
y1, y2, ts = generateNextBatch(30)
plt.plot(ts_data.x_data, ts_data.y_true, label='sin(t)')
plt.plot(ts.flatten()[1:], y2.flatten(), '*', c = 'r', label='single training existen
plt.legend()
plt.tight_layout()

for int i
```




```
In [76]: import math

         plt.figure(figsize=[30,10])
         num_cols = 3
         num_images = 9
         num_rows = math.ceil(num_images / num_cols)

         for i in range(0, num_images):
             plt.subplot(num_rows, num_cols, i+1)
             plt.axis('off')
             y1, y2, ts = generateNextBatch(30)
             plt.plot(ts_data.x_data, ts_data.y_true, label='sin(t)')
             plt.plot(ts.flatten()[1:], y2.flatten(), '*', c = 'r', label='single training exis
             plt.title("Step Number: " + str(i + 1))
```



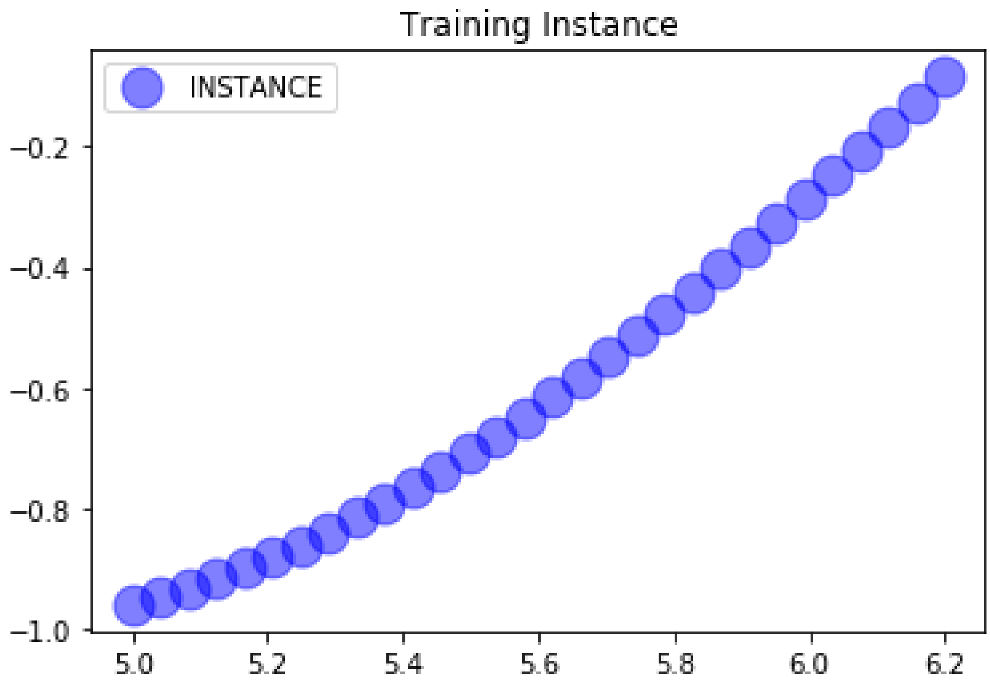

```
In [56]: train_instance = np.linspace(5, 5 + ts_data.resolution * \
                                      (num_timesteps + 1), num_timesteps + 1)
```

```
In [57]: train_instance
```

```
Out[57]: array([5.        , 5.04133333, 5.08266667, 5.124     , 5.16533333,
                5.20666667, 5.248     , 5.28933333, 5.33066667, 5.372     ,
                5.41333333, 5.45466667, 5.496     , 5.53733333, 5.57866667,
                5.62      , 5.66133333, 5.70266667, 5.744     , 5.78533333,
                5.82666667, 5.868     , 5.90933333, 5.95066667, 5.992     ,
                6.03333333, 6.07466667, 6.116     , 6.15733333, 6.19866667,
                6.24      ])
```

```
In [71]: plt.title('Training Instance')

         plt.plot(train_instance[:-1], ts_data.ret_true(train_instance[:-1]),
                  'bo', markerSize=15, alpha=0.5, label='INSTANCE')

         plt.legend()
```

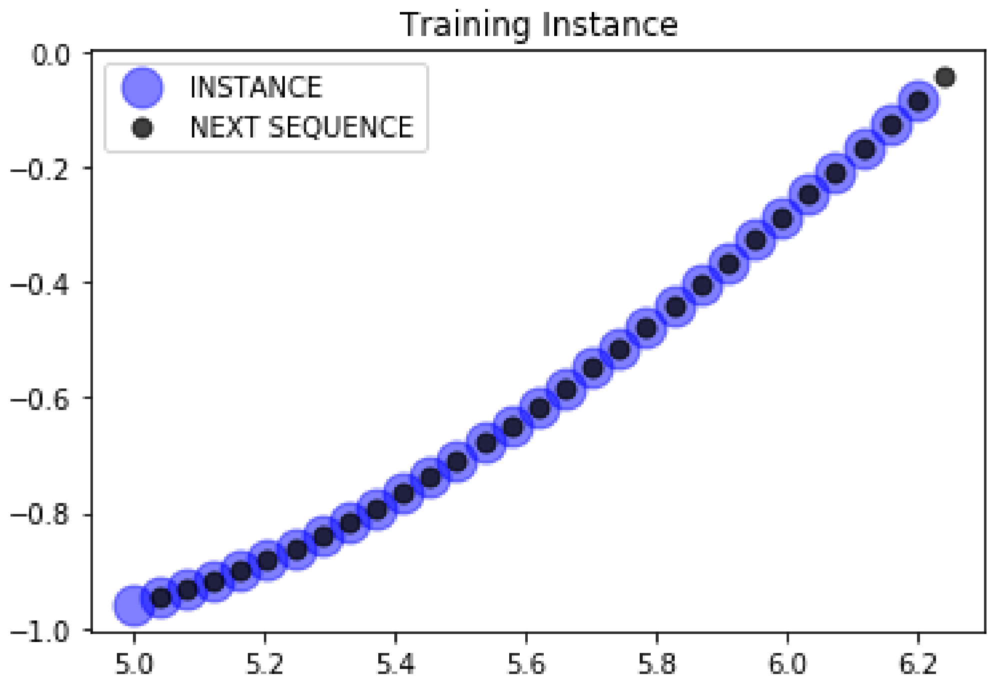
```
Out[71]: <matplotlib.legend.Legend at 0x7f282c417ac8>
```



We want to predict one time step ahead of it. [Goal]

```
In [74]: plt.title('Training Instance')

         plt.plot(train_instance[:-1], ts_data.ret_true(train_instance[:-1]),
                  'bo', markerSize=15, alpha=0.5, label='INSTANCE')
         # doing for next time step (1: )
         plt.plot(train_instance[1:], ts_data.ret_true(train_instance[1:]),
                  'ko', markerSize=7, alpha=0.75, label='NEXT SEQUENCE')

         plt.legend()
```

```
Out[74]: <matplotlib.legend.Legend at 0x7f282d6b00b8>
```


Training Instance
INSTANCE
NEXT SEQUENCE
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
5.0
5.2
5.4
5.6
5.8
6.0
6.2