



Erik Hallström

[Follow](#)

Studied Engineering Physics and in Machine Learning at Royal Institute of Technology in Stockholm. Also...

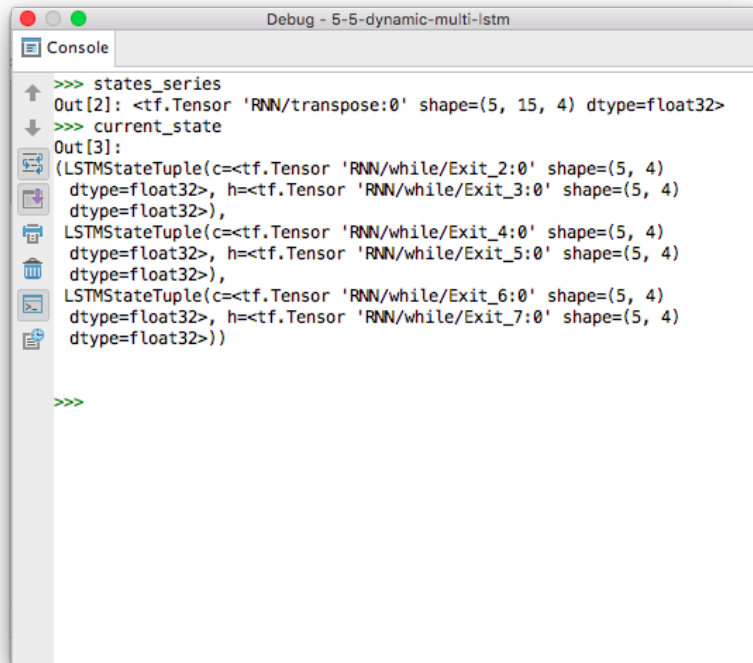
Nov 19, 2016 · 3 min read

Using the DynamicRNN API in TensorFlow (5/7)

In the [previous guide](#) we built a multi-layered LSTM RNN. In this post we will speed it up by not splitting up our inputs and labels into a list, as done on line 41–42 in our code. You may remove these rows where `inputs_series` and `labels_series` are declared. Next change the `tf.nn.rnn` call on line 47 to the following:

```
1 states_series, current_state = tf.nn.dynamic_rnn(cell,  
2 states_series = tf.reshape(states_series, [-1, state_si  
3
```

The `dynamic_rnn` function takes the batch inputs of shape `[batch_size, truncated_backprop_length, input_size]`, thus the addition of a single dimension on the end. Output will be the last state of every layer in the network as an `LSTMStateTuple` stored in `current_state` as well as a tensor `states_series` with the shape `[batch_size, truncated_backprop_length, state_size]` containing the hidden state of the last layer across all time-steps.



```

>>> states_series
Out[2]: <tf.Tensor 'RNN/transpose:0' shape=(5, 15, 4) dtype=float32>
>>> current_state
Out[3]:
(LSTMStateTuple(c=<tf.Tensor 'RNN/while/Exit_2:0' shape=(5, 4)
dtype=float32>, h=<tf.Tensor 'RNN/while/Exit_3:0' shape=(5, 4)
dtype=float32>),
LSTMStateTuple(c=<tf.Tensor 'RNN/while/Exit_4:0' shape=(5, 4)
dtype=float32>, h=<tf.Tensor 'RNN/while/Exit_5:0' shape=(5, 4)
dtype=float32>),
LSTMStateTuple(c=<tf.Tensor 'RNN/while/Exit_6:0' shape=(5, 4)
dtype=float32>, h=<tf.Tensor 'RNN/while/Exit_7:0' shape=(5, 4)
dtype=float32>))
>>>

```

The states are not in lists anymore.

The tensor `states_series` is reshaped on the second row in the code sample above to shape `[batch_size*truncated_backprop_length, state_size]`, we will see the reason for this shortly. You may read more about `dynamic_rnn` in [the documentation](#).

Now input this two lines below the reshaping of the `states_series`.

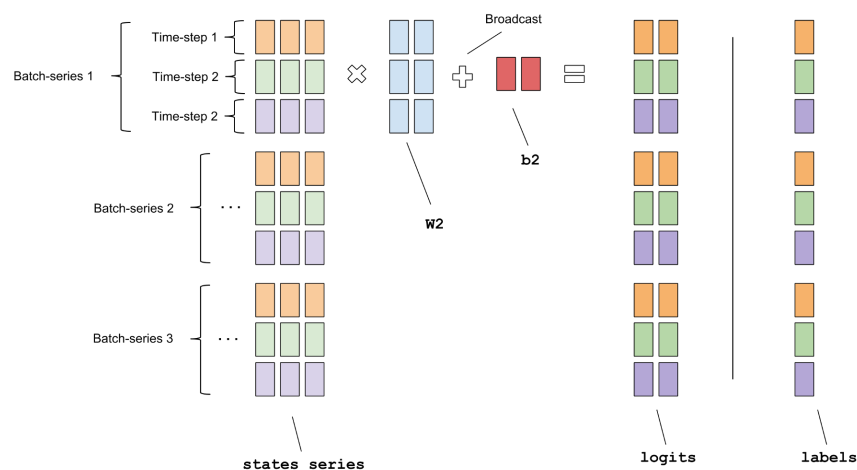
```

1 logits = tf.matmul(states_series, W2) + b2 #Broadcasted
2 labels = tf.reshape(batchY_placeholder, [-1])
3

```

Notice that we are now only working with tensors, Python lists were a thing of the past. The calculation of the `logits` and the `labels` are visualized below, notice the `state_series` variable that was reshaped earlier. In TensorFlow reshaping is done in C-like index order. It means that we read from the source tensor and “write” to the destination tensor with the last axis index changing fastest, and the first axis index changing slowest. The result of the reshaping will be as visualized in the figure below, where similar colors denote the same

time-step, and the vertical grouped spacing of elements denote different batches.



Visualization of the calculations, similar color denote same time-step, vertical spacing denote new batch.

Let's go through all the tensors in the figure above, first let's start with the sizes. We have that `batch_size=3` , `state_size=3` , `num_classes=2` and `truncated_backprop_length=3` . The tensor `states_series` have shape `[batch_size*truncated_backprop_length, state_size]` , `labels` have shape `[batch_size*truncated_backprop_length]` , `logits` have shape `[batch_size*truncated_backprop_length, num_classes]` , `w2` have shape `[state_size, num_classes]` and `b2` have shape `[1, num_classes]` . It can be a bit tricky to keep track of all the tensors, but drawing and visualizing with colors definitely helps.

Next calculate the predictions for the visualization:

```
1 logits_series = tf.unpack(tf.reshape(logits, [batch_size, truncated_backprop_length, num_classes]))
2 predictions_series = [tf.nn.softmax(logits) for logit in logits_series]
3
```

Here we actually split the tensors into lists again. This is perhaps not the best way to do it, but it's quick and dirty, and the plot function is already expecting a list.

The `sparse_softmax_cross_entropy_with_logits` can take the shape of our tensors! Modify the `losses` calculation to this.

```
1 losses = tf.nn.sparse_softmax_cross_entropy_with_logits
2
```

As we can read in [the API](#) the `logits` must have the shape `[batch_size, num_classes]` and `labels` must have the shape `[batch_size]`. But now we are treating all time-steps as elements in our batch, so it will work out as we want.

Whole program

This is the whole self-contained script, just copy and run.

```

1  from __future__ import print_function, division
2  import numpy as np
3  import tensorflow as tf
4  import matplotlib.pyplot as plt
5
6  num_epochs = 100
7  total_series_length = 50000
8  truncated_backprop_length = 15
9  state_size = 4
10 num_classes = 2
11 echo_step = 3
12 batch_size = 5
13 num_batches = total_series_length//batch_size//truncated_backprop_length
14 num_layers = 3
15
16 def generateData():
17     x = np.array(np.random.choice(2, total_series_length, dtype=int))
18     y = np.roll(x, echo_step)
19     y[0:echo_step] = 0
20
21     x = x.reshape((batch_size, -1)) # The first index is the batch
22     y = y.reshape((batch_size, -1))
23
24     return (x, y)
25
26 batchX_placeholder = tf.placeholder(tf.float32, [batch_size, -1])
27 batchY_placeholder = tf.placeholder(tf.int32, [batch_size, -1])
28
29 init_state = tf.placeholder(tf.float32, [num_layers, state_size])
30
31 state_per_layer_list = tf.unpack(init_state, axis=0)
32 rnn_tuple_state = tuple(
33     [tf.nn.rnn_cell.LSTMStateTuple(state_per_layer_list[idx],
34                                     tf.zeros((1, state_size), dtype=tf.float32))
35      for idx in range(num_layers)]
36 )
37
38 w2 = tf.Variable(np.random.rand(state_size, num_classes), dtype=tf.float32)
39 b2 = tf.Variable(np.zeros((1, num_classes)), dtype=tf.float32)
40
41 # Forward passes
42 cell = tf.nn.rnn_cell.LSTMCell(state_size, state_is_tuple=True)
43
44 # Training
45 for epoch in range(num_epochs):
46     for batch_idx in range(num_batches):
47         x_batch, y_batch = generateData()
48         _, _, _, _, _, _ = tf.nn.dynamic_rnn(cell, x_batch, dtype=tf.float32,
49                                             initial_state=rnn_tuple_state,
50                                             scope="rnn")
51         y_batch = tf.cast(y_batch, dtype=tf.float32)
52         loss = tf.nn.softmax_cross_entropy_with_logits(logits=_, targets=y_batch)
53         # Compute the average loss
54         loss = tf.nn.reduce_mean(loss)
55         # Compute the gradients
56         gradients = tf.nn.compute_gradients(loss)
57         # Apply the gradients
58         optimizer.apply_gradients(gradients)
59         # Print the loss
60         print("Epoch: %d, Batch: %d, Loss: %f" % (epoch, batch_idx, loss))
61
62 # Plot the results
63 x_test, y_test = generateData()
64 x_test = x_test.reshape((x_test.shape[0], -1))
65 y_test = y_test.reshape((y_test.shape[0], -1))
66
67 # Create the test set
68 test_set = tf.nn.dynamic_rnn(cell, x_test, dtype=tf.float32,
69                             initial_state=rnn_tuple_state,
70                             scope="rnn")
71
72 # Compute the test loss
73 y_test = tf.cast(y_test, dtype=tf.float32)
74 test_loss = tf.nn.softmax_cross_entropy_with_logits(logits=test_set, targets=y_test)
75 test_loss = tf.nn.reduce_mean(test_loss)
76
77 # Print the test loss
78 print("Test Loss: %f" % test_loss)

```

```

42 cell = tf.nn.rnn_cell.MultiRNNCell([cell] * num_layer
43 states_series, current_state = tf.nn.dynamic_rnn(cell
44 states_series = tf.reshape(states_series, [-1, state_
45
46 logits = tf.matmul(states_series, W2) + b2 #Broadcast
47 labels = tf.reshape(batchY_placeholder, [-1])
48
49 logits_series = tf.unpack(tf.reshape(logits, [batch_s
50 predictions_series = [tf.nn.softmax(logit) for logit
51
52
53 losses = tf.nn.sparse_softmax_cross_entropy_with_logi
54 total_loss = tf.reduce_mean(losses)
55
56 train_step = tf.train.AdagradOptimizer(0.3).minimize(
57
58 def plot(loss_list, predictions_series, batchX, batch
59     plt.subplot(2, 3, 1)
60     plt.cla()
61     plt.plot(loss_list)
62
63     for batch_series_idx in range(5):
64         one_hot_output_series = np.array(predictions_
65         single_output_series = np.array([1 if out[0]
66
67         plt.subplot(2, 3, batch_series_idx + 2)
68         plt.cla()
69         plt.axis([0, truncated_backprop_length, 0, 2]
70         left_offset = range(truncated_backprop_length
71         plt.bar(left_offset, batchX[batch_series_idx,
72         plt.bar(left_offset, batchY[batch_series_idx,
73         plt.bar(left_offset, single_output_series * 0

```

Next step

In the next part we will regularize the network to use dropout, making it less prone to overfitting.

