CECS 551
Assignment 9
Total: 30 Points

General Instruction

- Submit uncompressed file(s) in the Dropbox folder via BeachBoard (Not email).

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1. Design LSTM network and implement it using Keras library to learn simple arithmetic operations. The objective of the network is estimating result of addition or subtraction of two numbers.

   (a) (5 points) Implement a function to generate all pairs of query and answer. The query includes two integer numbers (0˜99) and the an operation (+ or -), and the answer includes correct results of the queries. You should have $100 \times 100 \times 2 = 20,000$ pairs of queries and answers. Please note that the lengths of queries and answers are fixed as 5 and 4, respectively.

   ```
   Data set
   Query(X): ‘0+0  ’, ‘0-0  ’, ‘0+1  ’, ‘0-1  ’, ..., ‘99+99’, ‘99-99’
   Answer(Y): ‘+0  ’, ‘+0  ’, ‘+1  ’, ‘-1  ’ ..., ‘+198’, ‘+0  ’
   ```

   (b) (5 points) Implement a function to encode a string into one-hot-encoding scheme. Please note that the dimensions of a queries and answers are fixed as 5×13 and 4×13, respectively.

   ```
   alphabet = [‘0’,‘1’,‘2’,‘3’,‘4’,‘5’,‘6’,‘7’,‘8’,‘9’,‘+’,‘-’,‘ ’]
   Encoding exmaple
   ‘4+27 ’
   [[0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0],
    [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0],
    [0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
    [0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0],
    [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1]]
   ‘+31 ’
   [[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0],
    [0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0],
    [0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
    [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1]]
   ```

   (c) (5 points) Implement a Encoder-Decoder LSTM network using the following code. Explain how this code implements Encoder-Decoder scheme.

   ```
   model = Sequential()
   model.add(LSTM(?, input_shape=(5, 13), return_sequences=False))
   model.add(RepeatVector(4))
   model.add(LSTM(?, return_sequences=True))
   model.add(Dense(13, activation=‘softmax’))
   ```

(d) (5 points) Shuffle the data set, and use 70% samples as the training set, 15% as the validation set, and 15% as the test set. Train the network and tune the hyper-parameters, then report the best test accuracy and its setting.

(e) (5 points) Reverse the query and answer strings in the data set, then repeat training with the settings of best test accuracy of (d).

```
‘4+27 ’ -> ‘ 72+4’
‘+31 ’ -> ‘ 13+’
```

(f) (5 points) With the setting of the best test(valid) accuracy, draw the chart of valid accuracy vs. epoch for both non-reverse(baseline) and reverse data set as shown in Figure 1. You can set `validataion_data=val_data` on `model.fit()` for this. (Actual numbers might be different.)

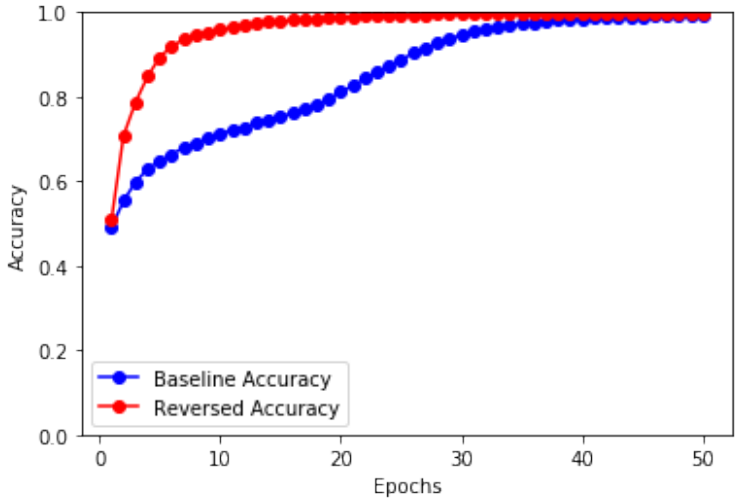

Figure 1: An example of accuracy vs. epoch