ECE194N: Homework 3

Part I: Written Part

Turn in this part during the lecture on March 6th.

1. Consider a RNN with following update equations

   $h^{(n)} = sigmoid(W_{hh}h^{(n-1)} + W_{hx}x^{(n)} + b_h)$

   $\hat{y}^{(n)} = softmax(W_{yh}h^{(n)} + b_y)$

   And below is the unrolled version of this RNN.

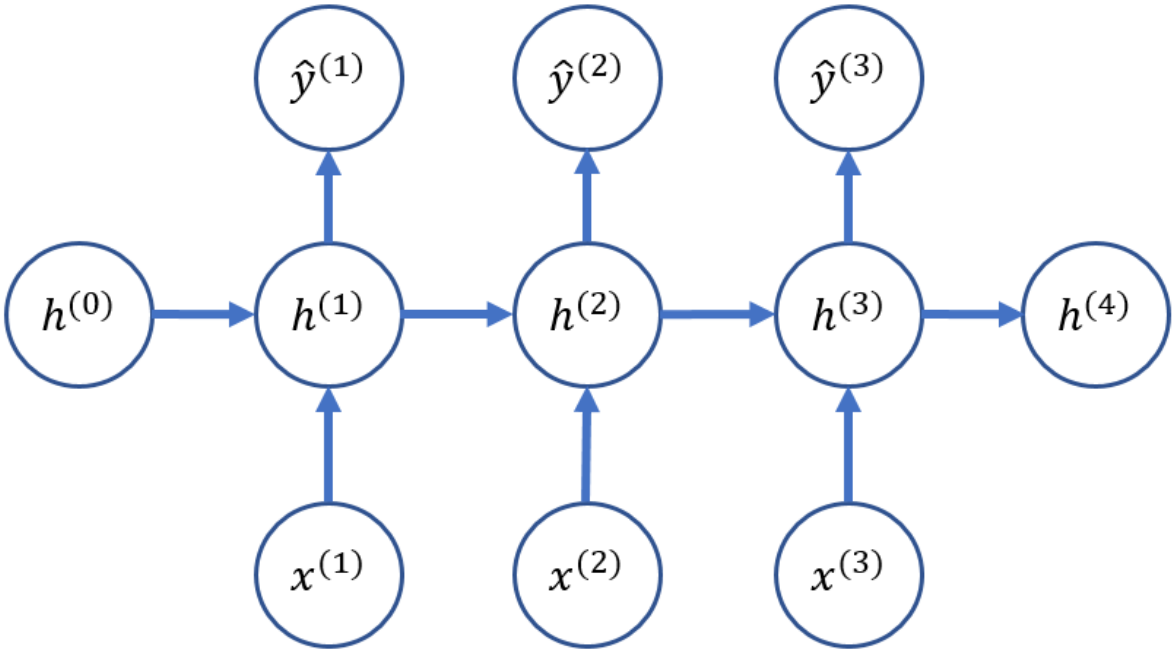

Figure 1: Unrolled RNN

Assume the loss to be cross entropy loss and the ground truth, $y_i^{(n)}$ to be a one-hot vector (which means only one of the elements of this vector can be 1 and the rest of them are zeros).

Let $L^{(n)}$ be the cross entropy loss at time n. Which is given by, $L^{(n)} = -\sum_{i=1}^{2} y_i^{(n)} log(\hat{y}_i^{(n)})$
Input vector, $x^{(n)} = \begin{pmatrix} x_1^{(n)} & x_2^{(n)} & x_3^{(n)} \end{pmatrix}$,
Hidden vector, $h^{(n)} = \begin{pmatrix} h_1^{(n)} & h_2^{(n)} & h_3^{(n)} & h_4^{(n)} \end{pmatrix}$ *and*

Output vector, $\hat{y}^{(n)} = \begin{pmatrix} \hat{y}_1^{(n)} & \hat{y}_2^{(n)} \end{pmatrix}$

Please answer the following questions

(a) Compute $\frac{\partial L^{(2)}}{\partial \hat{y}^{(2)}}$ and specify the dimensions

(b) Compute $\frac{\partial L^{(2)}}{\partial b_y}$ and $\frac{\partial L^{(2)}}{\partial W_{yh}}$ and specify the dimensions

(c) Compute $\frac{\partial L^{(2)}}{\partial h^{(2)}}$ and specify the dimensions

(d) Compute $\frac{\partial L^{(2)}}{\partial b_h}$ and $\frac{\partial L^{(2)}}{\partial W_{hh}}$ and specify the dimensions

(e) Compute $\frac{\partial L^{(2)}}{\partial h^{(1)}}$ and specify the dimensions

2. In this problem, we will be analyzing the dimensions and the receptive fields of each of the feature maps. Consider the model architecture from the following figure for a 10-class classification problem.

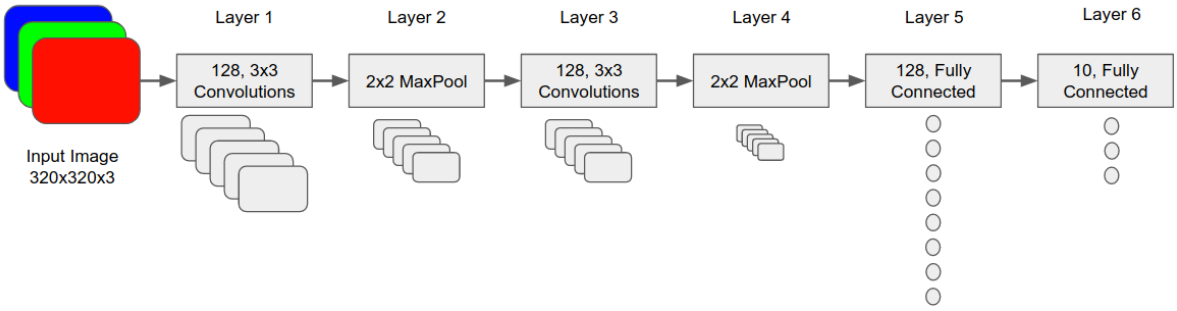

Figure 2: CNN Architecture

Figures underneath each layer represent the feature maps extracted after applying that layer. Answer the following questions for each of the 6 layers.

(a) For the following hyperparameters, find the feature map sizes of each layer.
Convolutions: Padding 'SAME', Stride 1
Max Pools: Padding 'VALID', Stride 2

(b) For the hyperparameters in (a), what are the dimensions of the trainable weights for each of the layers?

(c) For the hyperparameters in (a), what would be the receptive fields of each of the feature maps for layers 1,2,3,4?

(d) For the following hyperparameters, find the feature map sizes of each layer.
Convolutions: Padding 'VALID', Stride 2
Max Pools: Padding 'VALID', Stride 2

(e) For the hyperparameters in (d), what are the dimensions of the trainable weights for each of the layers?

(f) For the hyperparameters in (d), what would be the receptive fields of each of the feature maps for layers 1,2,3,4?

Part II: Programming Part

(Upload the zip file by midnight on Friday, March 8, on Gauchospace).

You will write a report on each of the questions below. Upload your report together with your code as a zip file to Gauchospace. Organize the main folder into three sub-folders and name them as "RNN". Name the main folder as "yourlastname_firstname". Include the individual reports for each of the sub-problems in the respective sub-folders. Organize the corresponding code into a subfolder named "code" inside the respective sub-folders.

1. **RNN:** In this problem we will be implementing an RNN. The objective of the RNN is that given a sequence of words, it will try to guess the next word. For this task we will follow the RNN tutorial for Tensorflow which can be found from this link:

   `https://www.tensorflow.org/tutorials/recurrent`

   (a) Download the data and read the reader code from the tutorial. Write a small script that displays the word ids and the sentences for the first 10 samples in the validation set. Hint: It should be something like this: "I like apples" [1,2,3] where 1:I, 2:like, 3:apples.

   (b) Create an RNN model following the tutorial. Train the model and save training and validation losses over time. Comment on if your model is overfitting or underfitting.

   (c) After your model achieves a good performance on validation data, report results on test set. Compare your test set results with validation and training.

   (d) Choose a word from the vocabulary as a starting word. Use your trained model to generate a sentence. Repeat this with 4 more different words and report the generated sentences.

   (e) Repeat (d) with the following set of words. Generate a sentence from each word separately. Words = {north, wall, truth, california, health}