CS7357 HW3, Noah Gardner, 000843905

1 Assignment 3

1. [**Points 5**] Write down the differences between feed-forward neural networks and convolutional neural networks.

   Answer:

   In a standard feed-forward neural network, the inputs are each multiplied by a weight matrix, and then the result is added to a bias vector. When we want to work with images or other types of data where the location of features is important, a feed-forward neural network is insufficient. A convolutional neural network applies a convolution operation to the input data and adds a bias vector. By applying convolution, we can preserve spatial structure. Additionally, the output of a convolution may be convolved further to learn deeper representations of spatial features (e.g. edges build up to shapes).

2. [**Points 95**] Suppose you are classifying cars, buses, and trucks images of shape 32x32, using a convolutional neural network and each image has three channels. Your convolutional neural network contains three convolutional layers, one fully connected layer, and then a SoftMax classifier. Your fully connected layer has 24 neurons. You are designing such convolutional layers so that you can get better performances. Your filter size for these layers can be any size between 1x1 to 7x7. You also apply the max-pooling layer after the second and third convolutional layer of any size between 2x2 to 5x5 that fits with your architecture. You are free to choose any number of filters (between 16 to 128) for each convolutional layer as well.

   (a) Draw this convolutional neural network diagram with details parameters. **Note: Show the configuration or dimensions of each layer as you see in the lecture slides**. [**Points 10**]

   Answer:

Layer	**Attributes**	**Output Shape**
Input	32x32x3	32x32x3
Convolution 1	3x3, 32 filters	30x30x32
Convolution 2	5x5, 16 filters	26x26x16
Max Pool	2x2, stride 2	13x13x16
Convolution 3	3x3, 16 filters	11x11x16
Max Pool	2x2, stride 2	5x5x16
Fully Connected	24 neurons	24x1
SoftMax	3 neurons	3x1

(b) Compute the number of parameters in each layer and showcase the total number of parameters of your network. Compute the number of parameters, for both with and without bias in each layer. [**Points 20**]

Answer:

Layer	**With Bias**	**Without Bias**
Convolution 1	896	864
Convolution 2	12816	12800
Max Pool	0	0
Convolution 3	2320	2304
Max Pool	0	0
Fully Connected	9624	9600
SoftMax	75	72
Total	25731	25640

(c) Is it possible to reduce the total number of parameters by following adding additional filters (any size of 1x1 to 7x7)? Please show your detailed calculation to showcase the lower number of parameters of such a CNN network. Also, draw the overall diagram with each layer dimension of your reduced parameter-based CNN network. **Note that you need to add additional filters to reduce the number of parameters of your initial CNN model. You cannot increase the size of the filter and/or change (decrease) the number of filters to reduce the total number of parameters. See the lecture slides to get an idea**. [**Points 30**]

Answer:

Layer	**With Bias**	**Without Bias**
Convolution 1	896	864
Convolution 2	528	512
Max Pool	0	0
Convolution 3	6416	2304
Max Pool	0	0
Fully Connected	9624	9600
SoftMax	75	72
Total	25731	25640

(d) Compute the total number of convolutional operations for each layer of your both networks (a) and (c). Assume each pooling operations cost is 1. Show the total computational cost of your networks. **Note: show each layer's computation separately to be considered partial grading in case of wrong calculations**. [**Points 35**]