

COMP9444 Neural Networks and Deep Learning

Term 3, 2020

Exercises 5: Hidden Units and Convolution

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1. Hidden Unit Dynamics

Consider a fully connected feedforward neural network with 6 inputs, 2 hidden units and 3 outputs, using tanh activation at the hidden units and sigmoid at the outputs. Suppose this network is trained on the following data, and that the training is successful.

Item	Inputs	Outputs
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	123456	123
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1.	100000	000
2.	010000	001
3.	001000	010
4.	000100	100
5.	000010	101
6.	000001	110

Draw a diagram showing:

- for each input, a point in hidden unit space corresponding to that input, and
- for each output, a line dividing the hidden unit space into regions for which the value of that output is greater/less than one half.

2. Softmax

Recall that the formula for Softmax is

$$\text{Prob}(i) = \exp(z_i) / \sum_j \exp(z_j)$$

Consider a classification task with three classes 1, 2, 3. Suppose a particular input is presented, producing outputs

$$z_1=1.0, z_2=2.0, z_3=3.0$$

and that the correct class for this input is Class 2. Compute the following, to two decimal places:

- $\text{Prob}(i)$, for $i = 1, 2, 3$
- $d(\log \text{Prob}(2))/dz_j$, for $j = 1, 2, 3$

3. Convolutional Network Architecture

One of the early papers on Deep Q-Learning for Atari games ([Mnih et al, 2013](#)) contains this description of its Convolutional Neural Network:

"The input to the neural network consists of an $84 \times 84 \times 4$ image. The first hidden layer convolves 16 8×8 filters with stride 4 with the input image and applies a rectifier nonlinearity. The second hidden layer convolves 32 4×4 filters with stride 2, again followed by a rectifier nonlinearity. The final hidden layer is fully-connected and consists of 256 rectifier units. The output layer is a fully-connected linear layer with a single output for each valid action. The number of valid actions varied between 4 and 18 on the games we considered."

For each layer in this network, compute the number of

- a. weights per neuron in this layer (including bias)
- b. neurons in this layer
- c. connections into the neurons in this layer
- d. independent parameters in this layer

You should assume the input images are gray-scale, there is no padding, and there are 18 valid actions (outputs).
