EECE 5136/6036: Intelligent Systems

Homework 4: Given 10/26/17; Due 11/21/17

This homework is a continuation of Homework 3. You should use the same code and datasets for this homework. You should have laid the groundwork for this homework in Homework 3, so this should not take nearly as much time.

1. (200 points) In this problem, you will repeat Problem 1 from Homework 3 using the simulator you developed and the same training and testing sets as before, but with one big difference. This time, instead of setting the weights from the inputs to the hidden neurons randomly, you will set them to the final weights from the input to the hidden layer obtained after training in Problem 2 from Homework 3 , and then you will only train weights from the hidden layer to the output units using back-propagation (actually LMS, because now you are only training one layer). Basically, you are using the feature detectors found by the auto-encoder, and using them as hidden neurons for the classification problem, relying on the assumption that the auto-encoder must have found high-quality features in order to achieve good reconstruction, and that these features are informative enough to be the basis of classification without further training.

Specifically, you will train a network where the weights from input to hidden neurons are set to the final values of the same weights from the best final network obtained in Problem 2 of Homework 3, while the weights from hidden to output neurons are initialized randomly. During training, each data point is presented to the network and, after the error is calculated, only the hidden-to-output weights are adjusted. The input-to-hidden weights remain fixed.

Follow all the same procedures for collecting data and results as in Problem 1 of Homework 3, and write a report with the following sections:

- **System Description:** A description of all the choices you made – learning rate, momentum, output thresholds, rule for choosing initial weights, criterion for deciding when to stop training, etc.
- **Results:** Report performance of the final network on the training set and the test set using confusion matrices just as you did in Homework 3. Also plot the time series of the error (1 - Hit-Rate) during training using the data saved at every tenth epoch for both networks.
- **Feature Comparison:** Take a large sample of hidden neurons from the final network in Problem 1 of Homework 3, and plot the images for their features (i.e., using their weights). Comment on how these features compare to the features you see in hidden neurons for the network in this problem (which are actually the hidden layer features from Problem 2 of Homework 3).
- **Analysis of Results:** Describe, discuss and interpret the results you got, and why you think they are as they are. In particular, comment on what differences, if any, you see in the performance of networks from Problem 1 in Homework 3 and the network in this problem.

The text part of the report, including the figures, should be no more than 3 pages, 12 point type, single spaced. Since this problem does not require any new program, you do not need to include a program with this.

2. (200 points) Repeat Problem 1, but this time train both the hidden weights and output weights using full back-propagation (i.e., the features taken from the auto-encoder are trained further once they are put into the classifier). You may want to use a smaller learning rate for the hidden layer weights than for the output layer. This is called *fine tuning*.

Follow all the same procedures for collecting data and results as in Problem 1 above, and write a report with the following sections:

- **System Description:** A description of all the choices you made – learning rate, momentum, output thresholds, rule for choosing initial weights, criterion for deciding when to stop training, etc.
- **Results:** Report performance of the final network on the training set and the test set using confusion matrices just as you did in Homework 3. Also plot the time series of the error (1 - Hit-Rate) during training using the data saved at every tenth epoch for both networks.
- **Feature Comparison:** Take a large sample of hidden neurons from the final network in Problem 1 above, and plot the images for their features (i.e., using their weights). Do the same with features obtained after training in this problem. Comment on how these features compare.
- **Analysis of Results:** Describe, discuss and interpret the results you got, and why you think they are as they are. In particular, comment on what differences, if any, you see in the performance of network from Problem 1 and the network in this problem. Does the feature comaprison help explain the difference?

The text part of the report, including the figures, should be no more than 3 pages, 12 point type, single spaced. Since this problem does not require any new program, you do not need to include a program with this.

If you have questions, please send me mail at. Ali.Minai@uc.edu.

Points will be awarded for: 1) Correctness ; 2) Clarity of description; 3) Quality of the strategy; and 4) Clarity of arguments and presentation.

As in previous homeworks, the report text should not be mixed in with the program. It should be a stand-alone document with text, tables, figures, etc., with the program as an appendix. *None of the information required in the report should be given as a comment or note in the program. It must all be in the report.*

You may consult your colleagues for ideas, but *please write your own programs and come to your own conclusions.*