E9 205 – Machine Learning for Signal Processing

Homework # 5
Due date: Nov. 23, 2018

Submit the assignment as pdf file to mlsp18 doT iisc aT gmail doT com

November 14, 2018

1. Read the following article *https* : *//arxiv.org/pdf/*1609.04747.*pdf* What are the methods of

   (a) Adagrad
   (b) RMSprop
   (c) Adadelta
   (d) Adam

   Comment on the intution as well as the mathematical formulae used in implementing the method. What are the heuristics in choosing one method over the other. (**Points** 20)

2. **M**NIST data - Download the dataset of hand-written digits
   http : *//yann.lecun.com/exdb/mnist/*
   containing 10 classes. [Reduce the number of samples in training data if your computing powers are limited as required by random subsampling]. The Keras package is needed for the rest of the question *https* : *//pypi.python.org/pypi/Keras*

   (a) **I**mplementing CNNs - Use the Keras package to implement a CNN model with one layer of convolutions (kernel size of 3×3 with a 2-D convolutional layer and having 128 filters) followed by two dense layers of 256 neurons. Compare the performance of the CNN with the DNN used in Assignment # 4.
   (b) Comment on the use of momentum parameter, Nesterov accelerated gradient, Adagrad, Adam optimizers in improving the classification result on the test data.
   (c) Provide your answers with analysis for different choices of hidden layer dimensions $(128, 256, 512)$, maxpooling (no max pooling and (2×2) max pooling) and filter sizes $(3 \times 3$ and $5 \times 5)$ in the CNN.

   (**Points** 30)

3. **Dimensionality reduction for MNIST** For the MNIST handwritten digit dataset, choose a random subset of 10000 images for training and 1000 images for validation and original MNIST testset for blind testing. Vectorize the images as 784×1. Use one of the following dimensionality reduction methods trained with the 10000 image training set,

(a) Apply PCA to 25 dimensions, and train a DNN with dimensions $(25, 256, 256, 10)$ with softmax non-linearity and two hidden layers to classify the 10 handwritten digits.

(b) Apply LDA on the PCA reduced images to 9 dimensions, and train a DNN with dimensions $(9, 256, 256, 10)$ with same output non-linearity for digit classification.

(c) Train a Gaussian Bernoulli RBM model with PCA input and 9 dimensional hidden activation. Once the RBM is trained, forward pass the PCA input and use the 9 dimensional hidden activation from RBM for training the digit classification similar to LDA case (using the same DNN configuration).

(d) Train an autoencoder using 25 PCA reduced image with size $(25, 128, 9, 128, 25)$. Use a ReLU activation and MSE loss for the Autoencoder. Following the training of the autoencoder, generate the embeddings from 9 dimensional latent layer and use them for training a DNN similar to the LDA case.

Implement all the above classifier models in Keras. Use the validation data to check the accuracy of the training on each epoch. Plot the training and validation accuracy for each of the above methods for every epoch of training. Comment on classification performance on the test data of each of the dimensionality reduction methods using the same MNIST test data. Does any of the methods show advantage over the others. If so, why ?
(**Points** 50)