Assignment 3: CS 754, Advanced Image Processing

Due: 4th April before 11:55 pm

Remember the honor code while submitting this (and every other) assignment. All members of the group should work on and understand all parts of the assignment. We will adopt a zero-tolerance policy against any violation.

Submission instructions: You should ideally type out all the answers in Word (with the equation editor) or using Latex. In either case, prepare a pdf file. Create a single zip or rar file containing the report, code and sample outputs and name it as follows: A4-IdNumberOfFirstStudent-IdNumberOfSecondStudent.zip. (If you are doing the assignment alone, the name of the zip file is A4-IdNumber.zip). Upload the file on moodle BEFORE 11:55 pm on 4th April. Late assignments will be assessed a penalty of 50% per day late. Note that only one student per group should upload their work on moodle. Please preserve a copy of all your work until the end of the semester. If you have difficulties, please do not hesitate to seek help from me.

1. Your task here is to implement the NNSC algorithm we saw in class for the task of Poisson noise removal. Let the noisy image be denoted Y and X be the original clean image. Let y_i be the vectorized patch (containing n pixels in total) from Y with its top left corner at pixel i, and let x_i be defined likewise in X. Then we have $y_i \sim \text{Poisson}(x_i)$ where $x_i = Wh_i$ where W is a non-negative dictionary with unit-norm columns and h_i are the non-negative sparse coefficients of patch in the dictionary W. Your job is to minimize the objective function: $E(W, \{h_i\}) = \sum_{i=1}^{N} \sum_{j=1}^{n} (-y_{ij} \log(Wh_i)_j) + (Wh_i)_j)) + \lambda \sum_{k=1}^{K} \sum_{j=1}^{N} h_{kj}$ where N is the number of patches, K is the number of dictionary columns, and λ is a regularization parameter. The method of optimization is projected gradient descent with adaptive step size.
   You should work with the image provided in the homework folder. Adjust the intensity range of the image in such a way that its peak is 30, 60 or 100. In each case, generate a Poisson noisy version of the image using $Y_i \sim \text{Poisson}(X_i)$ over every pixel i using the 'poissrnd' function in MATLAB. Note that Poisson noise is not 'added' unlike Gaussian noise - it is generated by drawing random numbers from the Poisson distribution.
   In every case of peak intensity, you need to divide the image in overlapping patches of size 7×7, and then perform the denoising learning a dictionary of $K = 80$ columns. The final result can be generated by averaging the overlapping patches. You will need to run the experiment multiple times with different values of λ so that you get a result with clear denoising.

   In your report, you should write the expression for the derivatives you used in the descent procedure, state the λ values you used for your best result, and also state the PSNR before and after denoising in each case of peak value. Also include the original, noisy and denoised images.

   Marking scheme: Correct implementation - 60 points (as evidenced by reasonable denoising - see lecture slides on grayscale images for a sample), 10 points for plotting the images systematically, 20 points for carefully writing out the derivatives, and 10 points for stating the λ values carefully and stating the PSNR values.

   Tips: In the beginning, work with smaller portions of the image, while you are debugging. You can speed up your code by using MATLAB's vectorization for the formulae of the derivatives.