Assignment 4

Digital Signal Analysis & Applications

April 4, 2019

- **Deadline is 11th April 2019, 11:55 PM**
- All questions are compulsory. Follow the instructions carefully.
- **Make a detailed report for all the questions**
- **Ensure that submitted assignment is your original work. Please do not copy any part from any source including your friends, seniors and/or the internet. If any such attempt is caught then serious action will be taken.**
- Report should contain details of algorithm implementation, results, observations & answers to the subjective questions (if any).
- **You are expected to use vector operations in all your Matlab codes. Non vectorized codes will be penalized**

Problem 1.

1. Implement the following functions:

   (a) *create_mat_dct()*, which outputs the the 8-point 2D-DCT basis function F. The function for computing the basis is given as: $F(v,u) = r\cos(\frac{\pi(2u+1)v}{2N})$, where $r = \sqrt{\frac{1}{N}}$ if $v = 0$ and $r = \sqrt{\frac{2}{N}}$, otherwise (verify your result using *dctmtx()* function in Matlab).

   (b) *myDCT(im, F)*, which takes as input any given 8 x 8 image *im* and the basis matrix *F*. The output of this function is the DCT transformed image.

   (c) *myIDCT(im, F)*, which computes the inverse DCT transform

   (d) *myDCT_quantization(imDCT, qm, c)*, which takes as input the DCT transformed block *imDCT*, the quantization matrix *qm* and the compression factor *c* (divide image by *c* times the quantization matrix). Output is the quantized DCT image (*imqDCT*).

   (e) *myDCT_dequantization(imqDCT, qm, c)*, which de-quantizes the quantized DCT image

(f) *RMSE(im1, im2)*, which computes RMSE error between two images of arbitrary size

(g) *My_entropy(im)*, which computes the entropy of a given image (you can use the *imhist()* function in Matlab to do it efficiently)

2. Observe the DCT, quantized DCT and reconstructed image for the 8x8 sub-windows extracted from the LAKE image and whose top left corners are at the coordinates: (420, 45), (427, 298) and (30, 230). For that you will use the classical quantization matrix for luminance and $c = 2$. Comment on the observations.

3. Apply the DCT transform (and quantization) to all 8x8 sub windows of the LAKE image and create an image with all the resulted DCT images at the same positions as their corresponding image. Comment on your observations.

4. Reconstruct the image. Find the highest value of c so that the distortions of the reconstructed image are just perceptible. Give the corresponding entropy and RMSE for each case (for different values of c). Explain the results obtained with $c = 10$

Problem 2.
You are the lead developer in a software engineering firm and have been given the task of compressing facial images. You have recently learnt about PCA in the class and decide to apply it for the given task. The images are given in the folder *images.zip* and are of size 256x256 each. Use PCA to reduce the dimensionality of the images and answer the following

1. Reconstruct the images back using a small number of components (35)

2. Use scatterplots to examine how the images are clustered in the 1D, 2D and 3D space using the required number of principal components.

Note that the images are large enough that you might not be able to compute the covariance matrix C due to memory limits. However, you can find the eigenvectors of $L = A^T * A$, and compute the eigenvectors of $C = A * A^T$ using L or vice-versa.