1. **Software Requirement:**
   MATLAB

2. **Prerequisites:**
   You may refer to your lecture notes and the textbook.

3. **Assignment Requirements:**
   Give extra attention to report document of this assignment, that is, providing only some piece of MATLAB code does not satisfy requirements. For all questions, you need to provide clear and scientific justifications; otherwise you cannot receive full points from that question.

4. **Code Style and Naming Conventions**

It is also required that you need to follow a standard coding style.

- All of the questions must be implemented as separate functions and function names must obey following format; “question_id_letter”. For example, if you are writing a code for question-4.a, your function name must be “question_4_a”.
- At the beginning of the each function, there must be a comment header describing the general inputs/outputs for your function. (Comment header’s format is specified in the file “comment_style.m”)
- All functions must be called by a single MATLAB script, whose name is “main.m”
- All of the output images must be written into a folder named as “outputs”.
  (see: MATLAB’s imwrite function)

5. Assignment Questions

1) Noise Models (15 pts):

You are given three probability density functions;

1. Normal PDF : $n(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
2. Log-Normal PDF : $n(x;\mu,\sigma) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(lnx-\mu)^2}{2\sigma^2}}$, x>0
3. Exponential PDF : $n(x;\gamma) = \gamma e^{-\gamma x}$, x>0 , x>0

a) Generate three different random noise images from these PDFs in spatial domain. Your noise image should be in size of 512x512.
b) Sketch the histograms of the noise images.
c) Plot the PDFs. Then, visually compare these plottings with histograms of the noise images. Do noise image histograms resemble the PDF plottings?

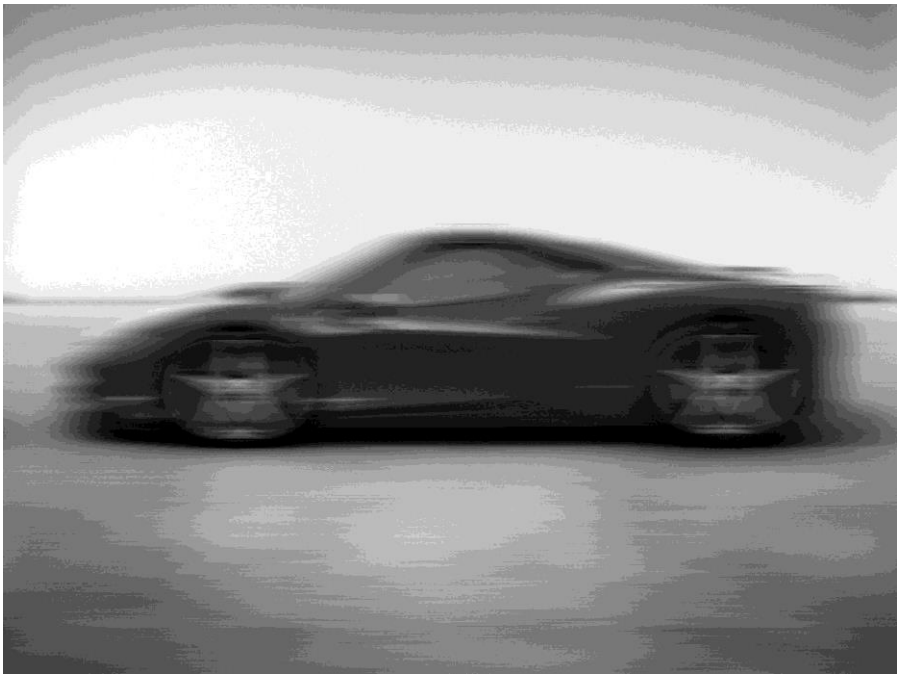
2) Image Restoration in Spatial Domain – Adaptive Filtering (20 pts):

You are given a noisy image, "Assignment5_Noisy.bmp"

a) Filter the noisy image with arithmetic mean, geometric mean and median filters separately.
b) Devise your own adaptive noise removal algorithm, which makes use of local features of the image such as standard deviation, minimum, maximum and mean etc. Run this algorithm on the noisy image.
c) Visually compare the outputs of questions 2.a and 2.b. Explain the difference. Which technique is more promising? What are the advantages/disadvantages of your adaptive method over ordinary linear/nonlinear spatial filters? (Note that to get full points from this question, your adaptive algorithm must provide better outputs.)

3) Image Restoration in Frequency Domain – Wiener Filtering (30 pts):

Assume that you have captured an image of Ferrari while it has been driving in the latest rally competition. However, you have realized that the captured image has been exposed to motion corruption and some random noise due to speedy movement of the Ferrari. The captured image can be seen below:



(**Note**: Motion corruption can be modeled by MATLAB's motion blur filter, and you are given the parameters of this filter as LEN=80 and THETA=0.)

a) By using Wiener filter, restore the given image assuming no noise. Provide corresponding output and comments on the result.
b) By using Wiener filter, restore the given image with an estimate of noise to signal power ratio. Provide corresponding output and comments on the result. (Note: Assume that the image noise is random. It has zero mean and a variance of 0.0001)
c) Compare the outputs obtained at 3.a and 3.b and explain the difference. Can you suggest a better noise estimate?

4) Color Image Processing (35 pts):

a) You are given a 3-band RGB image "rgb.png". RGB color space uses additive color mixing, that is, color values in this space indicate the amount of emitted light. Calculate the subtractive representation of this image. Save the output as "rgb_subtractive.png". What are the names of colors you have obtained by using subtractive color mixing?
(**Hint**: Subtractive color mixing employs the values for absorbed light.)

b) Is RGB a device-dependent or device-independent color space? Why? Is an **exact** color space conversion between RGB and CMYK possible? Why?

c) For given RGB image, "Peppers.ppm", calculate the RG chromaticity. In your report, include chromaticity images and compare red band of the given image with red chromaticity you have calculated. What is the implication of red chromaticity? In which way RG chromaticity is useful? What are the possible applications of this color space?
(Note: RG chromaticity is a 2D color space, so you cannot display it in MATLAB directly.)

d) In the image processing community, there are two different RGB to grayscale conversion procedure exist. First one calculates a weighted sum of red, green and blue bands (see MATLAB's rgb2gray function). The second technique includes a conversion from RGB to HSV and HSV's value component is taken as grayscale image.
Implement both techniques and explain the visual difference. Comment on the advantages/disadvantages for both of them.

5) Submission and Grading Policy

Assignments will be submitted via METU-Online. Create a rar or zip archive containing plain source codes (*.m files) and the document explaining your algorithms, implementations, results and discussions. Please pay attention on the documentation of your assignment.

The assignments are due at 23:59 PM on the deadline.

Any late submission will have 10% deduction for each late day.

No submissions will be accepted 2 days after the deadline.

You are expected to work individually NOT in groups. You will also be expected to follow the academic integrity rules.

Policy for Copying: ***Passing the work of others (either from another student or a code on internet etc.) off as your own is a breach of academic ethics and also of the University's disciplinary rules. Students are expected to work on the homeworks individually, not as a group. When you submit a work, it automatically implies that you claim the ownership of the work.***

Note that METU is subscribed to some tools which allow cross checking of submitted works as well as checking with any work on internet or any university subscribed to the system. No exceptions will be allowed and any work found to be copied will result in failing the course.

Please send your questions about the assignment to **ucinar@metu.edu.tr**.