Assignment 2

Digital Signal Analysis & Applications

February 15, 2019

- **Deadline is 25th February 2019, 11:55 PM**
- All questions are compulsory. Follow the instructions carefully.
- All coding questions have to be done in MATLAB only.
- **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.**
- The submission - Roll number.zip - should contain the given files: $q1.m$, $q2.m$, $q4.m$, $q5.m$, $q6.m$, $q7.m$, *Report.pdf* as well as the auxiliary functions.
- 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.
This question comprises of 5 parts. Avoid using non-vectorized code as far as possible.

1. Create a Matlab function called $gauss\_filter$ that takes the following two arguments as input:
   - N: Kernel size
   - $sigma$: Standard deviation sigma

   This function will return a N x N Gaussian filter with standard deviation sigma. Try different values for N (>64) and sigma and submit the images produced. Compare the output of the filter produced by the above function with the one produced using fspecial (Normalize the output so that the values sum to 1)
2. Create a Matlab function called $median\_filter$ that takes the following arguments as input:

- I: Image
- N: Kernel size

This function will run median filtering on the image I using a N x N window. (Use im2col and col2im to vectorize the code)

3. Run both these filters on the image *cameraman.tif*. Submit the outputs for the same. Try different values for the arguments N and *sigma*. (Use imfilter to apply a filter on an image)

4. Read the image called *inp*1.*png* given in the assignment directory. Try removing the noise using the various filters taught in the class. Which filter is the most suitable for this type of noise?

5. Remove noise from the image *inp*2.*png* given in the assignment directory. What type of filter can be used for this purpose? (You may have to work in the frequency domain for this one)

Problem 2.
An image of size (Width, Height, Channels) is convolved with N filters of size (F,F,Channels).The convolution is done with a step size of S units, and the input is also padded with a zero padding of Z. The convolution always happens in such a way that the filter is always contained in the image.

(a) Predict the dimensions of the output of this convolution.

(b) How many additions and multiplications are involved in this convolution?

Problem 3.
You have just spotted the most wanted fugitive from the FBIs most wanted list. She is at a phone booth and has pressed a few numbers on the phones keypad. You have tampered with the phonebooth and have an audio recording of the numbers that she has dialed. Help the FBI in chasing her partner down by identifying which numbers she has dialed. Note that all the numbers have been pressed for the same duration. You have been given the audio files for the sounds of the individual dial tones.

Problem 4.
Download the file corresponding to your Roll Number mod 8 from here and design your own filter to remove noise from the file, as much as possible.Write a MATLAB code to denoise the signal with your filter and also write a brief description about the implementation of the filter in the report. Also analyze the resulting signal and write your observations in the report.

Problem 5.
Implement 2D Fast Fourier Transform (Recursive Formulation) and DFT. In report pick any 3 images and show the output generated from your code and in-built function. Compare the run times of your version of dft and fft on different sized inputs and plot them. Write your observations in the report.

Problem 6.
Calculate the Fourier transform of the Fourier transform of any image. You would observe that the image you get is similar to the original image. How is it different from the original image? Write your observation and explanation in the report. How can you fix this in the frequency domain so that we would get the original image back instead?

Problem 7.
This question consists of 3 parts as well. ☹

1. Write a Matlab function to compute the spectrogram of a given audio file (Use window size and the length of the stride as the input to your function). Write your observations by varying the window size and length of the stride in the report. Compare your results with the inbuilt spectrogram function in Matlab for the audio file *chirp.wav*.

2. Darth Vader has surrounded the rebel ship and the admiral was forced to send you the Death Star plans and a sound file via mail. The mail is password protected and a clue about the password is given in the sound file called *message.wav*. You must recover the password in order to get the Death star plans as you are the sole hope of the Rebellion. (You may use any signal processing techniques taught in the class for the same.)

3. Create a Matlab function called *dial_tone* that takes your roll number as input. The function will create a tone corresponding to the roll number based on the touch tone for each frequency. Plot a spectrogram for the created tone. A sample tone like *tone.wav* is expected. You may add a pause of $0.2 - 0.3$s between each tone. (For the frequencies corresponding to each digit, refer to this link: DTMF)