Homework 1

Due: 2020/10/20, 11:50pm

1. (5%) Please search for the definition of “Convolution”, in the textbook of Engineering Mathematics, or online. Please read it and then use your own word to describe the basic meaning of “convolution”. Please define it with math equation. Please give an example of convolution by first drawing two signals in time domain. Then draw another figure to illustrate what we should do to get the result of convolution.
2. (5%) Please search for the definition of “Fourier Transform”, in the textbook of Engineering Mathematics, or online. Please read it and then use your own word to describe the basic meaning of “Fourier Transform”. Please define it with math equation.
3. (5%) Please describe how to compute “convolution” of two signals by using “Fourier Transform”. Why do we want to use such method? What advantage can we get?
4. (5%) Please search for the definition of “cross-correlation” in signal processing field, in the textbook of Engineering Mathematics, or online. Please read it and then use your own word to describe the basic meaning of “cross-correlation”. Please define it with math equation.
5. (5%) Please describe how to compute “cross-correlation” of two signals by using “Fourier Transform”. Why do we want to use such method? What advantage can we get?
6. (50%) Following problem is to do with image cross-correlation. Please extract the file “OCR.zip” and put all files at the same directory.

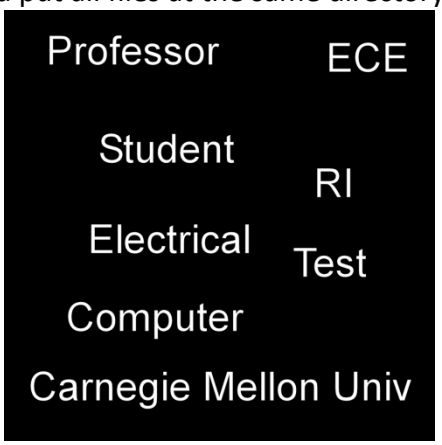

Figure 1

   (a) (10%) Load the image scene.bmp into Matlab. This contains a 1024x1024 image with letters. Load the letter ‘e.bmp’. Create a matched filter and correlate the letter e with the scene. Use standard correlation where you extract each window (same size as e) in the scene, perform inner-product of e with that window and store the correlation value. Repeat this for all spatial locations of the window. Measure the time it takes to do this (use tic and toc in Matlab).
   (b) (10%) Plot the resulting correlation output from (a) as a 2D image but also as a 3D plot using the ‘surf’ Matlab command.
   (c) (10%) Choose an appropriate threshold that will detect all the ‘e’s in the correlation output in (a) and draw a rectangular bounding box in the original

scene image. Plot this scene image with the detected 'e' characters. Also give us your threshold value.

(d) (10%) Do the same experiment as in (a) but use FFTs to perform correlation using the Fourier transform properties we learned in class. Measure the time taken to perform the cross-correlation using FFTs. Draw the correlation output as a 2D image and compare to that of (a). Draw the bounding boxes of where the letter 'e' was detected just as you did in (c), comment on the differences or similarities with these results and the results you obtained in (c).

(e) (10%) Repeat (d) using FFTs but look for the letter 'O' using the 'o.bmp' file. Display the detection boxes, use a threshold which gives all 'o's but fewest other letters. Examine the outputs and comment on the detections observed.

Please write a *.m file for each of the above questions, and name them as:
Part_6a.m, Part_6b.m, Part_6c.m, … etc.

7. (25%) Please write a Matlab script ccNoise.m to generate the figure shown in the page 22 in our slide "Pattern Recognition using Correlation Filter". Basically, you need to do the following thing:
   (a) Generate a 2D noise image a
   (b) Perform auto-correlation using a (You can use the cross-correlation function written by yourself or the built-in Fourier Transform function in Matlab)
   (c) Plot the correlation plane (in time domain) with a 3D plotting method in Matlab

Please type your answer in a MS Word file, and compress this Word file with all Matlab *.m file into a single *.zip file. Please name this zip file with your student ID and your name, for example, 10101010101_王小明.zip. Submit it to LMS system before the deadline. You don't need to include the OCR.zip file in your *.zip file.
You are very welcome to contact with TA if you have any question. Good luck!

Prof. Yung-Hui Li