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**LABORATORY MANUAL**

**CE3007: Digital Signal Processing**

**Hardware Lab 1 (Location: N4-01a-03)**

**SESSION 2017/2018**

**SEMESTER 2**

**COMPUTER ENGINEERING COURSE**

**SCHOOL OF COMPUTER SCIENCE AND ENGINEERING**

**NANYANG TECHNOLOGICAL UNIVERSITY**

**LAB – 3**

**Discrete Time Fourier Transform**

**1. OBJECTIVE**

In this laboratory exercise, we will continue to use python to Fourier Analysis of discrete time signal. Fourier Analysis remains one of the most important topic in Engineering [2].

Snippets of python code which can help in this laboratory is provided in Lab3Example.py

The expectations of students taking this subject remain the same as in Laboratory 1.

**2. Tasks**

* 1. **Revision of Theory. Prepare brief answers to the following questions.**

1. Given a periodic sequence x[n] with period N samples, state and write the Fourier Analysis equations which can be applied to it to represent it in the frequency domain?
   1. **Practical – Python**
2. In this question, you will develop your own python routine to generate the forward and inverse DTFS (Discrete Time Fourier Series) and DFT (Discrete Fourier Transform) representation of a given periodic sequence x[n]. Your routine should have prototype as in the following:

Ydtfs[k] = myDTFS(ipX)

Ydft[k] = myDFT(ipX)

ipX = myIDTFS(Ydtfs)

ipX = myIDFT(Ydft)

where ipX is a real vector representing a single period of a periodic sequence. Compare your results to scipy.fftpack.fft which is the fast implementation of DFT.

1. Find Ydtfs[k] and Ydft[k] for ipX = [1,1,0,0,0,0,0,0,0,0,0,0]. Plot the absolute and phase representation for the found Fourier analysis values. Clearly label the x-axis values and interpret the corresponding (radian/sample) value for each k.
2. Show that your inverse DTFS and DTFT will generate the given ipX from Ydtfs and Ydft coefficients found.
3. Evaluate
4. Ydtfs1[k] of ipX1 = [1, 0, 0, 0 ,0, 0, 0, 0, 0, 0, 0, 1]
5. Ydtfs2[k] of ipX2 = [0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0]
6. Ydtfs3[k] of ipX3 = [10, 10, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]

What is the difference in the frequency domain representation to Q2a.

1. Provide the representation of DFT forward analysis using matrix notations. Each row of the analysis matrix W has a particular meaning. Plot the phase representation of row 0,1,2,… of matrix W, and hence suggest the characteristic of each row. Hint- Examine for the case of N=4,6,8,16.
2. Why is it not possible to realise DTFT of a discrete sequence. E.g, if the ipX sequence is aperiodic, ipX = [1,1,1,1,1,1,1,0,0,0,0,0,0,0,….],
   1. why is it not possible to write a routine to analyse it.
   2. Analyse ipX by truncating the ipX sequence with N = 12, 24,48,96. Then apply DTFS on the truncated sequence. Plot the resultant Fourier magnitude coefficients with respect to x-axis being k (integers) as well as . Hence interpret the relationship between DTFS to DTFT.

5. Write your own routine to perform convolution of two sequence in the Fourier domain.

y = myDFTConvolve (ipX,impulseH)

compare your results using scipy fftconvolve [1], as well as your convolution routine developed in Lab 2.

1. **References**

[1] Scipy’s convolution in frequency domain, <https://docs.scipy.org/doc/scipy/reference/generated/scipy.signal.fftconvolve.html>

[2] Many notes here: <http://complextoreal.com/wp-content/uploads/2013/04/fft5.pdf>