**2110233 Com Eng Math Lab - (1/2024) Take Home Quiz**

**Submission: (1) pdf file and (2) ipynb before 23:59, 19 September 2024**

**Instructions:**

* This exam is an open book exam.
* You are also allowed to open online resources, but you will have to answer in your own words and understanding. You must provide all references at the end of this document.
* The exam must be taken completely alone. You cannot share your answers or code with anyone.
* You can ask questions on discord in **#labexam1**, further announcement will be posted on **#announcement**
* You must complete the exam within this exam paper and submit in PDF file. The PDF file will be primarily scored, while the IPYNB file will be used as a reference for validating the PDF file. Make sure you provide **clear** and **original** **answers** to all questions **in your own words**.
* **Any student who does not obey the regulations listed above will receive punishment under the Faculty of Engineering Official Announcement on July 27, 2017 regarding the exam regulations.**

**a) With implicit evidence or showing intention for cheating, student will receive an F in that subject and will receive a lower ethical behavior score.**

**b) With explicit evidence for cheating, student will force to withdraw from Chulalongkorn University, or students will an F in that subject during that semester and will be required to withdraw all subjects and receive a lower ethical behavior score.**

I acknowledge all instructions above. This exam represents **only my own work**. I did not give or receive help on this exam.

Signature …………………………………………………………….............

Date ………………13 September 2024……....................

All required files and parameters have been sent to your Chula email.

**1. (15 points) Audio Analysis**

Download **file1.wav** and **file2.wav** from the links provided in your email. Perform a DFT to analyze and compare the signals.

* 1. Plot the **file1** and **file2** signals in time domain and its frequency spectrum (low frequency at the center)

**file1**:

|  |  |
| --- | --- |
| Time domain | Frequency domain |
|  |  |

**file2**:

|  |  |
| --- | --- |
| Time domain | Frequency domain |
|  |  |

1.2) Determine top three dominant frequencies of each signal in Hz. EXCLUDING the dc component and those that are the consequence of the **complex conjugate symmetry** property. Explain how you obtain these values.

**Note:** The 1st, 2nd, and 3rd dominant frequencies are those with the highest, second highest, and third highest magnitudes in the spectrum.

**File1**:

1st dominant frequency : *195.98 Hz*

2nd dominant frequency : *196.41 Hz*

3rd dominant frequency : *524.90 Hz*

*(honorable mention 4th dominant frequency : 785.21 Hz)*

**File2:**

1st dominant frequency : *440.03 Hz*

2nd dominant frequency : *124.62 Hz*

3rd dominant frequency : *119.50 Hz*

Explanation:

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| To find the top 3 dominant frequency of each file (Excluding the DC component and complex conjugate symmetry)  We do as follow:   1. Load the input signal (our file) to find its N value (total sample points) and its Sample Rate. 2. Use the sample rate to map the frequency domain’s bin in Hertz. 3. Perform the DFT on the signal and shift the DC component to the middle of the array. 4. To exclude the DC component and complex conjugate symmetry, we can just crop the signal to get the element of the array from index ‘N//2 + 1’ (n//2 is the DC component and all element before it is negative frequency) 5. sort the signal with argmax (first index have the most amplitude) to sort the index by amplitude. 6. Use the 1st 2nd and 3rd element of the sorted index as a query to get the frequency value (in Hz) and its corresponding amplitude. 7. From 6) this first 3 elements will be the 1st 2nd and 3rd Dominant frequencies in this order. |

1.3) Analyze and compare the frequencies of the two signals and their corresponding sounds in your own words.

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| From the graph of frequency domain:   * Frequency with significant amplitude of File1 are mostly under 10000 Hz while File2 have some high frequency with significant amplitude that are over 10000 Hz which suggest that file 2 have some very high pitch noise in the playback. (จริง I listen to it) * File1’s top three dominant frequency are 195.98(note G3), 196.41(also note G3), 524.89 Hz (note C5), which suggests that this 3 frequency are the most dominant(easiest to notice) when listen to. * File2’s top three dominant frequency are 440.03 Hz (note A4), 124.62 Hz (~note B2), 119.49 Hz(~note Bb2), which suggests that this 3 frequency are the most dominant(easiest to notice) when listen to. * If zoomed in closely at 0 – 2500 Hz (range with high amplitude for both file) File1 will have a sharper peak(amp ขึ้นสูง แล้วตัดต่ำเลยที่ ตวามถี่ใกล้เคียง ยอดแหลม ณ หลาย ความถี่) While File2 have a more distributed peak at most peak (amp ขึ้นสูง แต่มีความถี่ใกล้เคียงที่สูงด้วย ณ หลายๆ ช่วง) Which will probably result in a sound profile as follow: * FILE1: a CLEANER sounding with distinguishable notes from the sharp peak * FILE2: a more MUDDY or chaotic sounding as there is a lot of high amplitude that are in the same frequency range |

**Note:**

-If you use python, you can use “scipy.io.wavfile.read” for reading WAV file,

see <https://docs.scipy.org/doc/scipy/reference/generated/scipy.io.wavfile.read.html>

2) (15 points)

Hamtaro plans to design a system where the relationship between the input and the output is defined as follows:

The parameters and are defined in params.json. Provide the values below:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | -5 |  | -4 |  | 2 |  | -1 |  | 1 |

2.1) Determine the impulse response and frequency response of the system and demonstrate the solution steps in your own words.

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2.2) Plot magnitude and phase of the frequency response.

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2.3) Determine and plot the DFT of the system output using your student id as the input sequence to the system. For example, if your student ID is 6530000021, the input sequence . Finally, show the solution steps in your own words.

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| My student id is 6531347621 so:  x[n] = { 6, 5, 3, 1, 3, 4, 7, 6, 2, 1}  h[n] = {-5, -4,0,0,0,0,0,0,0,2} (due to circular shift?)        system output in time domain: [-24. -43. -33. -11. -11. -18. -39. -54. -32. -1.]  system output in freq domain : [266, 31.7, 98.5, 38.8, 6.1, 12, 6.1, 38.8, 98.5, 31.7]  We know that y[n] is equal to x[n] convolve with h[n] in time domain.  We can also obtain Y[k] directly by doing element wise multiplication of H[k] and X[k] in frequency domain  SOLUTION STEP:   1. First is to determine the N sample in one period which is len(studentid) = 10 2. Get the h[n] from problem 2.1) 3. Express the DFT as a matrix operation on the data vector by denoting matrix W with 10 rows and 10 columns like in the slide 4. With this we can easily perform DFT on the input signal and impulse signal. 5. get X[k] by calculating the dot product between W, x 6. get H[k] by calculating the dot product between W, h 7. calculate Y[k] by doing element wise multiplication of H[k] and X[k] 8. plot the real part, imaginary part , magnitude , and angle of the system output in frequency domain 9. (optional) check output validity by convolving x[n] and h[n] to get y[n] in time domain and then do DFT on y[n] and compare results 10. (optional) do Inverse DFT on the Y[k] from 7) it should be equal to convolving x[n] with h[n] |

References

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| 1. ChatGPT 2. Colab’s Gemini 3. Prof. Punnarai’s Slide (really good) 4. https://colab.research.google.com/drive/1lI2oGc084DbsbpLa2Q9xPNrpKfvMufpi?usp=sharing |