Deep Speech Processing (DSP) Assigment: 3

Sampling in Time and Frequency

Jan 2025

Instructions

- **Submission deadline: 29th Jan**
- When uploading to Google Classroom, compress your files into a ZIP archive. Name the ZIP file as `SRN_Name.zip`
- From now on, there is no need to upload a separate report. Instead, include your observations directly within the IPython notebook. For each experiment, create a text cell to write your observations. Additionally, embed audio files directly into the notebook.
- During evaluation, you will present the concepts using the IPython notebook exclusively.
- Any deviation from the guidelines may not be considered during evaluation.
- For all the questions in Basics section, ensure that both the time-domain representation and the magnitude spectrum plots are included in your Ipython notebook.
- If any doubts, please mail to `kishorks@iitdh.ac.in`
- Utilize the provided functions for generating a rectangular pulse, sinusoid, and train of impulses to perform the simulations.
- `https://colab.research.google.com/drive/1yDGsctDdYIyCzTv2hJPCsRkzFJB9aOO-?usp=sharing`

Basics [Q1]

Generate a ***Rectangular pulse*** and analyze the effect of varying the signal's duration on its frequency magnitude spectrum.

Basics [Q2]

Generate a ***Sinusoidal signal*** and analyze the effect of varying the signal's duration on its frequency magnitude spectrum.

Basics [Q3]

Generate a train of ***impulse***

- Analyze the effect of varying the signal's duration on its frequency magnitude spectrum.
- Analyze the effect of varying the ***impulse period*** on its frequency magnitude spectrum

Basics [Q4]

Verify the property that multiplication in the time domain results in convolution in the frequency domain.

- $x_1[n]x_2[n] \rightarrow X_1(e^{jw}) * X_2(e^{jw})$

Sampling in time [Q1]

Generate a sinusoid signal with
signal frequency = 5Hz
duration = 1sec
sampling rates = [10Hz, 20HZ, 50Hz, 100HZ]

- plot time domain and freqeuncy magntiude spectrum, for all 4 signals
- Use plt.stem for discrete time signals and plt.plot for continous time signals
- Utilize the provided FFT function

Sampling in time [Q2]

Simulate ***Aliasing in frequency domain***

- Plot time and magnitude spectrum: with alias and without alias
- Use sinusoidal signals for simulation.

Sampling in time [Q3]

Record speech signal

- $$x[n]: \text{16KHz} \overset{y[n]=x[2n]}{\rightarrow} y[n]: \text{8KHz}$$
- $$x[n]: \text{16KHz} \overset{resample}{\rightarrow} y[n]: \text{8KHz}$$
- Comment on Perceptual obervation

Sampling in frequency [Q1]

Suggested Reading:
`https://ocw.mit.edu/courses/6-341-discrete-time-signal-processing-fall-2005/698998c4f794f35ef0c3d947ae0d684c_lec15.pdf`

Sampling in frequency [Q1]

Review the given simulation of frequency-domain sampling. Understand the theory and the simulation provided, and write your observations based on your analysis.
Frequency sampling simulation:
`https://colab.research.google.com/drive/1yDGsctDdYIyCzTv2hJPCsRkzFJB9aOO-?usp=sharing`

Sampling in frequency [Q2]

Simulate aliasing in time domain

- $x[n] : \overset{FFT}{\rightarrow} X[k]$
- $Y[k] : \overset{\downarrow 2}{\leftarrow} X[k]$
- $y[n] \overset{IFFT}{\rightarrow} Y[k]$
- Use sinusoid signal, plots: time and freq. domain

Utils

- lab1: `https://colab.research.google.com/drive/1nX20djsBuHpdy29TNpbDCXc_6TCzyMlo?usp=sharing`
- lab3: `https://colab.research.google.com/drive/1yDGsctDdYIyCzTv2hJPCsRkzFJB9aOO-?usp=sharing`
- For recording audio, use wavsurfer or Audacity