Digital Signal Processing

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Contents

1 Software Installation

Run the following commands

```
sudo apt-get update
sudo apt-get install libffi-dev libsndfile1 python3
    -scipy python3-numpy python3-matplotlib
sudo pip install cffi pysoundfile
```

2 Digital Filter

2.1 Download the sound file from

```
wget https://raw.githubusercontent.com/
    gadepall/
EE1310/master/filter/codes/Sound_Noise.wav
```

2.2 You will find a spectrogram at https://academo.org/demos/spectrum-analyzer. Upload the sound file that you downloaded in Problem **??** in the spectrogram and play. Observe the spectrogram. What do you find?
Solution: There are a lot of yellow lines between 440 Hz to 5.1 KHz. These represent the synthesizer key tones. Also, the key strokes are audible along with background noise.

2.3 Write the python code for removal of out of band noise and execute the code.
Solution:

```
import soundfile as sf
from scipy import signal

#read .wav file

input_signal,fs = sf.read('sound_files/
    Sound_Noise.wav')

#sampling frequency of Input signal

sampl_freq=fs

#order of the filter

order=4

#cutoff frquency 4kHz

cutoff_freq=4000.0

#digital frequency

Wn=2*cutoff_freq/sampl_freq

# b and a are numerator and
    denominatorpolynomials respectively

b, a = signal.butter(order,Wn, 'low')

#filter the input signal with butterworth filter

output_signal = signal.filtfilt(b, a,
    input_signal)

#output signal = signal.lfilter(b, a, input
    signal)
#write the output signal into .wav file

sf.write('sound_files/
    Sound_With_ReducedNoise.wav',
    output_signal, fs)
```

2.4 The output of the python script in Problem **??** is the audio file Sound_With_ReducedNoise.wav. Play the file in the spectrogram in Problem **??**. What do you observe?
Solution: The key strokes as well as background noise is subdued in the audio. Also, the signal is blank for frequencies above 5.1 kHz.

3 Difference Equation

3.1 Let

$$x(n) = \left\{ \underset{\uparrow}{1}, 2, 3, 4, 2, 1 \right\} \tag{3.1}$$

Sketch $x(n)$.

3.2 Let

$$y(n) + \frac{1}{2}y(n-1) = x(n) + x(n-2),$$
$$y(n) = 0, n < 0 \quad (3.2)$$

Sketch $y(n)$.

Solution: The following code yields Fig. **??**.

wget https://github.com/gadepall/EE1310/raw/master/**filter**/codes/xnyn.py

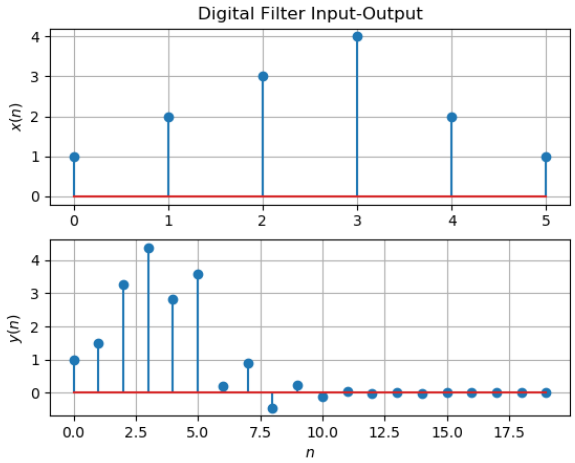

Fig. 3.2