Spectrum Analyzer Application

Lab 10, DSP

Objective

Students should understand the Discrete Fourier Transform, and be able to use the FFT algorithm in Matlab for frequency analysis of data.

Theoretical aspects

Exercises

1. Generate the signal $x[n] = 0.5\sin(2\pi f_1 n) + 0.7\sin(2\pi f_1 n) + noise$, where $f_1 = 0.1$, $f_2 = 0.15$, $n = \overline{1:10000}$ and `noise` is AWGN with variance $\sigma^2 = 0.1$.
   a. Plot the signal, in the top half of a sigure (use `subplot()`).
   b. Display the magnitude spectrum of the signal $x[n]$, one-sided (ω going from $\omega = 0$ to $\omega = \pi$), in the bottom half of the figure (use `subplot()`). Use the following code from the previous laboratories:

```
% Given a signal x with length N

% Compute the Fourier series coefficients and find their magnitudes and phases
c = fft(x);
m = abs(c);
phase = angle(c);

% Find the amplitudes of sinusoidal components
m = m(1:(N/2+1));
m(2:N/2) = 2*m(2:N/2);

% Frequencies' values = multiples of fundamental 1/N
f = (0:(N/2))*1/N;
```

2. Write a script file to implement a live spectrum analyzer.

    a. Read 8192 samples from the system's audio input device (use `recordblocking()` function of `audiorecord` object, see Matlab's Help on `recordblocking()` for an example)
    b. Plot the signal and its magnitude spectrum as in the previous exercise. Plot only the positive side of the magnitude spectrum (ω cgoing from $\omega = 0$ to $\omega = \pi$).
    c. Go back to a. and repeat forever (you can stop the program with Ctrl-C)

3. Write a function `p = dominant(x)` which returns the **dominant** frequency in the input signal x (the dominant frequency is the frequency for which the magnitude spectrum is maximum). Call the function from the iterations in the previous exercise, and display the dominant frequency in Matlab command line (use `disp()`) for each set of samples.

4. Write a function `p = fundamental(x)` which returns the **fundamental** frequency in the input signal x, knowing that:

    - the dominant frequency is either the fundamental one or a multiple of it
    - the fundamental frequency, even if it is not the dominant one, is still large enough (e.g. more than 50% the amplitude of the dominant frequency).

5. Based on the fundamental frequency, try to estimate what string is played in a guitar. Each open string in a guitar has a fundamental frequency, you can find it here: https://en.wikipedia.org/wiki/Guitar_tunings.

Final questions

1. TBD