Departamento de Eletrónica, Telecomunicações e Informática

Universidade de Aveiro

Sistemas Multimédia

2018/2019

Practical Class 04

I. Discrete Fourier Transform

1. Based on the function ***fft*(.)**, develop a MATLAB/Octave function, named ***SpectrumSM***, which returns and presents (in amplitude only) the spectrum of a signal (specified through its vector of samples, $\mathbf{x}$) sampled with sampling period T_a. The spectrum graphic must present, in the horizontal axis, the frequency in Hz, from $-f_a/2$ to $+f_a/2$, where $f_a = 1/T_a$.

   $$\text{function } [\mathbf{X}, \text{f}] = SpectrumSM\ (\mathbf{x}, T_a)$$

   $\mathbf{X}$ – vector of the same dimension of $\mathbf{x}$, with the DFT coefficients of $x(t)$.
   f – vector of the same dimension of $\mathbf{x}$, with the frequencies (in Hz) of each element of $\mathbf{X}$.

2. Try the function developed in point 1, representing the spectrum of the following signals:
   a) $x(t) = \sin(2\pi t)$, registered during 10 periods.
   b) $y(t) = \sin(10\pi t) + \cos(12\pi t) + \cos(14\pi t - \pi/4)$, registered for 5 secs.
   c) $z(t)$ – square wave between 0 and 1, of frequency 1 Hz, registered for 5 secs.
   d) $q(t)$ – triangular wave between -1 and 1, of frequency 1 Hz, registered for 5 secs.

3. Add to the function ***SpetrumSM***, developed in point 1, the possibility of implementing ***windowing***, to analyze the spectral content of sequences of samples that are not periodic. For such, add a third input argument, *w*, which, if nonzero, applies a Blackman window to the sequence of samples before applying the ***fft***.

4. Try the function of point 3 to create the spectrum of a signal composed of:
   - 500 samples;
   - sampling period equal to 1 ms;
   - the sum of 20 sinusoidal signals, each of unit amplitude, whose frequencies are randomly set between 1 and 20 Hz(with uniform probability density function);
   - the phase of each sinusoid is also randomly determined.
   Compare the obtained spectra, with and without ***windowing***.

5. Now, develop the function ***ReconstructSM*** that performs the reverse operation of that developed in point 1 (i.e., receiving the vector $\mathbf{X}$ of the Fourier representation, it reconstructs the time-domain sample sequence of the signal, $\mathbf{x}$, plotting, afterwards, the reconstructed signal). Try the function with the data obtained in the previous points.