ECE 695 (Numerical Simulations) – Homework 4

Due February 10, 2017 at 4:30 pm
Email to pbermel@purdue.edu
Please write your programs in C/C++, MATLAB, or Python

1. Consider electroencephalogram (EEG) data collected from electrodes on the surface of the skull of a healthy patient with his or her eyes open, as depicted below. The raw data is available as a downloadable file on the course website, and is sampled at a rate of 173.61 Hz.

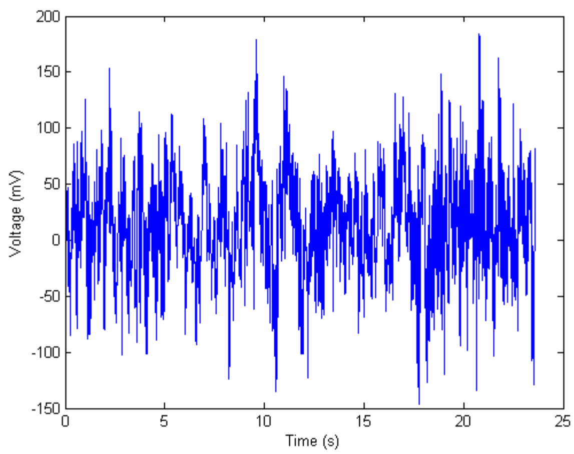

Figure 1: EEG data collected from a healthy patient. Adapted from R.G. Andrzejak *et al.*, *Phys. Rev. E*, **64**, 061907.

1a. Calculate and plot the fast Fourier transform (FFT) of this data. Make a note of the frequency scale and range.

1b. What overall structure is observed in the FFT of this data, and what possible significance could it have?

2. One of the weaknesses of Fourier analysis is in treating time-varying signals: for example, in second harmonic generation. As an alternative, consider the short-time Fourier transform (STFT), defined by:

$$X(\tau, \omega) = \int_{-\infty}^{\infty} x(t) w(t-\tau) e^{-i\omega t} dt, \tag{1}$$

where $x(t)$ is the time-domain signal, and $w(t)$ is a windowing function.

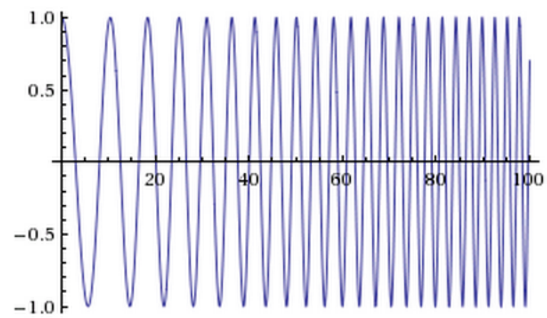

Figure 2: Input data for STFT analysis, described by $\cos\{[1 + 0.01(t-50)]\, t\}$ from $t = 0$ to $t = 100$.

2a. Now let the window function be a Gaussian, such that $w(t) = \exp(-t^2/\sigma_t^2)/\sqrt{2\pi}\sigma_t$. For a chirped signal described by $\cos\{[1 + 0.01(t-50)]\, t\}$ from $t = 0$ to $t = 100$ (see Fig. 2, above), calculate $X(\tau, \omega)$ for $\sigma_t = 0.5$; $\sigma_t = 5$; and $\sigma_t = 50$. Which result appears to be most useful, and why?

2b. In general, how will the frequency and time accuracy of $X(\tau, \omega)$ both vary with σ_t? Hint: consider the limiting cases where $\sigma_t \to 0$ and $\sigma_t \to \infty$.