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Released: 02.19.2004 Instructor: Aly A. Farag
Due: 03.04.2004 Spring 2004

ECE 521 Experiment #2: Sampling, Quantization, and Signal Reconstruction

The purpose of this experiment is the following:

a. Study the process of digitization of a continuous-time signal into a discrete-time sequence.

b. Study reconstruction of functions from its sampled version.

c. Compute the sequence Fourier transform of a sequence and correspond it with the continuous-time Fourier transform, and examine the effect of changing the sampling rate.

Part 1: Digitization of a Continuous-Time Signal

a. Generate 200 samples from the function $x(t) = 10sinc(100t)$. Select a suitable measure for the bandwidth and use the sampling theorem.

b. Quantize the sequence x[n] in (a) into 16-quantization levels between -10.0 and 10.0 using a suitable quantizer. Plot x[n] and its quantized version on the same graph.

c. Calculate an estimate of the quantization error power and compare it with the theoretical one. Do this for both quantizers. You can calculate the error as follows:

   i. Get error, $e[n] = x[n] - x_r[n]$, for $n = 0, 1, ..., N-1$, where $x_r[n]$ is the reconstructed sequence (using either interpolation or extrapolation).

   ii. Get $SNR = 10\log_{10}\frac{A}{B}$, where $A = \sum_{n=0}^{N-1}(x[n])^2$ and $B = \sum_{n=0}^{N-1}(e[n])^2$.

   iii. Theoretical error = $\Delta^2/12$. This is to be compared with an estimate of the variance of e[n] evaluated as follows: $\mu = 1/N\sum_{n=0}^{N-1} e[n]$, $variance = 1/N\sum_{n=0}^{N-1}(e[n]-\mu)^2$. Now, compare μ with a "0" and variance with "$\Delta^2/12$".

Part 2: Reconstruction of a Function From its Sampled Version

Using the sequence x[n] in part 1(a), reconstruct an approximation $\hat{x}(t)$ using zero and first order holds. Plot x(t) and $\hat{x}(t)$ on the same graph for the two cases with proper time referencing. Comment on your results.

Part 3: The Sequence Fourier Transform

a. Compute the sequence Fourier transform of the sequence $z[n]$ in the file z in the class website under (Lab2-data). Plot two periods of $Z(f_d)$; magnitude and phase with proper scaling.

b. Knowing that $z[n]$ was obtained from $z(t)$ by sampling at a rate of 25Hz, rescale $Z(f_d)$ in (a) and plot one period. What are the major frequency components in your plot?

c. Repeat (a)-(b) for $z_1[n] = z[4n]$, $z_2[n] = z[8n]$, and $z_3[n] = z[16n]$.

Note: *Write a neat report. All figures should have meaningful captions, properly labeled, and referred to in the text. Refrain from using any handwritten symbols, equations, etc. in your report, use a word-processor.*