Lab 2

Due Nov 3, In Class

Questions 1 and 2 tries to connect analytical and numerical understanding. Question 3 takes a first look at system visualization in the *z*-domain.

1. **Convolution:** we'll compare (a) analytical and (b) numerical solutions.

   (a) For each of the following plot $w(t)$ and $x(t)$ by hand, derive $y(t) = w(t) * x(t)$, and plot $y(t)$ by hand.

   i. $w(t) = u(t) - u(t-1)$ $\quad x(t) = u(t) - u(t-1)$

   ii. $w(t) = u(t) - u(t-1)$ $\quad x(t) = t \cdot u(t) \cdot u(2-t)$

   iii. $w(t) = e^{-|t|}$ $\quad x(t) = u(t)$

   (b) Now let's use the `conv` command in MATLAB to approximate the convolutions from (a). For each of i., ii., iii., submit a plot of `conv(w,x)`. Discretize the signals over $-1 \le t \le 3$ using a step size of 0.1; that is, `t = [-1:0.1:3];`. For example, part ii. then becomes

   ```
   w = 0*t; w(11:21) = 1; x = 0*t; x(11:31) = t(11:31);
   ```

2. **Impulse Responses and Difference Equations**

   For each of the following three causal systems:

   i. $y(n) - 0.5y(n-1) = 2x(n)$

   ii. $y(n) + y(n-2) = x(n) - x(n-1)$

   iii. $y(n) - \frac{1}{2}y(n-1) - \frac{1}{2}y(n-2) = x(n)$

   (a) Derive the impulse response $h(n)$. Assume the system is at initial rest and is causal.

   (b) Implement the recursion in MATLAB and plot the response of the system over $-5 \le n \le 20$ to an impulse input $\delta(n)$. Submit your plots and MATLAB code.

3. ***z*-transforms and System Response**

   For a system specified by

   $$y(n+1) - 0.8y(n) = x(n+1)$$

   we know that

   $$H(z) = \frac{1}{1 - 0.8z^{-1}}$$

   Do not explicitly solve for the magnitude and phase $|H|$, $\angle H$. Instead, because Matlab can do complex numbers, we can evaluate and plot H directly.

   For example, let `w=[-2*pi:0.01:2*pi]` then `H=1./(1-0.8*exp(-j*w))` is the transfer function evaluated on the unit circle, and the magnitude and the phase can be found as `ABS(H)` and `ANGLE(H)`.

   Submit a MATLAB plot of the magnitude and phase of H over $-2\pi < \omega < 2\pi$. Briefly discuss how the plot relates to the pole(s) and zero(s) of H.

   Repeat the above for

   $$y(n+1) + 0.8y(n) = x(n+1)$$