Assignment - 3
Properties of
Linear Time-Invariant Systems

April 19, 2021

A constant coefficient difference equation (CCDE) represents dynamics of a system. In the last lab, we built an echo producer which takes a sampled signal, adds a delayed signal to it and produces an echo effect. If we process one input sample at a time to produce one sample of the output, the effect required 22050 memory elements to delay the current signal. As an alternative, we try to produce the same effect using implementation by CCDE.

Task 1

Let

$$y[n] - y[n-1] = x[n] - x[n-1] + x[n-22050] - x[n-22051]$$

be the CCDE representing the dynamics of the echo system. You can attain the same CCDE by calculating $y[n] - y[n-1]$ in the echo system equation in the previous lab.

Write a MATLAB function `get_system_out(b, a, x, z)` that implements a CCDE with coefficients `b`, `a` as defined in the book, input sequence `x` and initial conditions vector `z`. Use your function to implement the above mentioned system using the input that you recorded in the previous lab. Throughout the task, you can assume that the first sample of the recorded voice is at $n = 0$, the second sample is on $n = 1$ and so on. You are allowed to use `for` loops in your code for this part.

Questions

1. Since the system we implemented last time was an LTI causal system, which initial conditions would you use to implement the CCDE.

2. Now suppose the initial conditions are $y[-1] = 3$. Is this a linear system? Why or why not ? Choose a suitable input and show the output using your function to justify your answer.

3. Plot the impulse response of the system for $y[-1] = 0$?

Task 2

Consider an LTI system with the following impulse response:

$$h[n] = u[n] - u[n-5].$$

Plot its frequency response using MATLAB. You need to calculate frequency response corresponding to a frequency ω using MATLAB only, not by first calcualting the expression on paper and then plotting it.

Questions

1. Calculate the frequency response of the system on paper. Plot the resulting expression. Is the plot similar to the one you obtained using MATLAB?.