Assignment - 2
Introduction to Sampling and Linear Time-Invariant Systems

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The course discusses discrete-time signal processing (DSP) in general that can be applied to any discrete-time sequences. One of the applications of DSP is in speech signal processing in which we process speech signals. In this lab, we will learn how to convert speech signal into discrete-time sequences using analog-to-digital converter (ADC) available in the sound cards of every computer. We will use these speech signals in future labs to experiment with DSP techniques we will learn later in the course.

A sound card can be regarded as a combination of an analog-to-digital converter (ADC) and a digital-to-analog converter (DAC). Any sound card has at least the following inputs:

1. Line-In
2. Mic Input
3. Speaker Output

Your sound card's ADC samples the signal coming from Line-In and Mic Inputs, whereas the DAC converts samples to an analog signal and send it to playback devices such as your laptop's speaker. In this lab, we will learn how to sample a speech signal using MATLAB.

Task 1

Read the following webpage and write a MATLAB script to sample your own voice at 11025 samples per second and 8-bit width samples.

`https://www.mathworks.com/help/matlab/ref/audiorecorder.html`

Questions

1. What is the length of the sampled sequence? How do you calculate this length on paper?

Task 2

Play the recorded voice on your computer's speakers using *sound* command in MATLAB at a DAC playback rate of 8000 samples per second with 8 bits per sample.

`https://www.mathworks.com/help/matlab/ref/sound.html`

Questions

1. Do you hear the same voice as yours? If not, why the voice played back on the speaker is different?

Task 3

Let

$$y[n] - 0.1y[n-1] = x[n]$$

with $y[-1] = c$ be the difference equation describing a system.

Write a MATLAB function `y = get_output_system(x, c, n1, n2)` to compute the output corresponding to input $x[n]$. The function should assume that the first and the last element of vector `x` corresponds to $x[-n_1]$ and $x[n_2]$, respectively. The first and the last element of vector `y` corresponds to $y[-n_1]$ and $y[n_2]$, respectively.

Questions

1. Is this a linear system? Why or why not ? Choose a suitable input and show the output using above MATLAB function to justify your answer.

2. Is this a causal system? Why or why not? Choose a suitable input and show the output using above MATLAB function to justify your answer.

Task 4

Consider the linear time-invariant system with impulse response

$$h[n] = \frac{c^n}{11}(u[n] - u[n-11]).$$

Write MATLAB code to calculate the output of the system to the excitation

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

Questions

1. Plot input and output of the system overlayed on each other in the same graph when $c = 1$. What is the name of this system with $c = 1$.
2. Repeat part 1 with $c = 0.9, c = 0.8, c = 0.5$. What is the difference between different outputs? What can you say about the effect of the constant c on the output.