SGN-11006, Basic Course in Signal Processing

Exercise #2.

The first 3 problems should be solved and returned to the teacher assistant before the deadline: Monday 19.09.2016 at 2pm.

Solutions can be returned either through Moodle or in the post box #527 located in Tietotalo next to the room TC421. Matlab part is done and checked during the exercise session.

19.09-23.09.2016

Problem 1: From the continuous-time cosine wave $x(t) = 5\cos(50\ \pi t + 1)$ we get a discrete-time version by sampling it with period $T_s = 0.03$. (3 points)

a) What is the frequency (in Hz) of the continuous-time sinusoid? What is the sampling frequency? What is the normalized digital angular frequency of the resulting discrete-time signal?

b) Write the equation of the discrete-time signal $x[n]$ $(= x(nT_s))$.

c) Find another continuous-time cosine wave with higher frequency, whose sampled version (with sampling period T_s) is identical to $x[n]$.

Problem 2: Consider a system with the following input-output relationship:

$$y[n] = \frac{(n+1)^2}{x[n-1]}$$

where $x[n]$ is the input to the system and $y[n]$ is the system's output. Is the system linear? Is it time-invariant? Is it causal? Is it stable? Could you determine the output of the system to an arbitrary input by using only the system's impulse response? Justify your answer. (2 points)

Problem 3: Determine the overall impulse response of the system of Fig. 1 , where the impulse responses of the component LTI systems are: $h_1[n] = 2\delta[n-2] - \delta[n+7]$, $h_2[n] = \delta[n] - \delta[n+5]$, $h_3[n] = -2\delta[n+8]$, $h_4[n] = 3\delta[n] - 2\delta[n-6]$. What is the output of the system for the input $x[n] = \mu[n] - \mu[n+1]$, where $\mu[n]$ denotes the step function? (5 points)

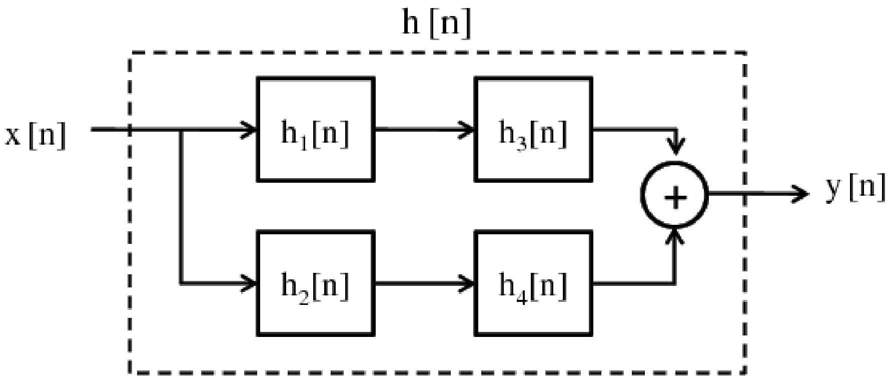

Figure 1: System composed of several sub-systems

Problem 4: (Matlab) Create one-second signals with frequencies of 1000 Hz, 2000 Hz, 3000 Hz, . . . , 8000 Hz and listen to them. Use a sampling frequency of 8192 Hz. What happens after 4000 Hz? (2 points)

Problem 5: (Matlab) Get the speech sample `toomuch` (http://www.cs.tut.fi/courses/SGN-1157/groupA/toomuch.mat), listen to it and draw its spectrogram. Convolve the speech sample with vector $B = [-0.0039\ 0\ 0.0321\ 0.1167\ 0.2207\ 0.2687\ 0.2207\ 0.1167\ 0.0321\ 0\ -0.0039]$. Listen to the result and draw its spectrogram. How has the convolution affected the frequencies? (3 points)

smooth

Problem 6: (Matlab) Get the sound sample `bird1` (http://www.cs.tut.fi/courses/SGN-1157/groupA/bird1.mat), listen to it and draw its spectrogram (`help spectrogram`). The sampling rate is now 8192 Hz. Resample the signal by picking every second sample from it (`help colon`). Investigate the resulting signal and try to explain what happened. Try also `decimate`-command. (3 points)

Problem 7: (Matlab) Emphasize low frequencies of the test signal (**load handel**, loads variable **y** - your signal, and **Fs** - sampling frequency) with few different gains. (Hint: emphasized version is the sum of the original signal and the one with only low frequencies). (2 points)