Signal and Image Processing - Assignment 2

Assigned March 22nd **Due April 22nd 23:55**

Time you spent on this assignment: ____ hours

You need to submit a PDF report and one Matlab/Octave function for each task, all in the same folder. Please write (at least) your name and student ID on top of each Matlab file and also on the PDF report. Feel free to define other auxilary functions.

The maximum amount of points awarded for this assignment is **15 points**.

1 Convolution [2 Points]

Define your own 1-dimensional convolution function with the name `conv1`, which takes two timesignals as input and returns the convoluted timesignal as output. The function must be able to handle timesignals of any lengths. Showcase the function with various input signals.

For this task, you are only allowed to use basic Matlab functions. Especially the use of `conv`, `conv2` and `convn` is prohibited.

Hint Don't confuse convolution with correlation!

2 LTI Systems [3 Points]

The input-output pair shown in Figure 1 is given for a stable LTI-system.

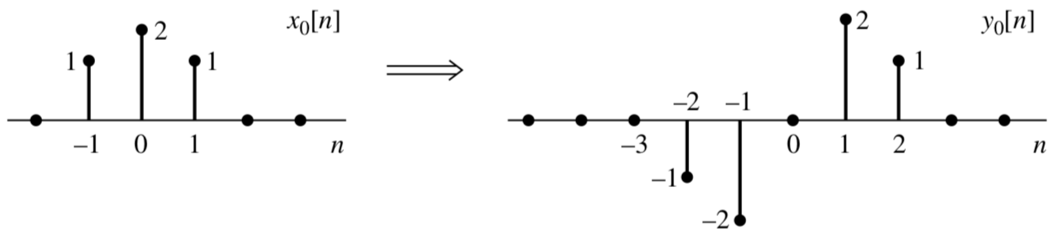


Figure 1: Input and output for a stable LTI-system

(a) Determine the response to the input $x_1[n]$ in Figure 2:

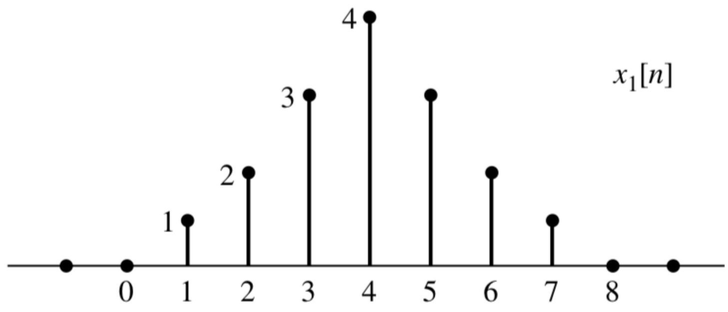


Figure 2: Input to the stable LTI system

(b) Determine the impulse response to the system.

Show the results for a and b as a stem-plot.

For this task, you should use your own convolution function from section 1.

3 Image Enhancement [3 Points]

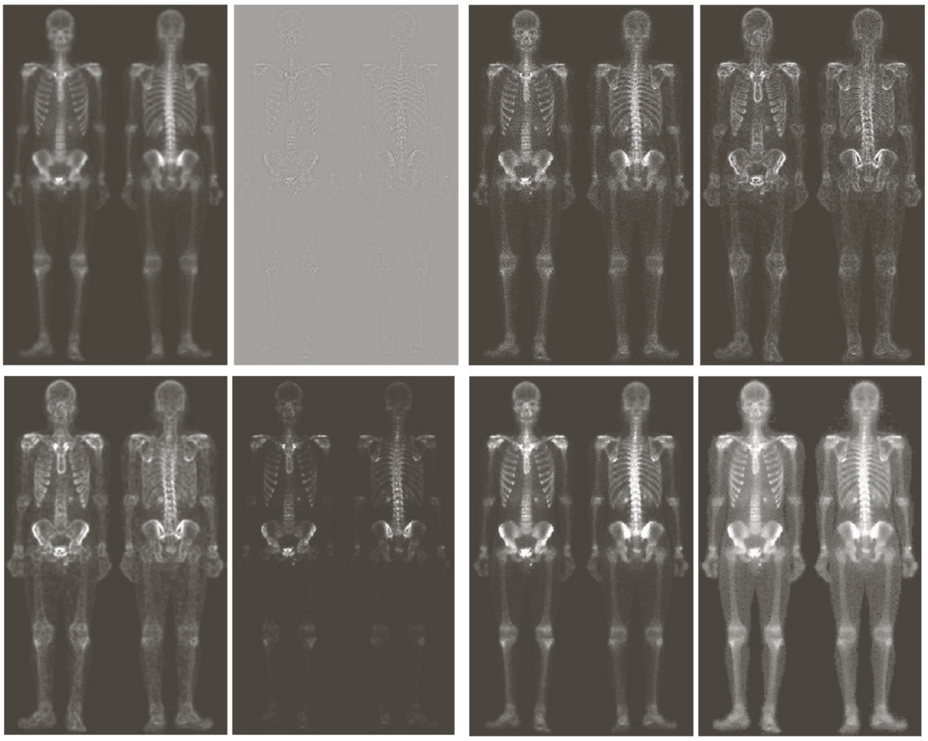


FIGURE 3.43 (a) Image of whole body bone scan. (b) Laplacian of (a). (c) Sharpened image obtained by adding (a) and (b). (d) Sobel gradient of (a). (e) Sobel image smoothed with a 5 × 5 averaging filter. (f) Mask image formed by the product of (c) and (e). (g) Sharpened image obtained by the sum of (a) and (f). (h) Final result obtained by applying a power-law transformation to (g). Compare (g) and (h) with (a). (Original image courtesy of G.E. Medical Systems.)

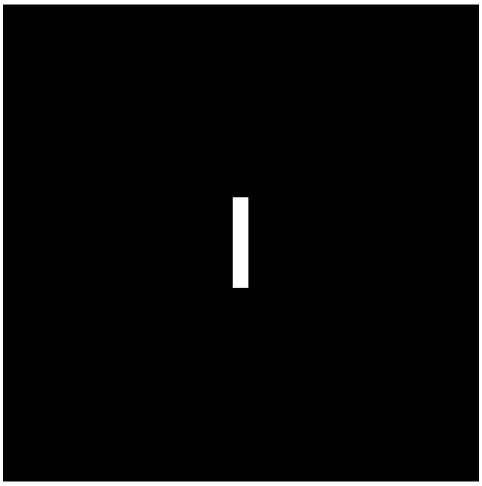
Figure 3: Image Enhancement (high-res image in slides)

Download the original image (a) in Figure 3 from `http://vda.univie.ac.at/Teaching/SIP/18s/Lab2/343a.tif`. Generate steps (b) through (h) by applying the respective filters in Matlab/Octave. Choose a suited factor for the power-law transform in the last step to visually match the resulting image (h) from above. The resulting program should output 8 images in order, starting from (a).

For this section you are allowed to use all built-in functions of Matlab/Octave.

4 2D Discrete Fourier Transform [2 Points]

Compute and display the magnitude of the DFT of the following pictures. The Matlab function for the 2D DFT is `fft2`. Use `fftshift` to move the DC component to the center, and use the logarithmic transformation so that your results look like Figures 4.24(d) and 4.29(b) from the *Gonzalez & Woods* book (also in the slides), respectively. In both cases use `imagesc` with `clim=[5 13]` to display the DFT log magnitude.



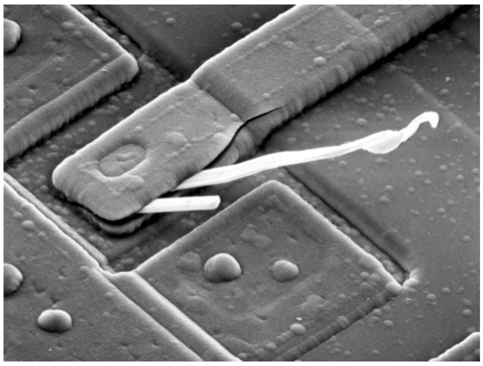


Figure 4: Figure 4.24(a) and 4.29(a) from the *Gonzalez & Woods* book (3rd edition).

The images can be downloaded from the website:
`http://vda.univie.ac.at/Teaching/SIP/18s/Lab2/424a.png`
`http://vda.univie.ac.at/Teaching/SIP/18s/Lab2/429a.png`

5 Image Enhancement in the Frequency Domain [5 Points]

a) Read the image blurry-moon.tif and sharpen it using unsharp masking. Use a Gaussian lowpass filter of your choice for the blurring step. Display your final result.

The image can be downloaded from the website:
`http://vda.univie.ac.at/Teaching/SIP/18s/Lab2/blurry-moon.tif`

b) Improve the sharpness of your result using high-boost filtering. Display the final result. [You should be able to achieve a result close to the right one in Figure 5]

Figure 5: left) Original, blurry image; right) enhanced image; Figure 4.56 from the *Gonzalez & Woods* book (4^{th} edition).

Hint You might have a closer look at the *Summary of steps for filtering in the frequency domain* as well as equation (4-116) in the *Gonzalez & Woods* book (4^{th} edition).