**Digital Image Processing** **Homework 2**
**Prof. S. Kasaei** **Deadline 31 Farvardin**

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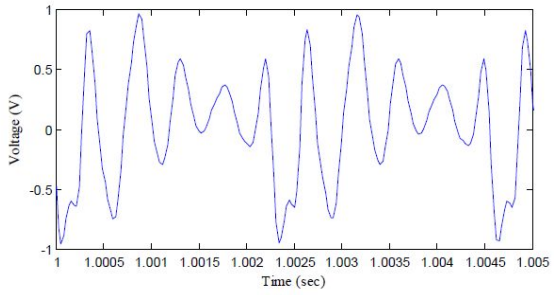
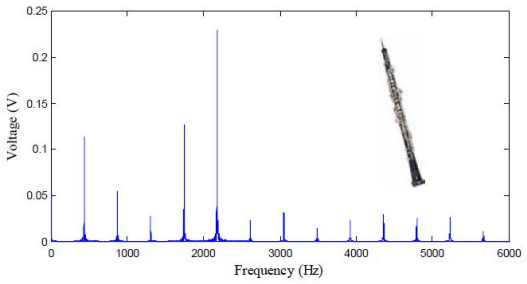
Please make a zip file named HW2_stdno_lastname and upload in cw. For practical exercises complete files Q1.py and Q2.py and a report file in pdf format is needed. Briefly explain about the problem and your solution, show and justify your results and use relative paths.
Feel free to contact me (abiraf.lotfi@gmail.com) if you have any questions.

## Theoretical

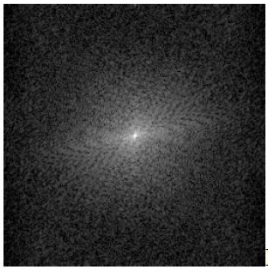
Q1. What is the maximum frequency present in the signal depicted below in time and frequency domain representations and what sampling rate must be exceeded in order to accurately reconstruct the signal from its samples? (5%)

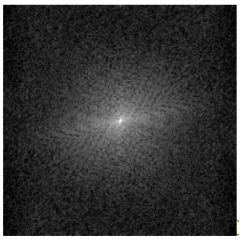
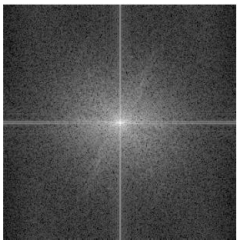
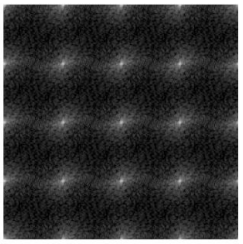
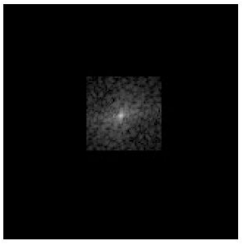



Q2. Explain aliasing and its outcome, Then suggest 2 solutions. (fully explain!) (10%)

Q3. If the spectrum of a continuous (not sampled) image is the image below, then the spectrum of its sampled version is which one? a, b, c or d? (fully explain!) (10%)



a)  b)  c)  d) 

Q4. Complete the following matrices (5%):

| | | |
|---|---|---|
| 1 | 5 | 9 |
| 3 | 2 | 4 |

1:2 upsampling H & V
Based on ZOH
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|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

| | |
|---|---|
| 1 | 7 |
| 3 | 6 |

1:2 upsampling H & V
Based on FOH
→

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Q5. Derive the Lloyd-Max decision and reconstruction levels for L=4 and the uniform probability density function.

$$p_u(u) = \begin{cases} \frac{1}{32} & -16 \le u \le 16 \\ 0 & otherwise \end{cases}$$

Calculate the MSE and Entropy of the reconstructed output. (10%)

Q6. For a uniform quantizer number of levels L = 32. Calculate the number of bits and SNR for the quantizer. If the number of output levels is doubled to L = 64 then the SNR will be changed by how many dB (specify increase or decrease) and how the bandwidth will be affected. (5%)

Q7. You are given the following basis images for 2*2 image patterns:

$$H_{00} = \frac{1}{2}\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix},\ H_{01} = \frac{1}{2}\begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix},\ H_{10} = \frac{1}{2}\begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix},\ H_{11} = \frac{1}{2}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

a) calculate the transform coefficient of the image F below using these basis images. (5%)
b) Find the reconstructed image obtained with the largest two coefficients in magnitude. (5%)

$$F = \begin{bmatrix} 4 & 7 \\ 3 & 5 \end{bmatrix}$$

## Practical

Q1. The python file Q1.py loads and displays an image within given amount of bits. Experiment by changing the number of bits (controlled by the bit variable).
How many quantization levels can you have before the visual quality is severely damaged? (5%)

Q2. First, read a gray_level image ‘mona.png’ and traverse every pixel in the image, and half the grayscale values.
Complete file Q2.py in order to read the image ‘mona.png’ and compute the difference between values in neighbouring pixels. That is, if f is the input image and g is the output image, compute $g[x,y]=f[x-1,y]-f[x,y]$ for all feasible values (x, y) in the image.
The image will be of type uint8 meaning that the data type of the value in each pixel is an 8-bit unsigned integer. This data type occupies 8 bit (1 byte), and ranges from 0 to 255. The above computation could result in negative values, thus giving us type overflow warnings (languages like python or matlab may silence these warnings and run anyway, but the general advice is to pay attention to your types). Therefore, try to add a bias to each pixel value in the resulting image.
Now, try to scale the difference image with a scalar value greater than 1. What happens to the contrast? (35%)