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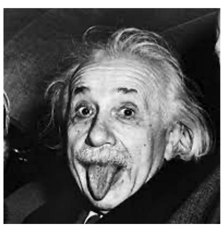
Started on	Tuesday, 24 October 2023, 2:50 PM
State	Finished
Completed on	Tuesday, 24 October 2023, 4:10 PM
Time taken	1 hour 20 mins
Grade	**25.00** out of 38.00 (**66**%)

Question **1**

Correct

Mark 1.00 out of 1.00

Consider the DFT of the following images.

The magnitude/spectrum images of these two portraits are

- a. None of the other choices is correct
- b. Related by a spatial shift
- c. Related by a scale factor
- d. Related by a 90-degree rotation ✔
- e. Identical to each other

Your answer is correct.

The correct answer is:
Related by a 90-degree rotation

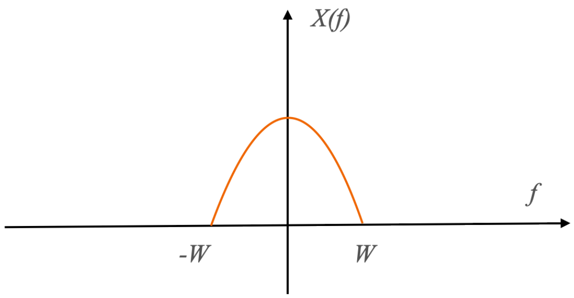
Question **2**

Correct

Mark 1.00 out of 1.00

What is the minimum sampling frequency that we should use for the following signal in the frequency domain?

Note that here W = 4Hz



a. 4 Hz

b. 16 Hz

c. 2 Hz

d. 8Hz

Your answer is correct.

Nyquist theorem. Minimum of twice of the max frequency is required for sampling.

The correct answer is:
8Hz

Question 3

Correct

Mark 2.00 out of 2.00

Which of the following filters are valid derivative filters?

a.
$$\begin{bmatrix} 0 & -1/5 & 0 \\ -1/5 & 1 & -1/5 \\ 0 & -1/5 & 0 \end{bmatrix}$$

b.
$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -6 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

c.
$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

d. ✔
$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

e. None of the other filters

f. ✔
$$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

Your answer is correct.

The sum of all elements should be 0. The arrangement of the filter elements is symmetric. The center of the element should have negative while the rest should be positive for 2nd order derivatives and 0 for 1st order derivatives

The correct answers are:

$$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix},$$

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

Question **4**

Correct

Mark 1.00 out of 1.00

Which of the following filtering operation in the spatial domain is equivalent to a high pass filtering in the frequency domain?

a. Median filtering

b. High boost filtering

c. Box averaging filtering

d. None of the other choices

e. Laplacian filtering ✔

f. Homomorphic filtering

Your answer is correct.

Linear image blurring is low pass filtering

The correct answer is:
Laplacian filtering

Question **5**

Correct

Mark 2.00 out of 2.00

For a **3-bit image**, its histogram is expressed in the following table:

Grey levels	0	1	2	3	4	5	6	7
# of pixels	5	10	30	20	40	50	25	0

If we need to perform histogram equalization on this image, what is the transformed grey level value for grey level = 2 in the original image? **Express your result as an integer**.

Answer: 2 ✔

Check out the histogram equalization formula

The CDF at grey level =2 is [(5+10+30)/180]=45/180=0.25. Then the transformed value is (8-1)*0.25=1.75=2

The correct answer is: 2

Question **6**

Correct

Mark 1.00 out of 1.00

Multiplication with a Gaussian function in the Fourier frequency domain is equivalent to

- a. Convolution with a box function in the spatial domain
- b. Multiplication with a Gaussian function in the spatial domain
- c. Multiplication with a sinc function in the frequency domain
- d. Convolution with a Gaussian function in the spatial domain ✔
- e. None of the other statements is correct

Your answer is correct.

The convolution theorem.

The correct answer is:
Convolution with a Gaussian function in the spatial domain

Question 7

Correct

Mark 1.00 out of 1.00

The following 3x3 spatial filter is a linear filter.

$$\begin{bmatrix} 0 & 0 & 1/5 \\ 1/5 & 1/5 & 1/5 \\ 1/5 & 0 & 0 \end{bmatrix}$$

Select one:

- True ✔
- False

This is a simple averaging filter, which is a linear filter.

The correct answer is 'True'.

Question **8**

Complete

Mark 3.00 out of 3.00

We would like to sharpen a grayscale image that contains both uniform (image noise in both high and low frequencies) and impulse noise (e.g., salt and pepper noise). What would be an ideal sequence of operations to achieve the goal?

1.

Sharpening a grayscale image that contains both uniform noise (high and low frequencies) and impulse noise (salt and pepper noise) can be done by following steps.

Noise Reduction:

Median Filter for Impulse Noise: Use a median filter to remove impulse noise (salt and pepper noise). The median filter is effective at preserving image edges while eliminating isolated noisy pixels.

Low-Pass Filter for Uniform Noise: Apply a low-pass filter (e.g., Gaussian filter) to reduce uniform noise. This will help smooth out the variations in low-frequency noise.

Image Enhancement:

Unsharp Masking or High-Pass Filtering: After noise reduction, you can enhance the image's sharpness. One common technique is to use unsharp masking or high-pass filtering to highlight edges and fine details.

The students should use Median filter first (1 pt) to deal with impulse noise and then averaging filter (or any low-pass filter) (1pt) before using using edge enhancement filter (denoised image + high-pass filtered version of the denoised image, or any high-frequency emphasis filters learn in class, including the high boost filter and homomorphic filter) (1pt)

When using order statistics filters, a pixel from the original image is selected from the image patch, so this pixel also contains the noise component that is not part of the impulse noise, aka the uniform noise.

If the order of application is wrong, and median filtering was mentioned as the first step, the student gains 1 pt, and if LINEAR filters are mentioned for the subsequent denoising and edge filtering, the order does not matter and they gain the rest of the full 2 pt.
If the edge filtering is based on NONLINEAR filtering and it is applied before denoising, then 0 pt out of 2 pt is given.
If the order of application is wrong, and other filtering actions than median filtering are mentioned first, 0 pt is given.

Comment:
median filter first +1

Gaussian filter second +1

High pass filter third +1

Question **9**

Correct

Mark 1.00 out of 1.00

The key structural information of an image is primarily included in the magnitude/spectrum image obtained from its Fourier transform.

Select one:

- True
- False ✔

phase image carries the crucial structural information

The correct answer is 'False'.

Question **10**

Partially correct

Mark 1.00 out of 4.00

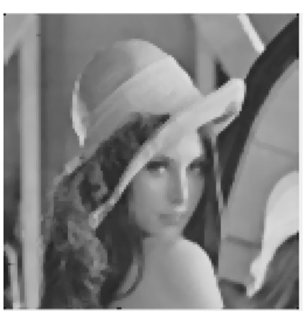
Given the input image bleow:

Please match the image processing technique that likely generated each of the output images.

The image processing techniques include: **Gaussian low-pass filter, median filter, homomorphic filter, and histogram equalization**.

Histogram equalization ✖

Homomorphic filter ✖



Median filter ✔

Gaussian low pass filter ✖

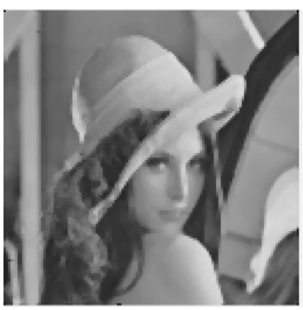
Your answer is partially correct.

You have correctly selected 1.

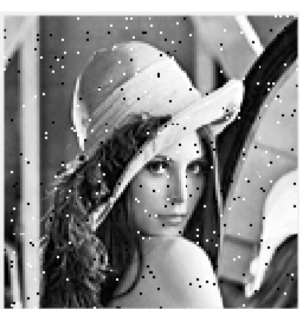
The correct answer is:

→ Homomorphic filter,

→ Gaussian low pass filter,



→ Median filter,



→ Histogram equalization

Question **11**

Correct

Mark 2.00 out of 2.00

Please compute the following integral:

$$\int_{-\infty}^{\infty}\left[\cos\left(\frac{\pi}{4}t\right)\delta(t-2)+4t^2\delta(t-1)\right]dt, \textit{ where } \delta(\cdot) \textit{ is an impulse function}$$

Answer: 4

Sifting property of impulse function.

In the first half, you are evaluating cos(pi/2)=0, and in the second half, you should evaluate it to 4.

The correct answer is: 4

Question **12**

Partially correct

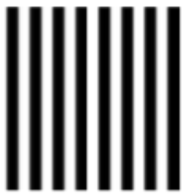
Mark 2.00 out of 4.00

Please match the Fourier transform spectrums with the corresponding images below:

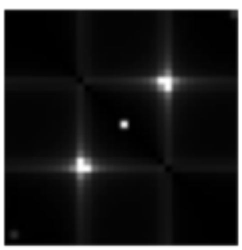
Beehive

Slanted lines

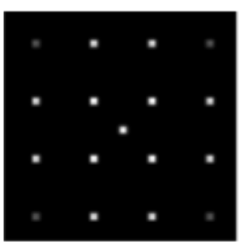
Checkerboard



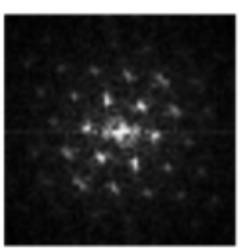
Vertical lines



Checkerboard ✖



Slanted lines ✖



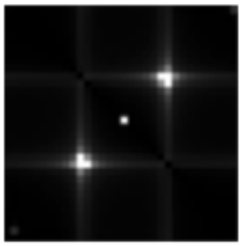
Beehive ✔

Vertical lines ✔

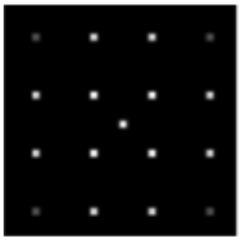
Your answer is partially correct.

You have correctly selected 2.

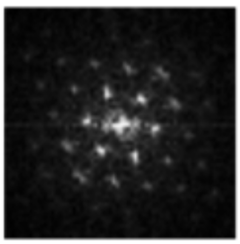
The correct answer is:



→ Slanted lines,



→ Checkerboard,



→ Beehive,

→ Vertical lines

Question **13**

Incorrect

Mark 0.00 out of 1.00

The Nyquist theorem is intended for band-limited signals only.

Select one:

- True
- False ✖

To avoid aliasing, the target signal to be sampled must have a max frequency limit. This means the signals must be band-limited.

The correct answer is 'True'.

Question **14**

Correct

Mark 1.00 out of 1.00

Applying histogram equalization twice in a row for an image cannot produce better contrast than applying the operation only once.

Select one:

- True ✔
- False

The correct answer is 'True'.

Question **15**

Complete

Mark 1.00 out of 3.00

How to **reduce** periodic noise in the input image (Left) in order to get a cleaner output image (right)?


- Switch to Frequency Domain: Change your noisy image to a special kind of view called the frequency domain using FFT.
- Spot Noise Frequencies: Look at the FFT result, and you'll see bright spots or lines that represent the noisy patterns.
- Use Filters:
  -
    - Notch Filter: If you identify regular patterns in the noise, like stripes or a grid, you will notice corresponding spikes in the frequency spectrum. Design a notch filter to specifically suppress these noise-related frequencies while preserving the rest of the image's frequencies.
    - Band-Reject Filter: In cases where the periodic noise occupies a frequency band, a band-reject filter is valuable. This filter eliminates a range of frequencies centered around a specific frequency.

  It's essential to be precise in targeting only the noise frequencies, leaving the actual image details intact.

Change Back to Normal Image: Go back to your regular image from the filtered frequency view.

Fix Remaining Issues: Sometimes, there might still be tiny issues. You can use filters to smooth them out.

1. mention notch filter (1 pt)

2. mention removal of periodic noise happens in Fourier space (1pt)

3. mention inverse Fourier transform to obtain the clean image (1pt) - This is important because we need a readable image in the end. The key word "Inverse Fourier transform" must be mentioned to gain the point.

Comment:
Mention of notch filter +1

No mention of periodic noise appearing in Fourier space -1

No mention of the inverse fourier transform -1

Question **16**

Correct

Mark 2.00 out of 2.00

Which of the filters stated below in the frequency domain reduce ringing artifacts? Select all the answers that apply.

- [x] a. Butterworth band-pass filter ✔
- [x] b. Gaussian high-pass filter ✔
- [ ] c. Ideal band-reject filter
- [ ] d. Ideal low-pass filter

Your answer is correct.

With ideal filters, the ringing effects exist in both low-pass and high-pass filtering. Other filter designs reduce the impacts.

The correct answers are:
Butterworth band-pass filter,

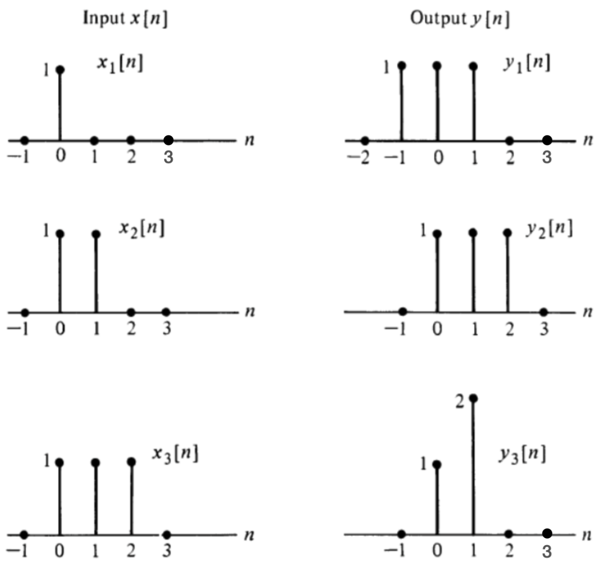
Gaussian high-pass filter

Question **17**

Correct

Mark 1.00 out of 1.00

Consider the following input signals x1, x2, and x3 and their responses when passing through a linear but NOT time invariant system, y1, y2, and y3, respectively.

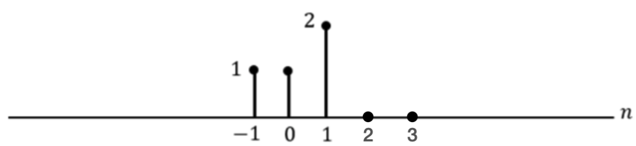


A new signal x4 can be expressed as

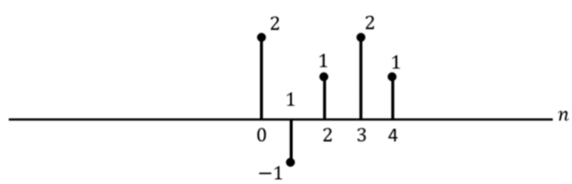
$$x_4 = 2x_1 - 2x_2 + x_3$$

Please choose the right response function for the signal x4 after passing through the same system.

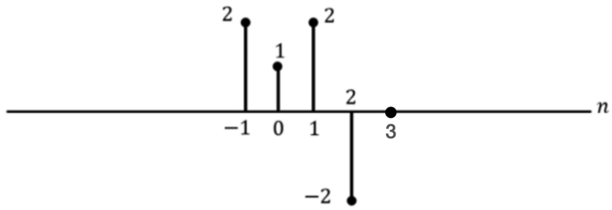
a.



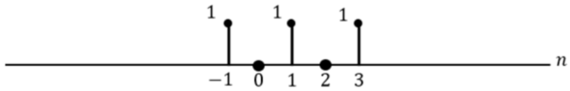
b.



c.

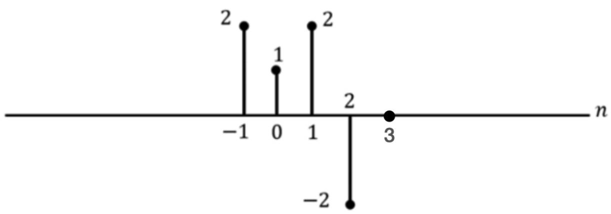


d.



Your answer is correct.

The correct answer is:



Question **18**

Complete

Mark 0.00 out of 3.00

If we want to combine **laplacian filtering** and **Gaussian low-pass filtering** as a means to achieve edge detection/extraction and image denoising altogether for an image with Gaussian noise. Does it matter which process is applied first? In other words, is there a difference between applying laplacian filtering first then Gaussian low-pass filtering, and applying Gaussian low-pass filtering first then laplacian filtering?

Explain your answer. If the order does matter, give the reason for using one or the other method first.

The sequence in which you use Laplacian and Gaussian filters matters. It's better to first apply Gaussian low-pass filtering followed by Laplacian filtering. This order is preferred because Gaussian filtering helps reduce image noise, making it smoother and aiding edge detection. Laplacian filtering then enhances and extracts edges effectively. Starting with Gaussian filtering improves image denoising, enhancing Laplacian's edge detection performance.

Hence, it's typically advised to start with Gaussian low-pass filtering followed by Laplacian filtering. This sequence reduces noise before boosting edges, leading to improved edge detection and image denoising.

The student should answer it does not matter (1 pt)

The reason for that the order does not matter: Both types of filters are linear filters (2 pt)

Comment:

Question **19**

Correct

Mark 1.00 out of 1.00

A high-boost filter is a high-pass filter.

Select one:

- True
- False ✔

It is a high-frequency-emphasis filter. The low frequency component still remains.

The correct answer is 'False'.

Question **20**

Complete

Mark 1.00 out of 3.00

What are the benefits of frequency domain image analysis and processing?

Frequency domain image analysis has a lot of benefits:

Localization of Features: It allows precise localization of image features, by examining the freq components you can identify specific elements such as edges textures and patterns, this makes it easier to manipulate and enhance particular aspects of the image without affecting the entire content

Noise Reduction : In the frequency domain it is easier to remove noise from the image's content without significant loss of details

Enhancement of Specific Frequencies: Frequency domain techniques enable selective enhancement or suppression of specific frequency components, which is valuable for emphasizing or reducing particular features.

Efficient Algorithms: The frequency domain offers efficient algorithms like the Fast Fourier Transform (FFT) for various image processing tasks, leading to faster and more streamlined operations.

Compression and Transmission: Frequency domain methods are vital for image compression and transmission, facilitating smaller file sizes and efficient data representation while maintaining acceptable image quality.

1. Mention trade-off for filter size vs. computational cost - very important. Frequency domain processing is only more efficient when the filter size is getting bigger. Generally when the need is a 3x3 filter, then spatial filtering can still be more efficient.

2. Allows more complex filter design - as we can use the size of the entire image to better define the shape of the filters.

3. Better understanding of the image properties before and after filtering - this is the case for periodic artifact removal, where these artifacts are shown as symmetric lines or dots in the frequency domain.

4. Efficiency in data representation to reduce data storage demand - signals are represented by coefficients with preset basis functions.

Mentioning any of the 3 points out of 4 will gain 3 marks.

We have discussed this question in class. It is important to inspect the answers for what has been asked. If the student only mentions the specific applications (e.g., filtering operations, then 0 point is given). Note that this question is asking about FT instead of DCT.

Comment:

Efficiency in data representation to reduce data storage demand +1

◄ Lab session 7

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