COMS30030 – Image Processing and Computer Vision

Problem Sheet MM01

Section II

3 – Imagine you have managed to construct a Camera Obscura. However, you are unhappy with the produced image since it appears too dark. Which of the following camera alterations will help towards producing a brighter image?

A. Using a smaller pinhole diameter.
B. Using a larger pinhole diameter.
C. Moving the image plane further away from the pinhole.
D. Using thicker material to punch the pinhole through.
E. None of the above.

Answer

B – A larger pinhole increases the amount of different light rays passing into the camera that are mapped to the same image location. As a result, this increases image brightness, at the cost of a reduction in image sharpness.

4 – Which of the following statements about the Shannon-Nyquist theorem is CORRECT?

A. An analogue signal containing components up to some maximum frequency f may be completely reconstructed by regularly spaced samples, provided the sampling rate is the same as that frequency f.
B. An analogue signal containing components up to some maximum frequency f may be completely reconstructed by regularly spaced samples, provided the sampling rate is below twice that frequency f.
C. An analogue signal containing components up to some maximum frequency f may be completely reconstructed by regularly spaced samples, provided the sampling rate is within one order of magnitude of twice that frequency f.
D. An analogue signal containing components up to some maximum frequency f may be completely reconstructed by regularly spaced samples, provided the sampling rate is above twice that frequency f.
E. None of the above are correct.

Answer

D

5 – An unit impulse function in continuous form is defined to be:

A. $\partial(t) = 1$
B. $\partial(t) = t$
C. $\partial(t) = \begin{cases} \infty, & t = 0 \\ 0, & t \neq 0 \end{cases}$
D. $\partial(t) = \begin{cases} \infty, & t = 0 \\ 1, & t \neq 0 \end{cases}$
E. $\partial(t) = 0$

Draw a little diagram to explain your answer.

Answer

C – note that this is the definition of a unit impulse function – its area under the curve sums to 1 when integrated between +/- infinity.

6 – What represents the transition between an image function's continuous values and its digital equivalent?

A. Rasterization
B. Quantization
C. Sampling
D. Smoothing
E. None of the above

Answer

B – Quantization is the mechanism that involves the conversion of a continuous range of values into a finite range of discrete values.

7 – What is the bit rate for transmitting uncompressed 600x600 pixel colour video of 60 frames per second at 8 bits per colour channel?

A. 2.8Mbps
B. 360 Mbps
C. 21.6 Mbps
D. 172.8 Mbps
E. 518.4 Mbps

Answer

E – 600x600x60x3x8 = 518,400,000 = 518.4 Mbps

8 – Consider the ideal Dirac delta function $\delta(x,y)$ in the context of image processing.

1. The delta function is often used in convolution, where convolving an image with $\delta(x,y)$ results in the original image.
2. In the frequency domain, the Fourier transform of a delta function is a constant, representing uniform intensity across all frequencies.
3. The delta function acts as a low-pass filter when applied in the spatial domain.
4. The delta function can be approximated in discrete image processing by using a unit impulse response in a discrete grid.

Which of the above statements are true regarding the function's properties and applications?

A- 1 and 2 only
B- 1, 2, and 3 only
C- 1, 3, and 4 only
D- 2, 3, and 4 only
E- 1, 2, and 4 only

Answer

E

- **Statement 1** is true: Convolution with the **Dirac delta function** results in the original image, as the delta function acts as the identity element in convolution.
- **Statement 2** is true: The **Fourier transform of a delta function** is a constant across all frequencies, implying uniform energy distribution in the frequency domain.
- **Statement 3** is false: The delta function is not a low-pass filter. In fact, it preserves all frequencies and acts like a "pass-all" filter when used in the spatial domain.
- **Statement 4** is true: In **discrete image processing**, the delta function can be approximated by a unit impulse, which has a value of 1 at a specific location and 0 elsewhere.

9- Which of the following fact(s) is/are true about sharpening spatial filters using digital differentiation?

A. Sharpening spatial filter response is proportional to the discontinuity of the image at the point where the derivative operation is applied.

B. Sharpening spatial filters enhances edges and discontinuities like noise.

C. Sharpening spatial filters de-emphasizes areas that have slowly varying graylevel values.

D. A & B are both TRUE, C is FALSE.

E. A, B & C are all TRUE.

Answer

E

10- What are the two 1D filters that can replace the 2D filter (in each example for W and X) if they were applied consecutively?

$$W = \frac{1}{9}\begin{pmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{pmatrix} = \frac{1}{3}\begin{pmatrix}1\\ 1\\ 1\end{pmatrix} x \frac{1}{3}(1 \quad 1 \quad 1)$$

$$X = \begin{pmatrix}1 & 1 & -1\\ 2 & 2 & -2\\ 1 & 1 & -1\end{pmatrix} = \begin{pmatrix}1\\ 2\\ 1\end{pmatrix} x (1 \quad 1 \quad -1)$$

11- This is a row of pixels from an image that can be considered as a signal:

0	0	0	0	0	0	20	19	20	16	10	100	11	0	0	0	0	0

Which of these is the correct second derivative of this signal?

A.

	0	0	0	0	-20	21	-2	5	2	-96	179	-78	-11	0	0	0	

B.

	0	0	0	0	20	-1	1	-4	-6	90	-99	-11	0	0	0	0	

C.

	0	0	0	0	20	-21	2	-5	-2	96	-179	78	11	0	0	0	

D.

	0	0	0	0	-20	1	-1	4	6	-90	99	11	0	0	0	0	

E. None of the above are CORRECT.

Answer

C – The correct answer may be obtained using:

$$\frac{\partial^2 f}{\partial^2 x} = f(x+1) + f(x-1) - 2f(x)$$

12- In the context of image sharpening, consider the following statements:

1. The Laplacian operator enhances image details by calculating the second-order spatial derivatives of pixel intensities.
2. The Unsharp Masking technique involves subtracting a blurred version of the image from the original image to enhance high-frequency details.
3. High-boost filtering can be seen as a generalization of Unsharp Masking, where the contribution of the original image is weighted.
4. The use of sharpening operators generally reduces the effect of noise in an image.

Which of the following statements are **correct**?

A- 1, 2, and 3
B- 1, 2, and 4
C- 1, 3, and 4
D- 2, 3, and 4
E- They are all correct

Answer:
A- 1, 2, and 3
Explanation:

- **Statement 1** is correct: The **Laplacian operator** works by calculating second-order spatial derivatives to highlight regions of rapid intensity change, which is used in image sharpening.
- **Statement 2** is correct: **Unsharp Masking** sharpens images by subtracting a blurred (low-pass filtered) version of the image from the original to enhance high-frequency details.
- **Statement 3** is correct: **High-boost filtering** is a generalization of Unsharp Masking where the original image is scaled by a factor before the subtraction, allowing control over the degree of sharpening.
- **Statement 4** is incorrect: Sharpening often **amplifies noise** in an image because it enhances high-frequency components, including noise.