COMS30030 – Image Processing and Computer Vision

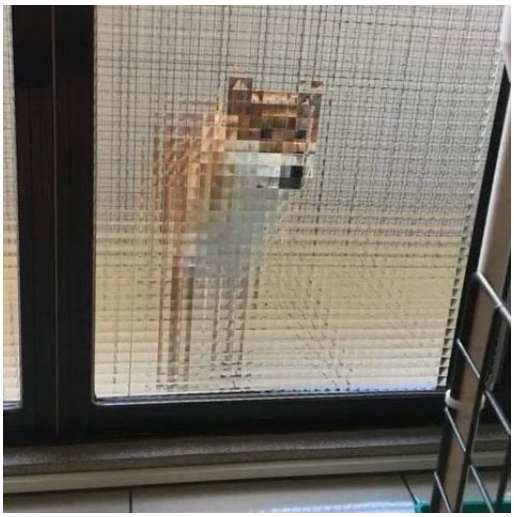
Problem Sheet MM01

Section I – No Solutions will be given! Do Your Own Research! Discuss with your peers!

1- What is a **C**amera **O**bscura?

a) Why does the image appear brighter in the centre of the projection and fades out towards the periphery?
b) What effect does a change of the size of the pinhole have on the image produced?
c) What is meant by the point spread function (PSF) and how does it relate to the Dirac Impulse?

2- What can you say about the appearance of the dog (or is it a fox?) in this photograph?



3- You are working at a movie production company and have just shot an advert for a new car model using HD and 25fps. However, during postproduction the client rings up and complains that in some video scenes some car wheels (structured as depicted in left figure) turn backwards whilst the car drives forwards. In another scene the car wheel design provided by the client (right figure) – he claims – was changed and now appears coloured! You confirm with the crew that no wheels turned backwards and no colour was added...

a) What has happened in each of the scenarios?
b) How does the backwards-turning problem relate to the Nyquist theorem?
c) Come up with 2 different ways to address the backwards-turning problem by modifying the movie script or camera specs?
d) Given the above problems, consider the importance of methods independent of our human visual system for judging the performance/quality of computer vision systems.

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.

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.

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.

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

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

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

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.

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?

$$W = \frac{1}{9}\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix} \qquad X = \begin{pmatrix} 1 & 1 & -1 \\ 2 & 2 & -2 \\ 1 & 1 & -1 \end{pmatrix}$$

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.

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