2020/5/11

Q1: How did we determine the direction of motion for the degraded image of Canyonlands National Park (degraded by linear motion blurring)? (ch5 p68)
Ans: Observe the distribution of DFT magnitude of the image and the motion direction is perpendicular to the direction of distribution.

Q2: What is the criterion for designing Wiener filter?
Ans: minimize the mean square error between the estimated and the actual noise-free (yet, degraded) image.

Q3: How to obtain the condition E[e(x1,y1)g*(x2,y2)] = 0 in the procedure of deriving Wiener filter (describe the assumptions)?
Ans: minimize expectation $E[|e|^2] = E[ee^*] = E[e(s-s^{cap})^*] = E[es] – E[e(h'*g)^*]$, and E[es]=0 <u>because e is zero-mean and uncorrelated with s</u> (and g); continuous derivation leads to the condition E[e(x1,y1)g*(x2,y2)] = 0.

Q4: In Wiener filter implementation, how to estimate the noise-to-image power ratio K?
Ans: by interactive test (trial and error), that is, by testing different K values until a desirable result is obtained.

Q5: Specify the region corresponding to colors of full saturation in the chromaticity diagram.
Ans: boundary of chromaticity diagram

Q6: How to construct the cross-sectional color plane (R, 127, B) by feeding three individual component images into color monitor? Refer to p19 note to specify each component image. (ch6 p19)
Ans: Switch the R-component image with the G-component image (R: linearly increase from black to white from left to right, G: constant, mid-tone gray)

Q7: Given the color values (0.8 0.9 0.5) of CMY color model, what are the corresponding CMYK color values?
Ans: (0.6 0.8 0 0.5)

Q8: What is the value of hue (H) for the RGB color (0.2 0.2 0.5)?
Ans: 240 degrees, or 0.67 (normalized)

2020/5/4

Q1: What's the assumption of the degradation process H so that the output (degraded) image can be computed as the linear convolution of the input (original) image and the impulse response of degradation process h? (ch5 p6)
Ans: Linear, shift-invariant

Q2: Briefly describe the degradation model. (ch5 p6)
Ans: a degradation process (assumed to be linear and shift-invariant) followed by the additive noise (assumed to be generated by random stochastic process); or, degraded image $g(x,y) = h(x,y)*f(x,y) + \eta(x,y)$, where $h(x,y)$ is the impulse response of LSI degraded process, $f(x,y)$ is the original image and $\eta(x,y)$ is the additive noise.

Q3: What are the assumptions for the noise model? (ch5 p9)
Ans: noise is random process, independent of spatial coordinates and uncorrelated with the image

Q4: Which Lena's image (on page 20 of ch5) is the one contaminated by salt-and-pepper noise (upper or lower one)? (ch5 p20)
Ans: upper one

Q5: For the noisy image, how to design the experiment to determine the possible noise model when only images are available?
Ans: select several smooth subimages which contain almost constant gray level and analyze their histograms to determine the possible pdf and compute the parameters of the pdf model.

Q6: When applying the contraharmonic filter with positive order, Q, to the image corrupted by 10% pepper noise, we can remove the pepper noise, however, at the expense of some undesired effect. What is this undesired effect?
Ans: Dark features are blurred.

Q7: Why can't we apply inverse filtering to the entire frequency range? (ch5 pp64-65)
Ans: Because the inverse filter is a highpass filter, empirical images always have noise problems that will be amplified by inverse filtering. Then the inverse filtering leads to the output image totally corrupted by the noise.

Q8: For the image degraded by severe turbulence, how can one apply the inverse filtering to only a selected circular frequency range (say, radius of 70 pixels)?
Ans: Before performing inverse filtering, we apply a lowpass Butterworth filter with the cutoff frequency selected as the radius (70 pixels) of the circular frequency range.

2020/4/27

Q1: List the two important properties for designing the 2D filter (frequency response H(u,v)).
Ans: zero phase, radially symmetric.

Q2: What is the serious problem of applying an ideal filter with such small cutoff frequencies as 30 pixels and 60 pixels?
Ans: Ringing effect.

Q3: What is the inverse FT of a square pulse (just give the name of the time-domain function)? (ch4 p58)
Ans: sinc function

Q4: Let h(t) be the impulse response of an ideal lowpass filter H(jω) with passband between –W and W. What is the relation between the mainlobe width of h(t) and the passband width of the lowpass filter? (p.59)
Ans: Mainlobe width of h(t) is inversely proportional to the passband width of H(jω).

Q5: Impulse response of Gaussian lowpass filter does not have ringing problem. What do we have to sacrifice to gain the benefit of such an impulse response? (ch4 p62)
Ans: Poor frequency response (poor, sluggish transition band).

Q6: How does order (n) of Butterworth lowpass filter affect the frequency response? (ch4 p66)
Ans: Adjust the transition band (increasing order makes the transition band sharper)

Q7: Why does the output image of ideal highpass filter (IHPF) using cutoff frequency 60 pixels have wider rings around edges than the output image of IHPF using cutoff frequency 160 pixels? (ch4 p81)
Ans: The IHPF using cutoff frequency 60 pixels has a wider mainlobe width of the impulse response than the one using cutoff frequency 160 pixels.

Q8: Why does the frequency-domain Laplacian operator perform better than the spatial-domain Laplacian operator (in consideration of the sharpening effect)? (p84)
Ans: Spatial-domain Laplacian mask is derived from rough approximation of second-order partial derivatives that is limited to finite neighboring range and finite resolution of numeric approximation. Frequency-domain Laplacian operation is derived from differentiation property of

Fourier transform that is the rigorous mathematic formula, instead of numeric approximation.

Q9: How can the homomorphic filtering separately treat the illumination and reflectance factors?
Ans: by applying logarithm to image before DFT.

Q10: In notch filter design, why should we design pairwise notches/holes for H(u,v)? That is, if we want to eliminate frequency (u0, v0), we also need to eliminate frequency (M-u0, N-v0), given an M-by-N H(u,v). (p95)
Ans: For a practically realizable system, the impulse response must be real. The DFT of a real function is circularly symmetric. So the design of frequency response must meet the criterion of circularly symmetric: H(M-u0, N-u0) = H*(u0,v0) = H(u0,v0) (because of zero phase, H(u,v) is real).

2020/4/20

Q1: Refer to the example given by Lecture 1 of today's video, f(x,y) is a 4-by-4 image containing elements {a_{xy} for $0 \le x,y \le 3$}. A new image g(x,y) = inverse 4-by-4 DFT{$F(u,v)(j)^{(u-v)}$}, where F(u,v) is the 4-by-4 DFT of f(x,y). What is g(1,1)?
Ans: a20 (or, f(2,0))

Q2: what's the highest frequency (in Hz) of a discrete-time signal sampled at fs Hz sampling rate? (ch4 p29)
Ans: fs/2 Hz.

Q3: What is the effect of spatial shift of an image on Fourier magnitude? (ch4 p34)
Ans: Fourier magnitude does not change by spatial shift of an image.

Q4: Let $F(u,v)$ be the DFT of an image. The local smooth regions of the output image become totally black when the DC component is removed from the DFT by setting $F(M/2,N/2)$ to 0. Why? (ch4 p47)
Ans: It's because the smooth local regions have zero frequency (contributes to DC component of DFT). F(M/2,N/2)=0 leads to zero response (output) for those pixels in the smooth regions.

Q5: What is the major factor that turns linear convolution into circular convolution?
Ans: limitation of array size.

Q6: Briefly describe the centering process.
Ans: It is the scheme applied to the input image before performing DFT (that is, $f(x,y)(-1)^{(x+y)}$) to generate the new DFT F′(u,v) that is the frequency shift of the DFT of f(x,y) by (M/2,N/2). So, F′(u,v) = F(u-M/2,v-N/2), F(u,v) is the DFT of f(x,y).

Q7: (3pts) Refer to the example given by Lecture 2 of today's video, f(x,y) is a 3-by-3 image containing elements {a b c d e f g h i} (from top row); and h(x,y) is a 1-by-2 impulse response of a filter, h(0,0)=1, h(0,1)= -1. We first compute the output image g1(x,y) by directly applying linear convolution in the spatial domain: h(x,y)*f(x,y). We then implement the filter in frequency domain to obtain the output image g2(x,y) = inverse 3-by-3 DFT{F(u,v)H(u,v)}, where F(u,v) and H(u,v) are respectively the 3-by-3 DFT of f(x,y) and h(x,y). Describe the differences between g1(x,y) and g2(x,y).
Ans: (1) g1 is a 3x4 array, g2 is a 3x3 array; (2) the 2nd and 3rd columns of g1 and g2 are the same; (3) the 1st column of g2 (effect of wrap-around) is the combination of the 1st column and the 4th column of g1.

2020/4/13

Q1: Which one is the output of Gy? Left or right? (ch3 p138)
Ans: the right one.

Q2: Which intensity transformation function can be used to compress the dynamic range of Fourier magnitude? (ch4 p14)
Ans: logarithm (cLog(1+FT magnitude)).

Q3: Explain briefly why spatial shift in (x,y) plane causes linear phase in (u,v) plane? (hint: spatial shift property of FT) (ch4 p20)
Ans: Spatial shift by (x0,y0) leads to Fourier transform with extra term of complex exponential exp(-jux0-jvy0) that contributes linear change with frequency (u,v) in the frequency domain.

Q4: What's the fundamental assumption for deriving the formula of discrete Fourier transform? (Or, What is the intrinsically basic assumption of the function $f(x,y)$ to support the existence of its DFT?)
Ans: Periodicity (even outside the image frame)

Q5: What is the major property that allows us to decompose the higher-dimensional transformation scheme into the one-dimensional transformation scheme?
Ans: Separability (of complex exponential kernel basis).

Q6: What is the major strategy used to realize *histogram Specification* scheme (question for chapter 3)?
Ans: histogram equalization.

Q7: (At the End of today's video lecture) What are x0 and y0 used to generate g(x,y)?
Ans: x0=3, y0=4   (or, x0 = -5, y0= -4)

Q8: (At the End of today's video lecture) What is the minimum DFT size MxN to generate h(x,y) that is the normal linearly-spatial shifted version of f(x,y) (without the problem of circular shift)?
Ans: 8x10