- Reading: Digital Image Processing, Gonzalez and Woods, Ed. 4; Chapters 5, 6, 9.
- Show your work to get credits and state any assumptions you make. You can use/state results derived in class.
- Submission after quiz. Subset of problems will have to be submitted.

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1. The white bars in the test pattern shown in Fig. 1 are 7 pixels wide and 210 pixels high. The separation between bars is 17 pixels. What would this image look like after application of a 3×3
   (a) Arithmetic mean filter ?
   (b) Geometric mean filter ?
   (c) Harmonic mean filter ?
   (d) Median filter ?

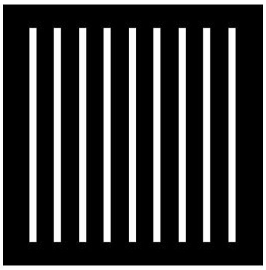


Figure 1: White bars

2. A linear, space invariant system has the impulse response

$$h(x, y) = \delta(x - a, y - b),$$

   where a and b are constants and x and y are discrete quantities. Assuming negligible noise in each case.
   (a) What is the system transfer function in the frequency domain?
   (b) What would the spatial domain system response be to a constant input, $f(x, y) = K$?
   (c) What would the spatial domain system response be to an impulse input, $f(x, y) = \delta(x, y)$?

3. [2 marks] *Consider a linear, position invariant image degradation system with impulse response

$$h(x, y) = e^{-\left[(x-\alpha)^2+(y-\beta)^2\right]}$$

   where x and y are continuous variables. Suppose that the input to the system is a binary image consisting of a white vertical line of infinitesimal width located at $x = a$, on a black background. Such an image can be modeled as $f(x, y) = \delta(x - a)$. Assume negligible noise and to find the output image, $g(x, y)$. What would happen if x and y are discrete quantities ?

4. During acquisition, an image undergoes uniform linear motion in the vertical direction for a time T_1. The direction of motion then switches to the horizontal direction for a time interval T_2 . Assuming that the time it takes the image to change directions is negligible, and that shutter opening and closing times are negligible also, give an expression for the blurring function, $H(u, v)$.

5. [2 marks] *Using the transfer function

$$H(u, v) = -8\pi^4\sigma^2(u^2 + v^2)e^{-2\pi^2\sigma^2(u^2+v^2)},$$

   give the expression for a Wiener filter transfer function, assuming the ratio of power spectra of the noise and undegraded image is a constant.

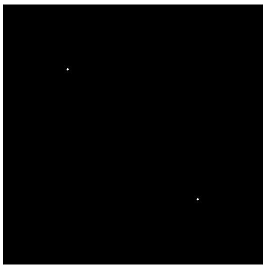


Figure 2: Two dots

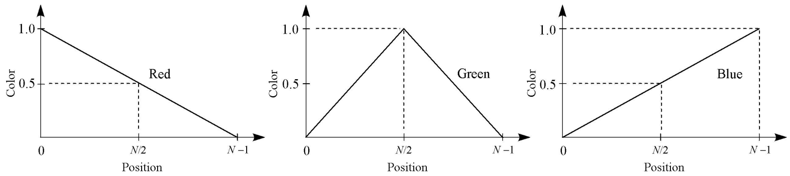


Figure 3: RGB components of an image

6. [2 marks] *Sketch the Radon transform of the $M \times M$ binary image in Fig. 2, which consists of two white pixels (dots) along the diagonal. Assume a parallel-beam geometry, and label quantitatively all the important elements of your sketch.
7. The R, G, and B component images of an RGB image have the horizontal intensity profiles shown in Fig. 3. What color would a person see in the middle column of this image?
8. [2 marks] *Sketch the HSI components of the image in Fig. 4 as they would appear on a monochrome monitor.

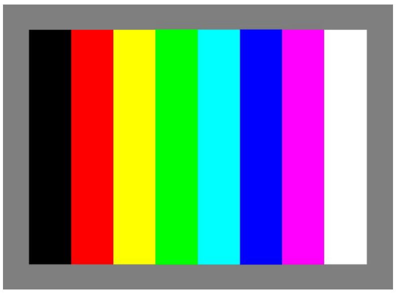
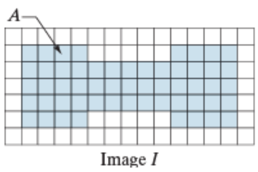
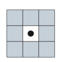


Figure 4: Gray border (50 % black), Black, Red, Yellow, Green, Cyan, Blue, Magenta, White are the colors.

9. Explain hue and saturation. What does HSI color model stands for and what it represents ?
10. [2 marks] *Use the image in Fig. 5a and structuring element in Fig. 5b.
    (a) Sketch the result of eroding the figure with the structuring element.
    (b) Sketch the result of dilating the figure with the structuring element.



(a) Image



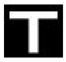
(b) Structuring element (SE)

Figure 5: Image and structuring element (SE)

11. What is the difference between dilation and convolution ? How is dilation different from erosion ?

12. [2 marks] *Sketch the result of applying hit-or-miss transform to the image in Fig. 6, using the SE shown. Indicate clearly the origin and border you selected for the structuring element.

(a) Image



(b) Structuring element (SE)

Figure 6: Image and structuring element (SE)